TEMPORAL ASPECTS OF WELL-BEING

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Thesis submitted to the University of Leicester in partial fulfilment of the requirements of the degree of Doctor of Philosophy.

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University of Leicester
1996
Acknowledgements

The study of shiftwork in nursing formed the final stage of a larger research programme on "Night and Shiftwork in Nursing and Midwifery" that was commissioned by the Department of Health (Ref: 195/0324). I am grateful to the Department of Health for financial support, to Miss E. J. C. Scott for her advice and encouragement, and to the many individual nurses concerned for their invaluable contributions.

The study of activity and mood was partly supported by the Medical Research Council and partly by a grant (SRA 1.3M/069) from Unilever Research, Port Sunlight, England. I am grateful to Professor Peter Warr and to Dr. Steve Evans for originally commissioning this research.

The views expressed in this thesis, however, are those of the author and do not necessarily represent the views of the Department of Health, Medical Research Council, or Unilever Research.
Dedication

The introduction and epilogue are for Brian Parkinson for supervising this thesis. Time is for Rob Briner for giving me all those books about time. Well-Being is for my family for shaping mine. The approach is for a school friend, Dave Sherry, who has a better theory of time. The methodology is for Steve Evans whose seminar inspired the development of the instrument, and Lawrence Smith and Angus Craig who were the respective principal investigators in the studies of power workers and air traffic controllers that helped validate the instrument. The study of shiftwork in nursing is for the Sheffield Shiftwork Team: Jane Barton, Simon Folkard, Ian Macdonald, Evelien Spelten, Lawrence Smith and Diane Thompson. Schedule is for Kamal Birdi for tea at 6, and the 2 Johns for annual drinks. Sequence is for Gillian Symon and Anthony Trollope. Duration, or time is the healer, is for my mother for all her proverbs. Interference, of the menstrual cycle, is for my sister Barbara for first making me aware that gender is an issue. Association I, on a day in the life of a shiftworker, is for Clare Warnock for giving me quality time between her shifts. The study of activity and mood is for the SAM team: Shirley Reynolds, Rob Briner and Brian Parkinson. Association II, on sleep, is for me for having a defective body clock. Awareness, is for Paschal Sheeran and Sheina Orbell for showing me that time passes fastest in pubs. Prediction is for the year Crystal Palace and Sheffield Wednesday win the Cup and League. Rhythm is for Simon Folkard for teaching me about rhythms. History is for John Potter for inspiring me to change direction at the Eleventh Hour. And finally, the discussion is for nobody in particular because language can’t be both complete and consistent.
Temporal Aspects of Well-Being

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Abstract

This thesis investigates the proposition that aspects of time influence well-being. In particular, it is theorised that a person's well-being is dynamically influenced by the temporal characteristics of social time, body time, and experiential time. Two intensive time-sampling studies were used to investigate this theory. The first was a study of sixty-one shiftworking nurses, who used a pocket computer to provide measures of sleep, affect and cognitive performance two hourly and daily for four weeks. The second was a study of thirty employed healthy volunteers who used the same instrument to provide similar measures for two weeks. The development and validation of the pocket computer as a research instrument is described. Ten investigations, five from each study, are reported. Each investigation tested hypotheses relating to a specific empirical research question and examined the influence of a different temporal characteristic on well-being. In general, the first study showed that changing the timing of people's activities affects their well-being. The second study showed that there are reciprocal relations between body time, experiential time and well-being. Individual findings have relevance to the understanding of work schedules, occupational health, the chronobiology of depression, affect regulation, and nonlinear affective processes. The thesis concludes by speculatively reformulating the temporal theory of well-being in the light of new evidence concerning consciousness, emotion and neurophysiology. The reformulated theory proposes stronger relations between time and well-being and is intended to provide a framework for future research in the area.
Publications

Parts of this thesis have been published in the following journal papers:


Research Instrument

The software programs developed for the research instrument described in chapter 5 have been made available to other researchers. Consequently, the programs have been used for a variety of research purposes by over 20 academic and commercial organisations from 10 different countries. The research instrument has been used to investigate effects of jet lag, diet, shiftwork, bright light, workload, age, consumer products, diabetes, activity, and psychopharmacology. French and Polish versions of the programs have also been produced. The software is about to be licensed to a commercial human factors organisation.
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Introduction

Yes it is a boring job, bloody boring actually, but all you can see is the tip of the iceberg - the present, the tedious here and now - what you're incapable of seeing is the rest of time, the rest of the iceberg, the past and the future, my future, which is a very interesting place to be. The thing about this job is that it gives me time and space to contemplate the future at my leisure whilst the city sleeps; free from the cacophonous curiosity of the hoi polloi. So, it's not a boring job, and I'm not boring either.

- Mike Leigh

_Naked_ (1993)

Time is at the heart of our feelings. Brian, the night security worker in the above extract from the film _Naked_, explains how his sense of well-being depends on his temporal perspective. By working at night Brian can contemplate his future, which he feels is an interesting place to be. This thesis examines some of the multiple ways in which time affects people's feelings.

Most people, especially those that live in a Western culture, usually equate time with linear clock time. People also commonly equate time with progress, meaning that time is conceived in terms of the advance towards goals. This view is encouraged from an early age. For example, children learn to see their future in terms of progress through school years. Each school year is intended to represent a development on the previous year. Many children also learn to anticipate a seamless passage onwards and upwards through further education, work career, marriage, offspring, and retirement.
However, the linear view of time is often at odds with people’s daily experiences, which are probably better characterised by ingrained routines and habits than by progress. It is reasonably safe to assume that most people will go to bed and get up at roughly the same time each day, that they will eat their meals at roughly the same time each day, and that they will work and play at roughly the same time each day. At a more microscopic level, people will usually have routines for dressing, for what they eat, and for what they do and how they do it. People’s experience of events is therefore cyclic as well as linear.

Most people also experience spurts, diversions, repetitions, and even reversions of events during their lifetime. People can also extend their consciousness into their past and into their anticipated future, which means that they do not just experience events in their order of external occurrence. The experience of time is therefore also probably nonlinear.

Most of us would like to believe that we are in control of how we spend our time, meaning that we can do things at times of our own choosing if we so desire. Unfortunately this is not always true. For example, anyone who has stayed up all night in the company of others, for example on a plane or a ferry or at a party, will be aware of people’s intense need to sleep during a certain time period and of the adverse, albeit temporary, consequences of them not doing so. There is also plenty of evidence, some of which will be described in subsequent chapters, to show that altering people’s routines or personal cycles can sometimes lead to acute and chronic disturbances of their well-being. These disturbances of well-being include adverse changes in affect, cognition, behaviour, performance, and health.

Alterations in personal cycles can arise from events such as intercontinental travel, the arrival of a new baby, unemployment, and shiftwork. The quote at the beginning of this chapter described how Ken, the night security worker, found some benefits to working at night by thinking about his future whilst everyone else sleeps. His experience of time was therefore positive and contributed positively to his well-
being. However, this thesis will show that working at night can also disrupt people's personal cycles and lead to a range of problems including reduced well-being.

Failure to understand and recognise the importance of the natural temporal characteristics of the body and of consciousness has led to the social enforcement of temporal requirements that are often out of step with people's natural rhythms. Longer and unsocial work hours are obvious examples. However, there are many other examples to be found in the timing, pace and structure of many jobs and in the rigidity of many school timetables. The lack of personal and social understanding of temporal factors restricts the potential well-being and health of many people.

Psychology is not immune to this criticism of failing to consider the effects of temporal factors. A later chapter will show that many methods in psychology are designed to remove or restrict the influence of time, and that many psychological investigations assume that equal time periods are psychologically equal and that effects are linear over time.

Aims

This thesis is therefore intended to address these shortcomings by developing a theory of the temporal aspects of well-being and using it to investigate applied research questions. In particular, the thesis investigates how some of the temporal characteristics of people's social world, their body, and their experience affects their well-being. This involves the use of two applied studies, both of which adopt an intensive time-sampling method in which quantitative measures are collected at frequent regular intervals from participants. The first is a field study of 61 shiftworking nurses, and examines what happens to well-being when time is disrupted by shiftwork. The second is a field study of 30 healthy volunteers, and examines temporal aspects of well-being without the disruptive influence of shiftwork. The two studies involve collecting sleep, mood, symptom, and cognitive performance measures as frequently as every two hours for up to four weeks. The thesis also describes the development and
validation of a research instrument - a suite of programs for a pocket computer - that enables and facilitates the collection of these measures.

The thesis therefore aims to provide evidence concerning the validity and benefits of a temporal approach to well-being, and aims to elucidate some issues of applied psychological importance. The theoretical framework of the thesis functions as a paradigm for research in that it is used to guide the investigation of specific empirical research questions. The answers to these research questions are intended to fill current gaps in temporal knowledge related to well-being, and usually have applied relevance.

In order to address the broad conceptual framework that is accommodated by the theory, the thesis reports five separate investigations from each study. Each investigation examines the influence of a different temporal characteristic by testing hypotheses pertaining to a specific empirical research question. These research questions will be identified in the overview of chapters presented next and will be elaborated in subsequent chapters. Although the investigations are associated within the theoretical framework, each investigation is designed to be self-contained and does not therefore depend on or arise from the results of the other investigations.

The thesis concludes with some speculations for a more complete theory of the temporal aspects of well-being. This reformulated theory makes stronger assumptions about the nature of the relationships involved and is intended as a springboard for future research.

Overview of chapters

The thesis basically divides into three sections. The first section, chapters 2-5, sets the scene for the subsequent research investigations. It contains a review of the relevant research literature, presents the theoretical framework of the thesis, and describes the development and validation of a research instrument that is used in the investigations. The second section, chapters 6-11, describes the field study of shiftwork in nursing and its associated investigations. The third section, chapters 12-
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17, describes the field study of activity and mood and its associated investigations. Finally, chapter 18 provides a summary of the results and a reformulation of the theoretical framework.

The two focal topics of this thesis are time and well-being. The review chapters, chapters 2 and 3, therefore examine each of these issues in turn. Chapter 2 presents a review of research on time with particular reference to well-being, and chapter 3 presents a review of research on well-being with particular reference to time.

Chapter 2 starts with a brief review of the history of time psychology and with a discussion of alternative concepts and characteristics of time. The chapter then reviews recent research concerning body time (including biological rhythms), experiential time (including awareness of time), and social time (including time structure). A large section of the chapter is devoted to the problems experienced by shiftworkers in order to provide the necessary background to the field study of shiftwork.

Chapter 3 begins by reviewing the concept and components of well-being. A number of temporal dimensions of well-being are identified in relation to changes in affect. Finally, the chapter considers the evidence that body time and experiential time contribute to the chronically disturbed well-being of affective disorders. Much of the research described in this chapter is particularly relevant to the investigations based on the field study of activity and mood.

Having presented the relevant background information in the previous two chapters, chapter 4 moves on to describe the development of a theoretical framework and the selection of a research method for the thesis. The first half of the chapter outlines and evaluates relevant theories, and then presents a new alternative theoretical framework. The general aims of the thesis are outlined, and the studies and individual investigations of the thesis are introduced. The second half of the chapter considers methodological issues. This includes describing the approach and intensive time-
sampling method used in the thesis. Alternative techniques, measures and analysis procedures that are available within this method are described and particular options are selected.

In order to implement the chosen research method, it was necessary to develop a new research instrument for use in the two field studies. Chapter 5 describes the development and validation of this research instrument. The chapter highlights the fact that available instruments were insufficient for intensive time-sampling of both affect and performance in field studies. The development of the new research instrument in the form of set of software programs for a pocket computer is described. The chapter also assesses the usability and performance of the instrument, and the validity and reliability of the measures using data from field and laboratory studies.

Chapters 6 to 11 describe investigations based on the intensive time-sampling study of 61 shiftworking nurses. The first of these chapters, chapter 6, describes the design of the shiftwork in nursing (SIN) study. This includes details of the context of the study, the sample, the procedure, the measures, the data analysis procedures, and relevant descriptive statistics.

The investigations described in chapters 7 to 11 explore various temporal aspects of the disturbance caused by shiftwork. Chapters 7 and 8 examine the influence of the timing and order of shifts, and chapter 9 examines the influence of accumulated work time and duration of time off on well-being. Chapters 10 and 11 then investigate more complex temporal relations by examining interactions between the shift cycle and the menstrual cycle (chapter 10), and by examining relations between variables that are temporally mediated by other variables (chapter 11).

Although shiftwork provides a convenient naturalistic means of exploring what happens to well-being when people adopt an unusual temporal structure, there are a number of questions concerning time and well-being that are better answered in the absence of a temporal intervention. The investigations based on the second study, described in chapters 12-17, therefore involved people that worked regular hours.
Chapters 12 to 17 describe the investigations based on the intensive time-sampling study of 30 healthy non-shiftworkers. The first of these chapters, chapter 12, describes the design of the field study of activity and mood (SAM) study. This includes details of the context of the study, the sample, the procedure, the measures, the data analysis procedures, and relevant descriptive statistics.

Chapter 13 continues some of the work reported in chapter 11 by examining temporal associations between sleep and well-being but without the interference of shiftwork. The next two chapters, chapters 14 and 15, investigate the conscious experience of time in relation to well-being. In particular, chapter 14 investigates the relations between the perceived speed of time and mood, and chapter 15 investigates people’s ability to predict their future mood. The final two investigations are concerned with the influence of people’s affective history on temporal patterns of affective response. Specifically, chapter 16 investigates the relations between people’s general level of depressed mood and diurnal (daily) and ultradian (within-day) rhythms in their mood. Chapter 17 examines whether states of well-being depend on previous states in ways that are deterministic but not necessarily linear or rhythmic. In particular, it applies a novel graphical nonlinear method to time-series in affect and cognitive performance.

Finally, chapter 18 reviews the general findings from the two studies. The individual investigations are self-contained and hence the results from each investigation are discussed in detail within the relevant chapters. However, chapter 18 briefly summarises the main findings from the individual investigations. The chapter also discusses the limitations of the research method and examines the implications of the findings for the psychological understanding of time and for the psychological understanding of well-being. The theory of the temporal aspects of well-being is then reformulated. The speculations contained in the reformulated theory are shown to be part of a philosophical tradition and are partially supported using new ideas emerging.
from research on embodiment, consciousness, neurophysiology, and well-being. This serves to signpost new directions for research on the temporal aspects of well-being.
2

Time

A Review of the Psychology of Time

Time is the most overlooked dimension in human nature. Astronomers know more about the timing of pulses from distant radio stars than we know about the pulses of our own body.

- Gay Gaer Luce

*Body Time* (1973)

This chapter reviews previous research in psychology concerning time and the impact of time on well-being. This chapter and the next are intended to give a broad overview of the relevant research literature in order to show where and how the research reported in this thesis fits into the wider research context. The two chapters will introduce the key issues relating to the research of this thesis and will make links with topics that are of related interest but that are not specifically covered within this thesis. Research that is of specific relevance to the individual investigations of the thesis will be described in greater detail within the chapters that describe those investigations.

*Overview of chapter*

This thesis has a particular concern with the issue of time. The chapter therefore begins by examining the history of the psychology of time. Time is a topic that has generally been neglected by psychology but there is nevertheless a history of related research. The historical review will show that the approach to time adopted in this thesis represents a relatively contemporary approach. The chapter then briefly reviews previous attempts to conceptualise time and describes the difficulty of breaking time into an agreed fixed set of fundamental characteristics. This is relevant
because the investigations reported in the thesis are used to illustrate different (but not mutually exclusive) characteristics of time.

The chapter then reviews research relevant to the relation between time and well-being. This research is reviewed under the headings of body time, experiential time, and social time. This structure will later provide the basis for the conceptual framework of the thesis. Research concerning the body clock and various types of rhythm in biological and psychological processes are described under the heading of body time. The section on experiential time briefly describes research relating to people’s conscious perspective on their past, present, and future, including their awareness of the passage of time. The influence of temporal structure in the external world and the importance of the timing of external events in regulating internal psychological processes are described in the section on social time.

Finally, the chapter reviews the effects on well-being of one particular type of temporal disturbance, namely that caused by shiftwork. This will include a review of the types of problem associated with shiftwork, the effects it has on well-being, the interventions that can minimise the problems, and individual differences in coping with shiftwork. This review of shiftwork provides the necessary background to the first study (and its associated investigations) reported in this thesis, which is a study of shiftworkers.

History of the study of time

Time is fundamental to every aspect of human existence and experience. Philosophy, physics, biology and many other disciplines have devoted considerable effort to understanding the concept of time. Yet, psychology has been strangely quiet on the topic. Michon and Jackson (1985) suggest three reasons for the lack of attention given to time by mainstream psychology. First, time adds methodological complexity to investigations and increases variability in data. Second, the study of time cuts across research areas in psychology. Third, time has traditionally been viewed as a
dimension in which to measure other variables rather than a variable in itself. Or as Adam (1988) puts it, "Time is seen as a parameter within which life is enacted".

McGrath and Kelly (1986) give similar reasons for the lack of attention to temporal issues in psychology. They observe that the usual approach in psychological investigation has been to strip out time from the phenomenon being studied to reduce complexity. Psychology generally considers systems to be mainly stable and therefore changes in systems are often viewed as error variance rather than information. Even longitudinal studies in psychology usually have minimised the possible influence of time by taking measurements on a very limited number of occasions and by making assumptions about what happens in the intervals between measurements. Consequently, many of the threats to the validity of causal interpretations in psychological studies are temporal. For example, the unknown influences of history and attrition during a study can threaten its validity. McGrath and Kelly also point out that there have been pragmatic reasons for not studying time, the most obvious of which is that it takes time to study time.

Despite psychology's general neglect of time, there is a long history of time-related research. Indeed, the topic has been in and out of fashion throughout the last century and is currently experiencing an upturn in interest. Increased interest in the topic has usually been spurred by methodological and technical innovations.

The first empirical studies on time began in the middle of the 19th century and concerned the perception of time. Some of the early findings were summarised in Vierordt's Law which stated that people overestimate short time intervals and underestimate long ones. Subsequent research has largely confirmed Vierordt's Law, but there have been different estimates for the neutral point at which time estimates are neither overestimated or underestimated. Mach, who was one of the first to conduct studies of time sense, proposed that the neutral point occurs when people are required to judge intervals of around half a second. Clausen (1950), however, estimated that the neutral point is between 5 and 10 seconds.
Interest in time psychology declined between 1910 and 1960 and largely shifted from Germany to France (Michon & Jackson, 1985). The greatest interest in time psychology has always been in the psychophysical domain, especially in estimates of brief time intervals. For example, Eisler (1976) referenced 111 studies that required people to judge the duration of brief intervals. The three main methods for estimating duration have been reproduction of an interval, production of an interval specified verbally, and verbal estimation of an interval. Reproduction appears to be the least reliable method. Production and estimation are usually highly negatively correlated but verbal estimates generally tend to overestimate the interval (Clausen, 1950). Pieron, and later Francois, showed that people's estimates of time intervals change with their body temperature. In America, Hoaglund (1933) found similar results and concluded that time perception depends on an internal clock that is sensitive to temperature. This led to an interest in biological rhythms as the mechanism for time perception.

However, there have also been other influential strands of time related research. For example, in the 1930s Piaget undertook some important studies of children's development of the use of objective time (see Edlund, 1987). Similarly, in the 1960's Melges conducted some important clinical investigations of changes in time sense during disease.

Interest in time psychology has increased since Fraisse reviewed a century of work on time perception in the 1960s (see Fraisse, 1984). Part of the reason for this increased interest may be that time has become embedded within other theoretical frameworks (Michon & Jackson, 1985) such as information processing and chronobiology. These two frameworks in particular can be distinguished by their respective alignments with event- and clock-based theories of time perception.

The information processing conception is that the perceived duration of an interval depends on the amount of information stored in memory during that interval: The more information that is stored, the longer the interval seems. Ornstein (1969), for example, performed nine experiments which demonstrated that duration depends on stimulus complexity, coding efficiency, and information storage. He believed that an
inner clock explanation was unsustainable because there wasn't a consistent
identification of the source of the clock. This situation has somewhat changed in that
the suprachiasmatic nucleus of the hypothalamus of the brain has been isolated as the
source of many of the body's endogenous rhythms.

The information processing account also has problems in explaining the finding
that the judgement of an interval in passing is not the same as the judgement in
retrospect (see McGrath & Kelly, 1986). McGrath and Kelly's own explanation of this
phenomenon goes some way towards reconciling information storage and clock
theories. They propose that when the external stimulus rate is greater than normal, an
interval seems fast in passing but is remembered as long in retrospect because the
amount of information stored normally equates with a longer interval. However,
increasing the rate of the internal clock, using stimulants for example, means that
external time seems to pass slowly because little is happening per unit of internal time.
A retrospective judgement should be unaffected because no more information is being
stored than normal.

A more recent information processing approach to time uses a context-based
rather than a stimulus-based paradigm. The contextual paradigm proposes that what is
stored in memory depends on the physical and psychological context of the experience.
Experiments have shown that duration is remembered as longer during periods filled
with mixed types of processing, irrespective of level of processing. People seem to rely
on the amount of change in context rather than on the storage size of stimuli in making
judgements of duration (Block, 1985; Block & Reed, 1978). One intriguing study has
shown that time estimates depend on the physical scale of the environment. For
example, people estimated that 30 minutes had passed after only 5 minutes following
prolonged observation of a miniature room of 1/6 scale (DeJong, 1981).

From a clock perspective, there is evidence that circadian (about 24 hr) body
clocks are used for estimating intervals of time (Groos & Daan, 1985). For example,
Aschoff (1984) found that participants under conditions of temporal isolation showed a
circadian distribution in their estimates of 1 hour intervals and a correlation between
their estimates and duration of wakefulness. However, circadian period was not related to estimates of intervals of 10 or 20 seconds. Estimates of the duration of sleep and wakefulness during another isolation study suggested that the passage of time is slower during sleep (Aschoff, 1992).

The increase in interest in time psychology since the 1960s has not yet spread to an interest in the relation between time and well-being. To date there has been little systematic research on time in relation to affective processes outside of the clinical domain. However, the recent surge of interest in intensive time-sampling methods in social and personality psychology (Tennen, Suls, & Affleck, 1991), suggests that this situation may soon change.

**Concepts of time**

Time has been conceptualised in many different ways. Adam (1988) remarked that social scientists are threatened with drowning in a "flood of times" and therefore need to engage in categorisation. McGrath and Kelly (1986) have produced a particularly coherent categorisation. They have divided conceptions of the structure, reality, flow and validity of time into two dimensions each. The structure of time is conceived as either atomistic or continuous, depending on whether it is thought to be divisible into a succession of events or not. It is also conceived as either homogeneous or differentiated, depending on whether all instants are thought to be the same or not. The reality of time is conceived as absolute or relational, depending on whether it is thought to exist independently of objects or not. It is also a concrete or an abstract concept, depending on whether it is thought to have real effects or not. The flow of time is either linear or cyclical, depending on whether it is seen as uniform or phasic. Time flow is also conceived of as either reversible or irreversible, depending on whether it is thought to flow in both directions or not. The validity of time is conceived to have high convergence if there is one single correct time but low convergence if there are multiple constructs for time. It also has high or low discrimination, depending
on whether or not it is seen as independent of other constructs such as space and motion.

McGrath and Kelly use these eight dimensions to distinguish between Classical/Newtonian, New Physics/Einsteinian, New Biology/Transactional, and Eastern Mystical conceptions of time. Time in the Classical Newtonian conception is atomistic, homogeneous, absolute, abstract, linear, reversible, unitary, and independent of space and motion. Time in the New Physics, which includes relativity, quantum mechanics, and thermodynamics, differs in that it is continuous, differentiated, relational, irreversible, and part of the space-time continuum. The Transactional view of living systems puts emphasis on cyclic phenomena and on their mutual synchronisation or entrainment. Time in this view is concrete, cyclical, irreversible and multiple. This in turn differs from an Eastern Mystical view which holds that time is both cyclic and reversible, and is therefore recurrent rather than developmental. According to McGrath and Kelly, Western culture generally holds a Classical Newtonian conception of time, except that time is believed to be irreversible. However, it uses time as though it were differentiated, concrete, and cyclic.

Much of the work on time in psychology has made an additional distinction between objective and subjective time. Objective time is the time of clocks and calendars and is treated as the true time against which the subjective experience of time is measured. Edlund (1987) conceives objective and subjective time slightly differently by classifying any time measured by a clock, whether it be an external clock or an internal body clock, as objective time. Subjective time in his view consists of awareness and perspective. Awareness refers to people's sense of the present or their feel for the passage of time. People can sometimes estimate intervals of time accurately but feel that it is moving fast or slow. Perspective refers to the relations that people make between their past, present and future. A common method for measuring perspective is to ask a person to mark events in their life along a time line (e.g., Rappaport, 1990). Events in the present and recent past normally take up a large proportion of the line,
showing that time is differentiated by the meaning and affective significance of
particular events.

The philosopher McTaggart was influential in establishing the distinction
between objective and subjective time. He proposed two types of time: A-series and B-
series. B-series time describes permanent temporal relations between events, for
example the fact that event A happens before event B. A-series time refers to the
properties of pastness, presentness, and futureness inherent in events. It has generally
been assumed that B-series time is objective and A-series time subjective. For example,
Gell (1992) states that, "A-series time applies in human sciences because agents are
embedded in a context of situation about whose nature and evolution they entertain
moment to moment beliefs". In particular, Gell refers to the beliefs of pre-modern
societies as being A-series dominated. However, in his view only the B-series is
genuine and it is made up of two series: the outer one of events and the inner one of
mental models and maps.

Adam (1988) believes that this distinction between natural and social time is
based on an outdated understanding of the natural sciences. She points out, for
example, that the physical chemist Prigogine has established that all processes towards
order entail some form of feedback, rhythmicity, and self-organisation. Systems
entailing these processes possess a property known as internal time which represents
the history of the system and is consistent with the irreversibility of time (see Coveney
& Highfield, 1991). This in Adam's view establishes A-time as a law of nature. She
points out that quantitative or clock time is in fact a uniquely human creation, whereas
qualitative time is a fundamental aspect of nature. In Adam's view, natural time is
constituted through social interaction. The transactions of social interaction express
irreversible processes through which time has passed, meaning that they have definite
effects that cannot be undone.
Characteristics of time

There have been numerous attempts to produce a set of fundamental characteristics or parameters for describing the temporal aspects of social behaviour. Hassard (1991) summarises some of these attempts, including those of Moore, Zerubavel and Lauer. For example, Moore listed three aspects of time essential to social behaviour: synchronisation, sequence, and rate. Synchronisation refers to the requirement that some activities must happen at the same time, sequence refers to the requirement that some activities must follow on from others in a particular order, and rate refers to the requirement that a certain number of activities must happen within a time period. Variations on this categorisation include Zerubavel's four element set of timing, sequence, duration, and tempo, and Lauer's five element set of timing, sequence, duration, periodicity and tempo.

Rappaport (1990) has proposed that people's sense of time can be described by the elements of succession, duration, perspective, orientation, and rhythm. Succession and duration are self-explanatory and are considered necessary for the perception of change. Perspective is the integration of past, present and future. Orientation is the tendency to focus on particular periods of time. Rhythm is the tempo that emerges from the interaction between duration, succession and perspective.

More ambitiously, McGrath and Kelly (1986) have attempted to formulate a common language for talking about time. Using a standard set of formal logic terms they define occurrence, recurrence, duration, period, interval, order and regularity. Rhythm, rate, simultaneity, synchronicity and coordination are shown to be derivative of these definitions. However, they also point out that many of these parameters are relative to the scale of measurement, which is of course arbitrary. For example, two events can be viewed as simultaneous or successive depending on the scale of measurement.
Domains of Time

Body time

This chapter has already described how some researchers in time psychology have aligned themselves with a clock-based view of time perception, in which an internal body clock is considered responsible for the perception of time. This section considers the evidence that some form of body clock is also responsible for generating dynamic nonconscious changes in biological and psychological processes.

Homeostasis and related concepts such as stability, equilibrium and steady states have been viewed as the norms for healthy living systems for well over a century (Edlund, 1987). The homeostatic view presumes that a healthy system will always try to maintain a normal steady state. Medicine therefore generally either ignores deviations from the equilibrium or treats them in an attempt to restore the system to normal. Increasingly, however, the homeostatic medical model is being challenged. Dynamic changes such as adaptive responses, developmental transitions, internal rhythms, and even instabilities are now seen as important characteristics of healthy living systems. Indeed, some diseases can now be identified by their abnormal temporal organisation (Glass & Mackey, 1988). Understanding how the body sustains dynamic temporal changes is therefore clearly important.

There is accumulating evidence that the temporal organisation of living systems is greatly influenced by the presence of rhythms within biological processes and by the synchronisation or mutual entrainment of those rhythms. Most physiological markers such as body temperature, blood pressure, and hormones show rhythmicity of some kind. Many psychological processes show rhythmicity too (McGrath & Kelly, 1986).

Rhythms can be classified according to the period of their cycle, which is the duration of time that it takes to reach the same point in the cycle. There are rhythms of less than 20 hours known as ultradian rhythms, rhythms of about 24 hours known as circadian rhythms, and rhythms of more than 28 hours known as infradian rhythms.

Ultradian rhythms. The ultradian range includes the 90 minute Basic Rest and Activity Cycle (BRAC) which is thought to maintain both mental activity during
wakefulness and the REM cycle during sleep (Broughton, 1975), and which may be
disturbed during depression (Berger & Riemann, 1993). Slower ultradian rhythms
within the 3-9 hr range have also been reported for EEG activity (Tsui, Fukuda,
Okuno, & Kobayashi, 1981), and the sleep-wake cycle of babies (Menna-Barreto,
Benedito-Silva, Marques, Morato de Andrade, & Louzada, 1993). A later chapter,
chapter 16, will investigate the possible existence of ultradian rhythms in mood.

Infradian rhythms. The infradian range includes circaseptal rhythms of about a
week, circatrigintan rhythms of about a month such as the menstrual cycle, and
circannual rhythms of about a year (see Reinberg, 1974). For example, infradian
rhythms in mood between 1 and 9 weeks in duration have been reported (e.g., Hersey,
1931, Whitten, 1978). A number of studies have shown a weekly rhythm in mood,
usually with a peak in positive mood around Friday and a trough around Monday (e.g.,
Almagor & Ehrlich, 1990; Larsen & Kasimatis, 1990). This circaseptal rhythm is
probably culturally influenced by our seven day week but it could also have biological
origins. However, the best known infradian rhythm is the circa 28 day rhythm of the
menstrual cycle. In her review of menstrual related changes, Patkai (1985) concluded
that the premenstrual and menstrual phases of the cycle are associated with some
negative moods and somatic complaints in a majority of women but that results are
conflicting regarding the pattern, incidence and severity of symptoms.

Circadian rhythms. Most research has concentrated on circadian rhythms.
Circadian rhythms have been found for a wide range of physiological, mood and
performance measures (Folkard, 1990). The majority of studies on circadian rhythms in
mood have used subjective alertness as the index of mood (e.g., Folkard, Hume,
Minors, Waterhouse & Watson, 1985) but reliable circadian rhythms in happiness have
also been found (e.g., Monk, Baysse, Reynolds, Jarrett & Kupfer, 1992).

Circadian rhythms probably gave organisms an evolutionary advantage by
allowing them to anticipate daily events, in particular the changes between light and
darkness. This would make an organism less vulnerable to unusual external
circumstances. Humans evolved as a diurnal species and therefore many of our
psychological as well as physiological functions exhibit circadian rhythms that prepare us for wakefulness during the day and sleep at night (e.g., Folkard, 1983). These rhythms therefore usually reach their trough at about 04:00 and their peak about 12 hours later (the time of the peak is often referred to as the acrophase).

Lesioning of the suprachiasmatic nucleus (SCN) in the hypothalamus of the brain and its projections to the limbic system has been found to disrupt many circadian rhythms. The SCN is therefore thought to be the site of an endogenous oscillator (e.g., Stephan & Zucker, 1972) but there may also be other oscillators. There is also evidence that circadian rhythms are generated by a genetic mechanism (e.g., Ashkenazi, Reinber, Bicakova-Rocher, & Ticher, 1993). The cell proteins that regulate circadian rhythms are thought to be coded by a gene known as the per gene but the exact mechanism is unknown.

Under normal circumstances, circadian rhythms are synchronised or entrained to oscillate with a periodicity of 24 hours. Entrainment is enforced by external cues, known as zeitgebers, such as light and dark, social cues such as meal times, and by internal mechanisms such as the sleep-activity cycle. However, studies in which humans have been isolated from all time cues for long periods of time have shown that the natural period of the body clock is closer to 25 hours (e.g., Wever, 1979). Participants in these studies unknowingly tend to go to sleep one hour later each day, although there are large individual differences. Other experiments, in which the day has been artificially shortened or lengthened beyond the range of entrainment, have shown that the circadian rhythms of different psychophysiological functions desynchronise from each other and eventually free run at their own natural period (e.g., Folkard, Wever and Wildgruber, 1983). Some rhythms, such as rectal temperature and serial reaction time, are more strongly coupled to the endogenous clock than others, such as alertness and memory search speed (Folkard, Totterdell, Minors, & Waterhouse, 1993).

Circadian rhythms differ from one individual to another along a number of dimensions, including periodicity (time to complete one cycle), acrophase (time at which rhythm reaches its peak), amplitude (strength of rhythm measured by the
distance between the midline/mesor and the maximum height/peak of the rhythm),
stability and rate of adjustment of the rhythms. A number of questionnaire scales have
been developed to distinguish between people based on these dimensions. For
example, questionnaire scales have been developed to distinguish between people that
are morning and evening types (e.g., Horne & Ostberg, 1976; Smith, Reilly, & Midkiff,
1989). The circadian rhythms of morning types normally peak earlier in the day than
those of evening types. This means that morning types are likely to be more active and
feel more energetic earlier in the day than evening types. The Circadian Type
Questionnaire (Folkard, Monk, & Lobban, 1979) categorises people according to their
ability to sleep at different times of day (flexibility) and their ability to overcome
drowsiness (vigorousness). These dimensions may relate to the stability and amplitude
of circadian rhythms.

People usually report general feelings of malaise when their circadian rhythms
are disturbed. When people change to a different time zone this disruption is labelled
jet lag. On arrival at the new time zone people's circadian system is still set for the
original time zone. There is therefore a period of time during which people experience
internal desynchronisation whilst their rhythms adjust to the new time zone. However,
adjustment is encouraged by external cues such as light, activity and local custom.
Nightworkers are also required to displace their activities in time but for them all the
cues encourage them to remain on a diurnal schedule. The consequences of nightwork
for well-being will be discussed later in the chapter.

Experiential time

The last section considered temporal processes that are probably the
consequence of nonconscious mechanisms. However, people also have a conscious
awareness of time. People are aware of the passage of time, for example how quickly it
passes. They can also recall events from the past and can anticipate future events. This
ability to move awareness in time is known as temporal perspective. In relation to well-
being, this means that people can have awareness of their previous, present, and
potential future body states. This section therefore reviews what is known about these experiential aspects of time.

**Past perspective.** When people recall experiences, they are usually able to remember whether those experiences were pleasant or unpleasant. Intuitively, a pleasant or unpleasant experience that lasted longer would be expected to have a greater impact on the retrospective evaluation of that experience. However, Fredrickson and Kahneman (1993) found that people neglect duration when making retrospective evaluations: Short boring films were judged the same as long boring films.

Recollection of negative affective states is influenced by general affective state at the time of recollection. For example, people who are depressed are more accurate than those who are not depressed in recollecting the intensity of their previous moods but are also more likely to over-estimate their level of depression (e.g., Schrader, Davis, Stefanovic, & Christie, 1990).

There is evidence that people generally reconstruct events during recollection in order to produce a self-enhancing account of themselves. For example, Smith (1993) found that women's retrospective accounts of their pregnancy were different to those produced in real time, changing so as to emphasise personal growth and continuity.

**Present perspective.** The previous examples illustrated that recollection of previous affective states can be distorted by the present. However, previous affective state is also capable of influencing current affect. For example, reminiscing about past events can have a congruent effect on present affect if the reminiscence evokes affect in the present, otherwise a contrast effect results in which current affect is opposite to the affective valence of the recalled event. In other words, remembering a sad event can make you feel sad because it evokes sadness or it can make you feel better because things are no longer so bad now (Strack, Schwarz, & Gschneidinger, 1985).

The temporal patterning of people's previous affective experiences can also influence their current happiness. For example, range-frequency theory (Parducci, 1968) suggests that the frequency of different experiences is the standard of
comparison for judging current satisfaction. In particular, it predicts that happiness will be greatest if a person experiences happy events frequently but ecstatic events very rarely. This is due to the fact that people make judgements based on a compromise between the range and the frequency of their experiences in such a way that a negatively skewed distribution of happy experiences should increase average happiness.

_Future perspective._ Obviously people do not have knowledge of the future in the same way as they do of the past but they can mentally simulate a future self or selves by making predictions about the likely course of events and about how they are likely to feel in the future. However, research has shown that people are not very good at making predictions. People seem to predict outcomes that appear most representative of the evidence, rather than using reliability of evidence or prior probability of outcome (Kahneman & Tversky, 1973). People are not even very accurate when they have to make predictions about their own behaviour (Sherman, 1980). It has been suggested that people have little or no access to their own cognitive processes and therefore rely on a priori theories to explain their behaviour (Nisbett & Wilson, 1977). Chapter 15 will examine whether people can predict their own mood with any degree of success.

Expectations concerning events may also influence current affect. According to Tversky and Griffin (1991), expectations can have a hedonic impact whether or not they happen. They suggest that expectations can produce both endowment and contrast effects on mood, but that one can outweigh the other. Their example is that the dream of winning the lottery may enhance mood more than the disappointment of not winning.

Similarly anticipated emotions can affect subsequent behaviour (Baron, 1992). For example, consumers who anticipate regret over a wrong decision are more likely to purchase a currently available item than wait for a better sale (Simonson, 1992). Barbalet (1995) persuasively argues that emotions are the basis on which people evaluate their circumstances and prepare their actions because the future is
unknowable and therefore beyond reasoning. He describes a number of emotions that have temporal states as their object. For example, confidence is assurance about the future, hope is a feeling of positive anticipation, and anxiety is fearful anticipation.

The extent to which people are concerned with the future - their future orientation - seems to be a stable individual difference. Strathman, Gleicher, Boninger and Scott Edwards (1994), for example, have developed a Consideration of Future Consequences scale (CFC), which measures the extent to which people consider distant versus immediate consequences of behaviours. The CFC has been shown to predict the extent to which individuals are persuaded by arguments focusing on short or long term benefits, and it predicts their concern for their health, the number of cigarettes they smoke, and the extent of their environment-friendly behaviour.

*Tempo.* People not only have a sense of their past, present and future but they also have a sense of the pace or tempo of time. Chapter 14 will examine whether people’s perception of the speed of time is affected by or affects their well-being. There is evidence that different tempos can produce different affective outcomes. Experiments have shown, for example, that satisfaction with outcomes depends not just on how positive the outcome is but also on the change, rate of change (velocity), and change of velocity (quasi-acceleration) in outcomes over time (Hsee, Salovey, & Abelson, 1994). For example, investments that increase in value slowly but speed up are preferred to steady increases. People will also arrange events, such as the order of opening birthday gifts, to obtain a velocity effect (Salovey, Hsee, & Mayer, 1993).

According to Carver and Scheier’s (1990) control process model, affect arises from discrepancies between expected and actual rates of movement towards goals. Progress towards a goal that is faster than expected produces positive affect. A change in the rate of progress is experienced as a change of affect, and fast acceleration towards a goal is accompanied by a feeling of exhilaration.

People also seem to have preferences concerning the temporal contiguity of events. For example, people prefer to experience two positive or two negative events
Time

separated in time rather than simultaneously but prefer to experience a positive and a negative event together (Linville & Fischer, 1991).

**Social time**

The previous two sections have shown that people's behaviour and feelings are influenced by the nonconscious and conscious processes that govern their body time and experiential time. However, these processes are also influenced by the structure of external or social time. This section therefore considers how time becomes socially structured and what happens when people experience conflicts in time structure.

*Time structure.* Hassard (1991) has stated that a major element of socialisation is the structuring of time sense within formal organisations. Family, school, and work all educate people about the rules of social time and often dictate how time will be spent. For example, work organisations faced with temporal problems such as temporal uncertainty, activity conflicts and temporal scarcity commonly respond by structuring employee's time using temporal rules such as scheduling, synchronisation, and time allocation (Hassard, 1991).

Schriber and Gutek (1987) have identified 13 dimensions that describe people's experience of time at work. These dimensions include various aspects of scheduling such as punctuality, deadlines and the sequencing of tasks, time allocated to tasks, the synchronization and coordination of work with others, perceived routine, autonomy over the use of time, time boundaries within the organisation and between work and nonwork, the speed and pace of work, awareness of time as a resource, and the future orientation of the organisation. Schriber and Gutek believe that these dimensions could be used to identify and compare the temporal norms of different organisational cultures and to identify the fit between individuals and the temporal norms of their organisation.

The temporal fit between the individual and the organisation may be an important factor to identify because there is evidence that organisational time structure can affect people's well-being. For example, George (1991) showed that the relationship between workers' job satisfaction and life satisfaction was mediated
through work's influence on people's sense of time being spent in structured and
purposive ways. The degree to which individuals perceive their time to be structured
and purposive has been operationalised by Bond and Feather (1988) in their Time
Structure Questionnaire (TSQ). They found that greater time structure was positively
associated with purpose in life, self-esteem, reported health and optimism, and
negatively associated with depression, distress, anxiety, neuroticism, physical
symptoms, hopelessness and anomie.

Social entrainment. McGrath and Kelly's (1986) social entrainment model
provides a potential explanation of how people's time becomes structured. They
propose that it is not only physiological changes but also many interpersonal
behaviours that are regulated by rhythmical processes. These processes become
mutually entrained during interaction and hence produce a characteristic tempo or
structure. They cite turn-taking in conversation, the balance between privacy and
intimacy needs, and the shifts between instrumental and expressive activities in group
behaviour as examples of social entrainment. The rhythms, entrainment, and tempo
mechanisms are also subject to the influence of external pacer events or zeitgebers. For
example, Nelson (1971) found that students' mood was entrained to the academic term
in so far as it changed in response to changes in work pressure and the arrival of
deadlines. Thus, cheerfulness was normally highest at the start of term and lowest at
the end. However, this kind of temporal patterning of mood probably represents a
relatively weak form of entrainment because the mood cycle would probably have
disappeared as soon as, or fairly soon after, the specific academic demand cues were
removed.

A number of studies have demonstrated mutual entrainment between people's
moods. For example, Mansfield, Hood and Henderson (1989) found that some couples
show significant positive correlations in their daily mood reports, suggesting a process
in which one person catches the mood of the other. This process has been termed
emotional contagion (Hatfield, Cacioppo, & Rapson, 1994). Mansfield and colleagues
demonstrated that in some instances one partner was driving the mood of the other.
The amount of time that people spend together seems to be an important determinant of mutual entrainment. For example, women that spend more time together are more likely to show menstrual cycle synchronisation (McClintock, 1971). Similarly, roommates of depressed persons are more likely to become depressed over time themselves (Howes, Hokanson, & Loewenstein, 1985). It has been demonstrated that this effect is not due to the influence of shared negative events (Joiner, 1994).

Birchall (1988) has argued that social solidarity or fraternity develops as a consequence of stable reciprocal interactions between people over time (Birchall, 1988). In support of this view, there is evidence that the degree of synchronisation between people’s behaviours and feelings is a good indicator of how they feel about each other. For example, Levenson and Gottman (1983) found that 60% of marital dissatisfaction was accounted for by linkage or relatedness between changes in physiological measures during discussion of a marital problem. They also found that some patterns of affect reciprocity were more likely in a dissatisfactory marriage. Similarly, Hoskins (1989) discovered that greater desynchrony in activation between partners sometimes correlated with greater interactional-emotional needs.

Merten and Krause (1994) found that psychotherapy sessions were more successful when the facial affect between therapist and client was out of phase at the start. It appeared that in these sessions the therapist affectively regulated the client rather than the other way about. In this case, an initial conflict between the time structure of the therapist and client was beneficial. However, conflicts in time structure are not usually beneficial.

Frankenberg (1988), for example, provides some excellent illustrations of how conflicts in time structure can cause problems for hospital patients. He observes that time in hospitals is structured to fit the needs of the medical establishment rather than the needs of the patient. In particular, doctors' time is seen as the precious commodity and patients are therefore constantly required to wait for treatment. The patients’ power and status is consequently diminished. Patients are also woken, fed and washed at times that fit with shift changeovers and ward rounds rather than at times that fit
with the patient's normal routine. Such practices are therefore likely to exacerbate the disturbance that the patient is already feeling.

Temporal Disturbance

The most widely known and researched example of disturbed time structure is probably unemployment. When people are unemployed, they are deprived of the time structure provided by work. Deprived of this external time structure, people that are unemployed often lose the regular structure of their daily routines. For example, Bond and Feather (1988) demonstrated that an unemployed group scored lower on their Time Structure Questionnaire. The loss of routine and purpose during unemployment can lead to reduced self-esteem and increased depression (Feather & Bond, 1983). A number of researchers now believe that regularity in daily routines may be an important determinant of well-being (e.g., Monk, Petrie, Hayes & Kupfer, 1994). Another problem for people that are unemployed is filling time. Warr, Banks and Ullah (1985) found that ability to fill time was negatively associated with psychological distress in an unemployed sample.

Subjective time sense can also be distorted by unemployment. According to Jahoda (1988), time usually passes more slowly during unemployment but seems short in retrospect. Jahoda's classic study of unemployment in an Austrian village during the depression of the 1930s showed that even people's walking speed slowed down during unemployment.

Although unemployment is the most researched example of disturbed time structure, work itself can lead to a similar disturbance. In particular, irregular work schedules, including many shift systems, can disrupt people's normal routines (e.g., Nachreiner, Baer, Dielmann, & Ernst, 1984). This section will therefore review research showing that the temporal interference caused by shiftwork results in disturbances to health and well-being. It will also consider how the temporal disturbance caused by shiftwork can be minimised.
Problems of shiftwork

Interference with the body clock. Although human activity is normally aligned with the human circadian system, there are occasions when people are required to stay awake when their body clock indicates that it is time to sleep. Occasional attempts to stay up at night cause few problems but staying awake at night on a regular basis can be the source of a range of problems. Nightworkers, for example, are required to work when their circadian rhythms are at the lowest ebb and their resistance to sleep is at a minimum, and to sleep when their rhythms are preparing them for wakefulness. Studies of nightworkers have frequently concentrated on the problems caused by disturbance of the circadian timing system (Åkerstedt, 1990a). Over a series of night shifts the circadian system begins to adjust to the changed schedule but different rhythms adjust at different rates. This means that nightworkers' rhythms are not only running with different periodicities but they are out of phase with each other, meaning that they reach their peak at different times of day. The amplitude of rhythms is normally also flattened during this period of desynchronisation, meaning that the rhythms are weaker. Adjustment to nightwork can take several weeks and for many individuals the circadian system may never fully adjust (Knauth & Ilmarinen, 1975).

Interference with sleep. Shiftworkers are required to change the timing of their sleep. For example, nightworkers have to sleep during the day instead of the night. This can lead to sleep disturbance and reduced sleep (Åkerstedt, 1990b; Regestein & Monk, 1991). For example, about 60-70% of shiftworkers complain of sleep disruption (Rutenfranz, Haider, & Koller, 1985) and the average length of daytime sleep in two studies of female full-time permanent nightworkers was about 6 hours (Gersten, Duchon, & Tepas, 1986; Verhaegen, 1987).

Shiftworkers often attribute their curtailed sleep to social and environmental factors such as increased noise and disturbances during daytime sleep. Undoubtedly these factors play a part but the body clock is also responsible. Research has shown that there is a strong relationship between the time of day at which sleep begins and the subsequent duration of sleep (e.g., Zulley et al. 1981). The ease with which people can
fall asleep also depends on the time of day (Lavie, 1986). Indeed, it appears that there is only a four hour period between 22:00 and 02:00 during which people can fall asleep easily and subsequently sleep for seven or more hours. This period is known as a sleep gate, and contrasts with the preceding four hour interval known as the forbidden zone for sleep during which it is difficult to fall asleep and stay asleep.

Interference with social activity. Shiftwork can adversely affect social and family life because the shiftworker's non-work periods are generally at different times from those of family, friends and much of the rest of society. As a consequence, the amount and quality of contact with partners and children may be reduced. This can have a number of adverse effects (see Wedderburn, 1993). For example, marital dissatisfaction has been found to be higher in shiftworkers than dayworkers. There is also some evidence that the children of shiftworkers achieve less at school even after controlling for the father's level of qualification. Shiftworkers are also less likely to have membership or hold office in social organisations. However, shiftwork does appear to have some advantages for pursuing solitary activities and for fulfilling domestic responsibilities (also see Wedderburn, 1993).

Schedule and family conflicts can arise through working particular shifts or particular hours (Staines & Fleck, 1983). Rotating shiftworkers in particular have problems scheduling social events or participating in regular activities because of the variability in their work schedules. Afternoon shifts, although physiologically the least disruptive, often cause the most social dissatisfaction. This is because the afternoon shift extends into the evening which is the time perceived to be the most valuable for shared activity (see Colligan & Rosa, 1990).

Social activity has its own rhythms. McGrath and Kelly (1986) refer to the versatility of time and the temporal flexibility of activities. Evenings are highly versatile because they can be used for many activities, whereas nights have low versatility. Some leisure activities have high flexibility because they can be done at any time but most have low flexibility because they can only be done at certain times. A number of studies have shown that weekday evenings and weekends are the times of day and
Effects of shiftwork

The desynchronised body rhythms, sleep disturbance, and social disturbance caused by shiftwork are not only disruptive in themselves but they can also lead to a number of psychological and physical complaints experienced by shiftworkers (Scott & LaDou, 1990). In the short term, shiftworkers may experience acute problems that occur on a day to day basis, and in the longer term they may develop more chronic problems that threaten their health (see Folkard, 1993).

Acute effects. Mood disturbance and impaired performance have been associated with shiftwork. Most studies of the effects of nightwork on mood have concentrated on changes in fatigue and alertness. For example, Folkard and Akerstedt (1989) have developed a model that can predict shiftworkers’ alertness at different times of day based on the combined effects of the body clock and the sleep-wake cycle. In one of the few studies to examine daily changes in mood across a series of night shifts, Bohle and Tilley (1993) found that nightwork affected fatigue and activity dimensions of mood but not tension, depression, anger or confusion. However, higher levels of depressed mood have been found among rotating shift nurses (Tasto, Colligan, Skjei, & Polly, 1978). Other studies have found increased psychological and somatic symptoms among shiftworkers, such as job strain, irritability and muscle pain (see Cole, Loving, & Kripke, 1990).

Many performance capabilities are naturally at their lowest ebb during the early hours of the morning. When this low ebb is combined with loss of sleep, a reduced ability to resist sleep, and work fatigue, then efficient task performance is likely to be compromised. (Folkard & Monk, 1979). Performance speed can be slower and errors and accident risk can increase at night (Monk, 1990; Folkard, 1987). However, a lot depends on the nature of the task being performed and the conditions under which it is
performed. For example, performance on some high-load memory tasks actually peaks in the early hours of the morning (Monk, 1990).

Most of the studies of acute effects of shiftwork have concentrated on the direct association between particular shifts and outcome variables. However, it is likely that some of the effects are mediated by other variables. For example, moods and symptoms could be affected by sleep loss due to a particular shift rather than by the shift itself. Chapter 11 investigates this issue by testing temporal associations between variables across the course of a shiftworking day. The relation between sleep and well-being is also investigated in chapter 13.

Similarly, the acute effects of shiftwork may depend on interactions between variables. For example, using a retrospective method, Pokorski, Iskra-Golec, Czekaj, and Noworol (1990) found an interaction between different shifts and phase of the menstrual cycle on ratings of physical discomfort. Chapter 10 uses a prospective method to investigate this interaction in relation to well-being.

**Chronic effects.** One of the difficulties in determining the long term effects of shiftwork is that the workers who remain in shiftwork are often those with the greatest tolerance, resulting in a self-selected survivor population. It is therefore the workers that have transferred onto daywork that are likely to have the greatest problems. Despite this difficulty, shiftwork has still been associated with a range of physical and mental health problems.

Shiftworkers frequently experience increased incidence of gastrointestinal disturbance, including: loss of appetite, constipation, heartburn, stomach pains and flatulence. They are also more likely to develop peptic ulcers (e.g., Costa, Apostoli, d'Andrea, & Gaffuri, 1981). Possible contributory factors include internal disturbance, and changes to the timing and composition of meals. For example, nightworkers typically increase their consumption of carbohydrates by having more snacks (Cervinka, Kundi, Koller, & Haider, 1984).

There also appears to be an association between shiftwork and coronary heart disease (Knutsson, 1989). The research has shown that the risk of heart disease
increases with the number of years of exposure to shiftwork, even when other possible factors such as increased levels of smoking are taken into account.

So far there is very little evidence that shiftworkers die younger. In a study of over 8000 male manual workers carried out over a period of 13 years, Taylor and Pocock (1972) found that the death rate for day workers, shiftworkers and ex-shiftworkers was not statistically different from the national death rate. However, Teiger (1984) found that a group of printers on permanent nights had more long term sick leaves, a higher percentage of early retirement through incapacity, and died earlier and prematurely in larger numbers than three other groups with similar occupational risk.

There has been little research on the possible effects of nightwork on the menstrual cycle. In a study of day and night workers employed as either nurses or telephone operators, Uehata and Sasakawa (1982) found higher rates of menstrual problems, such as irregular cycles and severe pains, among the night workers. A higher number of clinic visits for menstrual problems among night workers has also been recorded (Colligan, Frockt, & Tasto, 1979). However, not all studies have found these effects.

A number of studies have suggested that night work is probably a risk factor for medical problems during pregnancy (Costa, 1990). Uehata and Sasakawa (1982) found higher rates of fertility problems, abortion and stillbirths amongst night workers. Some studies have indicated a higher risk of miscarriage (e.g., Axelsson, Lutz, Rylander, 1984) but others have failed to confirm this finding (e.g., Axelsson, Rylander, & Molin, 1989). A number of studies, but by no means all, have also found an association between night work and pre-term delivery (e.g., Axelsson et al., 1989).

In terms of mental health, a number of studies have found that shiftworkers have a higher incidence of neurotic disorder (e.g., Costa et al., 1981) and it has been proposed that shiftwork can induce neurotic symptoms. Estryn-Behar, Gadbois, Peigné, Masson and Le Gall (1990) found that female night shift workers scored significantly worse on a measure of mental health than day workers. Shiftworkers also
have an increased risk for psychiatric hospitalisation, although the proportion of shiftworkers in the population hospitalized for depression is no higher than the proportion of shiftworkers in the general population (Koller et al., 1981). There is no evidence that shiftworkers are more likely to commit suicide (Taylor & Pocock, 1972).

Minimising the adverse effects of shiftwork

There are a variety of different ways in which the problems induced by shiftwork can be reduced. The stress and strain model of shiftwork (Colquhoun & Rutenfranz, 1980) distinguishes between the external stress that comes from the shift system itself and the internal strain that develops in individuals as they attempt to cope with the shift system. The options, therefore, are to intervene at the societal level to limit the possibilities for temporal interference, or at the organisational level to reduce the interference effects of a shift system, or at the individual level to reduce the temporal interference that the individual experiences.

Societal interventions. Most countries have regulations concerning hours of work for night and shift workers. These regulations can be in the form of national government legislation, local legislation (e.g., the United States), or national or local collective agreement (e.g., the United Kingdom). Agreements on hours of work also exist between countries. For example, the International Labor Organization (ILO), which has 150 member countries, has adopted many conventions and recommendations on hours of work and shiftwork (see Kogi & Thurman, 1993). The proposed European Community Directive on Working Time also contains legislation pertaining to shiftwork (Commission of the European Communities, 1991).

Unfortunately, there is a lack of empirical evidence available to support many of the specific time parameters used in the regulations. The regulations have, therefore, often had to extrapolate from general research on the effects of shiftwork, and have been influenced by prevailing opinion and economic requirements. For example, most of the regulations contain legislation on minimum weekly rest periods, yet there is very little research on relevant temporal factors such as the cumulative effects of work shifts.
and recovery from work shifts. Chapter 9 addresses this problem by investigating these issues in relation to changes in shiftworkers’ well-being as a consequence of working different numbers of shifts and having different numbers of days off.

Organisational interventions. The obvious organisational intervention is to change the shift system. This can involve changing the way the night shift is covered, changing the speed and direction of rotation between shifts, changing the timing of shifts, and changing the duration of shifts.

A system of permanent nights, in which different workforces cover the day and night, may be the best solution for shiftwork because it gives the body time to adapt (Wilkinson, 1992). However, for this to succeed it requires the shiftworker to remain on a nocturnal routine on their days off because the circadian system quickly adjusts back to a diurnal routine (Knauth, Emde, & Rutenfranz, 1981). In practice most nightworkers revert to a diurnal routine on their days off to temporally realign themselves with the activities of family and friends. An alternative is to minimise circadian disruption by using rapidly rotating shift systems in which the worker is required to work no more than two or three night shifts in succession before working another type of shift such as a morning or afternoon shift (Folkard, 1992).

There is evidence that delaying or forward rotating shift systems, in which each type of shift starts later than the previous one (for example, morning to afternoon to night shifts) cause less interference than advancing or backward rotating shift systems (e.g., Czeisler, Moore-Ede, & Coleman, 1982). There are two likely reasons: First, a delaying system encourages a later sleep start time which is more in line with the 25 hour body clock. Secondly, a delaying system avoids "quick returns" or "quick changeovers" in which there are only a few hours between the end of one shift and the start of the next shift, and hence insufficient time for recovery.

The timing and duration of shifts is also important. For example, Folkard, Arendt and Clark (1990) found that an 06:00 start to a morning shift caused more problems for a group of police officers than the night shift in terms of reduced sleep and mood disturbance. The combined influence of social pressures and the forbidden
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zone for sleep make it very difficult for the shiftworker to sleep earlier than normal before a morning shift (Folkard & Barton, 1993).

Some organisations use 12-hour rather than 8-hour shifts to condense the working week and give the employee longer breaks. There is some evidence that 12-hour shifts reduces sickness (Lees & Laundry, 1989). However, 12-hour shifts may increase fatigue and decrease alertness and performance (e.g., Rosa, 1991; Todd, Reid, & Robinson, 1989). The Ottawa shift system, which retains an 8 hour night shift but extends the day shift to 10 hours to provide a 6 day break following night shifts, may be a suitable compromise. Totterdell and Smith (1992) found that police officers who changed to the Ottawa system slept more, experienced less personal and social disruption, and scored higher on a measure of mental health.

Chapters 7 contributes to the debate concerning the best type of shift system by comparing permanent night shift systems with rotating shift systems, and by comparing the effects on well-being of working different types of shift. Similarly, chapter 8 examines the effects on well-being of changing the order of shifts.

**Personal interventions.** A wide range of interventions involving individual employees have been investigated, including naps, fitness, drugs, and phototherapy. Taking a nap before (e.g., Harma, Knauth, & Ilmarinen, 1989) or during a night shift (e.g., Smith & Wilson, 1990) may have beneficial effects for alertness and performance; although negative effects have also been found (e.g., Rosa, 1993). Naps may compensate for sleep loss but they may also increase drowsiness immediately following the nap and may slow circadian adaptation. There is some evidence that improving fitness may improve adaptation to nightwork. For example, Harma, Ilmarinen, Knauth, Rutenfranz, & Hanninen (1986) found that a group of nurses who undertook a fitness training programme for 4 months were more alert and performed better on memory tests than a control group, especially on night shift.

There is also promise of interventions that can shift the phase of the shiftworker's circadian system to suit their work schedule. For example, oral ingestion of melatonin has been found to induce phase shifts of endogenous melatonin; melatonin
is normally secreted at night by the pineal gland. Taking melatonin at the desired bedtime has been found to improve the sleep and alertness but not the performance of shiftworkers (Folkard, Arendt, & Clark, 1993). Lewy, Wehr, Goodwin, Newsome and Markey (1980) discovered that very bright light (about 2500 lux) could suppress the secretion of melatonin at night. Subsequent research has shown that appropriate timing and magnitude of bright light can advance, delay and even suppress circadian rhythmicity (e.g., Jewett, Kronauer, & Czeisler, 1991). A short treatment of relatively low intensity bright light has been shown to produce marked phase shifts in humans (e.g., Arendt, Deveson, Folkard, Totterdell, & English, 1992), and studies of bright light treatment during simulated night shifts have demonstrated large circadian phase shifts, and enhanced alertness and performance (e.g., Campbell & Dawson, 1990; Czeisler et al., 1990; Eastman, 1992).

Other factors that have received attention include diet, ambient temperature, various drugs, and caffeine. There is also interest in behavioural and cognitive techniques for shiftworkers, such as sleep hygiene programmes which encourage shiftworkers to adopt particular sleep habits, and counselling programmes (see Penn & Bootzin, 1990; Rosa et al., 1990). There are also efforts to produce and evaluate educational programmes and guidelines for shiftworkers (e.g., Tepas, 1993; Wedderburn & Scholarios, 1993). Giving shiftworkers some control or flexibility over the shifts that they work may also increase tolerance (e.g., Barton, Smith, Totterdell, Spelten, & Folkard, 1993).

Uniformity of response. It would be misleading, however, to give the impression that individuals respond uniformly to shiftwork. For example, it has been estimated that up to 20% of shiftworkers dislike nightwork enough to leave (sometimes due to health problems), but that up to 10% of shiftworkers positively enjoy working shifts (see Waterhouse, Folkard, & Minors, 1990).

Individual difference measures based on circadian rhythms have had limited success in predicting shiftwork tolerance. For example, morning types generally experience more problems coping with the night shift, but fewer problems coping with
an early morning shift. Vigorousness and flexibility have also been found to predict people’s ability to cope with a rotating shift system (Costa, Lievore, Casaletti, Gaffuri, & Folkard, 1989).

There appear to be few gender differences in response to shiftwork (see Singer, 1989). However, the “double burden” of domestic work and shiftwork appears to reduce sleep length and increase fatigue and irritability in women with children (e.g., Estryn-Behar, Gadbois, Peigne, Masson, & LeGall, 1989; Gadbois, 1981).

The age of the shiftworker may influence his or her tolerance of shiftwork. There is evidence that the circadian timing system deteriorates with age (Czeisler et al., 1992). Older people typically have more sleep problems (e.g., Monk et al., 1991) and may find it more difficult to adapt to nightwork (e.g., Akerstedt & Torvall, 1980).

Then again, older nightworkers with lots of experience of shiftwork have sometimes found ways of coping with nightwork.

The development of appropriate coping strategies may help shiftworkers. For example, shiftworkers scoring higher on a scale of coping were found to have better psychological health (Spelten et al., 1993). Adaptation to shiftwork has also been shown to be greater in those shiftworkers that are more prepared to arrange their lives to fit with their work schedule (e.g., Adams, Folkard, & Young, 1989; Folkard, Monk, & Lobban, 1978). However, shiftworkers may also habituate to their problems. For example, one study (Spelten, Barton, & Folkard, 1993) has shown that retired shiftworkers realise that the problems they experienced during shiftwork were worse than they had thought at the time. This is an example of the influence of temporal perspective.

Summary

This chapter has reviewed some basic concepts in the psychology of time and has made a distinction between the nonconscious processes of body time, the conscious processes of experiential time, and the structure of social time. Evidence that shiftwork can disturb well-being by interfering with aspects of body time and
experiential time has been presented. The next chapter will describe the components of well-being and will review the evidence that well-being has a temporal structure.
3
Well-Being
A Review of the Psychology of Well-Being

Time is different now. Its flux and pattern is new, seeming so clear, so precise, so deeply understood yet inexplicable. I am calm and quiet. The manic alternations between despair and euphoria seem to have less potency. When I feel them coming I can set them aside and prevent their theft of my understanding.

- Brian Keenan
An evil cradling (1992)

This chapter reviews some of the previous research in psychology concerning well-being, with a particular focus on time-related issues. The last chapter began with the concept of time and ended by showing that temporal disturbance can affect well-being. This chapter begins with the concept of well-being and ends by showing that disturbed well-being may be related to time. The chapter pays particular attention to research on changes in well-being over time.

Overview of chapter

The chapter begins by describing the components of well-being. It then reviews some of the main theories of well-being and highlights those theories that have a temporal dimension. Given that the thesis is concerned with changes in well-being over time, it is important to know the extent to which well-being changes and the factors that are thought to bring about these changes. The chapter therefore considers the stability of well-being and some of the key influences.

Much of the research in this thesis will be concerned with changes in affect. A major section of this chapter is therefore devoted to affect, including how it is
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measured and what relations it has with other psychological variables. The chapter examines what is known about the dynamics of affective change, including its variability, speed of change, and unpredictability. Some of the types of affective change described, such as diurnal variation, will be empirically investigated in later chapters.

The previous chapter included a review of people's conscious awareness of time. Similarly, this chapter briefly reviews what is known about people's awareness of their own affect and how they deliberately try to maintain or change it using affect regulation processes.

The chapter concludes by looking at disturbances of well-being in the form of affective disorders. In particular, it describes evidence that affective disorders are frequently associated with disturbances of body time and experiential time.

Concepts of Well-Being

Psychology generally uses the construct of well-being to refer to a person's general level of happiness or satisfaction with life. The structure of well-being is considered to have three components: positive affect, negative affect, and life satisfaction (Feist, Bodner, Jacobs, Miles, & Tan, 1995). Much of this thesis will be concerned with positive and negative affect but in some instances will also extend to aspects of satisfaction, and to related constructs such as minor symptoms and daily hassles. The concept of affect is therefore too restricted in scope for this thesis.

Diener (1984) describes three hallmarks of the study of well-being. First, it is about the experience of the individual. In fact, the term subjective well-being (SWB) is often used to explicitly exclude objective conditions of well-being such as health and income. However, the simpler term of well-being is used in this thesis to refer to people's subjective evaluation of their well-being. Second, it includes positive factors and therefore, unlike many mental health connotations, it is not just about the absence of negative factors. Third, it includes all aspects of a person's life; although, it may be operationalised within specific domains and over different time periods.
Theories

The study of (subjective) well-being has a short history in psychology, about two decades, but its roots can be found in the study of happiness which has a much longer history. A number of theoretical standpoints have developed even though theoretical progress has been slow. The gist of the main theories will be described here (see Diener, 1984 for more details).

Activity theories view happiness as arising from participation in activities. For example, Csikszentmihalyi (1975) has proposed that people experience optimal affect or “flow” when they engage in tasks that match their skills. Recent evidence, however, suggests that high levels of happiness can also be experienced in low challenge situations where skills exceed the challenge (Haworth & Evans, 1995). Telic theories hold that happiness is obtained when people reach their goals, or alternatively when they are progressing towards their goals. Judgement theories maintain that happiness results from a comparison between actual conditions and a standard. The comparison may either be with the person’s own aspirations or with other people; the latter is referred to as social comparison and may be upward or downward depending on the perceived fortune of others (e.g., Aspinwall & Taylor, 1993). Associationistic theories predict that a person with a more positive set of memories will be happier. These theories derive from studies of affective conditioning (e.g., Murphy & Zajonc, 1993) and memory networks (e.g., Singer & Salovey, 1988).

Theories of well-being have also been divided into top-down (personality) and bottom-up (exogenous) theories (e.g., Feist et al., 1995). Top-down theories maintain that people have temperaments that predispose them to interpret experiences in a generally positive or generally negative way. In contrast, bottom-up theories maintain that well-being arises from the sum of people’s positive and negative experiences.

It is interesting to note that a temporal historical factor is present in most of these theories of well-being. For example, the development of skills in activity theories, goals in telic theories, standards in judgement theories, memories in associationistic theories, and experiences in top-down/bottom-up theories. However, a temporal
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dimension is most obvious in adaptation and dynamic equilibrium models of well-being, which will now be considered.

Adaptation models. Adaptation models of well-being are based on the premise that people adapt or habituate to events so that events bring less happiness or unhappiness with repeated exposure. Although people react strongly to some events, they also adapt rapidly to both positive and negative events, including major life transitions (Costa, McCrae, & Zonderman, 1987). This means that they quickly return to their baseline level of well-being, even after major events such as severe injury or winning a lottery (Brickman, Coates, & Janoff-Bulman, 1978). Events that deflect levels of affect are thought to activate adaptive mechanisms that re-establish the baseline level. However, it is unclear how this adaptation takes place. One suggestion is that people's judgement of well-being is based on a standard derived from their own experiences and that it is this standard that is changed in order to bring levels back to normal following major events.

However, according to Solomon's (1980) opponent process theory, the loss of a pleasurable object to which a person has become habituated produces greater unhappiness than the unhappiness produced by losing the object prior to habituation. In other words, events have less influence on well-being with repeated exposure but the loss of those events has greater and opposite influences on well-being following repeated exposure. Therefore, it may take the loss of an event to reveal its importance for maintaining well-being. For example, winning the lottery may not have an enduring beneficial effect on well-being, but losing the money from a lottery win could be detrimental if the person has become acclimatised to possessing a large sum of money.

Dynamic equilibrium model. Personality models of well-being propose that well-being depends primarily on personality characteristics, whilst exogenous models propose that well-being depends primarily on life events. However, Headey and Wearing (1989) have shown that although personality characteristics predispose people to experience moderately stable life events and well-being, life events also have
an additional independent influence on well-being. They therefore developed a dynamic equilibrium model of well-being.

The dynamic equilibrium model proposes that each person has his or her own normal pattern of life events and normal equilibrium level of well-being, both of which are predictable on the basis of stable person characteristics. Deviations from normal events cause changes in a person's well-being but well-being eventually returns to its equilibrium because of the influence of the stable person characteristics. However, the return to equilibrium is slow enough that events have a measurable impact on well-being.

Headey and Wearing believe that this last part of the model makes it different to adaptation models in which adaptation is so rapid that there are no measurable effects. However, it should be pointed out that adaptation models do not necessarily require adaptation to be instantaneous, and that the dynamic equilibrium model could therefore be properly viewed as a type of adaptation model. One of the features of the dynamic equilibrium model that does set it apart, however, is the prediction that history is likely to repeat itself in people's lives, meaning that specific favourable and unfavourable events are likely to be experienced again because of personal characteristics (see Headey & Wearing, 1991).

Ormel and Schaufeli (1991) have also developed a dynamic equilibrium model, but for modelling changes in psychological symptoms over time. Their model assumes that each person has a characteristic level of symptoms or equilibrium that is deflected by external events and that is re-established by adaptive mechanisms. The model further assumes that it takes time for the person to return to normal equilibrium and that there is therefore a measurable impact on symptoms. In a test of their model, Ormel and Schaufeli (1991) found that two thirds of people's variance in distress over time was attributable to differences between people's characteristic symptom levels, and that the rest was attributable to change agents in the environment. They also found that deviations from equilibrium were eliminated within one year of onset.
Stability and influences

Well-being is considered to be a relatively stable construct. For example, Diener (1984) quotes long-term reliability coefficients ranging from .55 to .70. This stability may partly arise from personality but it may also reflect situational consistency (which may of course also reflect personality because people may choose situations that suit their personality). Diener, Fujita and Sandvik (1994) suggest that personality has a strong impact on long-term levels of affect but not on momentary affect, whereas situations exert a strong influence on momentary affect but not on long term levels.

However, not all researchers consider well-being to be stable (e.g., Schwarz & Strack, 1991). Headey and Wearing (1991) have shown that more than 25% of people show a shift of more than one standard deviation in their positive and negative affect and life satisfaction scores over a six year period.

Yardley and Rice (1991) found that well-being was predicted by both current mood and previous well-being (10 weeks previous). According to Schwarz and Strack (1991), people’s judgement of their general well-being is often based on their affective state at the time of judgement. Schwarz and Clore (1983) found that momentary mood, produced by pleasant reminiscences or a sunny day, influenced reports of well-being. However, people are less likely to use their current affective state if its informational value is questioned. For example, indirectly drawing people’s attention to the fact that the weather may be a cause of their unpleasant mood can eliminate differences in reports of well-being on sunny and rainy days (Schwarz & Clore, 1983).

Schwarz and Strack (1991) have found that judgements of general satisfaction with life are commonly based on momentary affective states, but that judgements of satisfaction with specific life domains are based on comparison processes. Judgements of general well-being are more likely to be based on comparison processes, such as comparison with past events, when moods are not strong. As a result of their studies, Schwarz and Strack have proposed that the impact of an event on well-being is a joint function of “its hedonic quality, its temporal distance, and the person’s emotional involvement while thinking about the event” (p. 41).
There have been numerous studies of causal influences on well-being. A range of demographic factors have been studied including age, gender, race, income, employment, education, religion, and domestic circumstances. However, demographic variables rarely explain more than 15% of the variance in well-being. Personality variables have been somewhat more successful in explaining variance in well-being. Self-esteem seems to be one of the most important predictors but perceived control, extraversion, and neuroticism also seem to relate to well-being; neuroticism being negatively related. Behavioural influences include social contact, life events and activity. Health also relates to well-being, although its main effect may be in enabling the person to lead a life in which the other factors can play their part.

Affect

This section reviews research concerning the sub-component of well-being known as affect. The term affect is generally used to refer to people's feelings, and implies some form of subjective evaluation. Affect has been used to describe both traits and states of a person. As a trait it is usually referred to as affectivity. For example, negative affectivity is the disposition to experience aversive emotional states (Watson & Clark, 1984). Affective states usually refer to either moods or emotions. Moods are relatively diffuse and enduring feelings, whereas emotions are usually more directed and momentary and often more intense than moods (see Parkinson, Totterdell, Briner & Reynolds, 1996).

Positive and Negative Affect

Independence. The prevailing view at present is that positive and negative affect are independent factors. For example, Watson and Tellegen (1985) factor analysed results from a number of studies of mood and found that positive and negative affect consistently emerged as the first two rotated dimensions. They refer to the unrotated factors as pleasantness and engagement. Unfortunately, the terms are confusing in that positive affect consists of items that commonly relate to activation
and negative affect consists of items that commonly relate to anxiety. Despite the consensus, many researchers have argued and continue to argue that positive and negative affect vary inversely. For example, Green, Goldman and Salovey (1993) believe that bipolarity in affect has been masked by measurement error.

Diener, Larsen, Levine and Emmons (1985) believe that independent factors are the result of using average levels of affect over time, which combine two components: frequency and intensity of affect. The more frequently a person feels one affect the less frequently he or she will feel the other because people rarely feel positive and negative affect at the same time: Hence frequency of positive and negative affect are inversely related. However, a person who feels positive affect intensely is also likely to feel negative affect to a similar degree of intensity due to a stable personality disposition for the experience of emotional intensity. Hence positive and negative affect covary in intensity. These two effects will tend to cancel each other out when frequency and intensity are combined into mean levels of affect, producing independence between positive and negative affect. In support of this view, Diener and Emmons (1985) found that the correlation between positive and negative affect decreases in a linear fashion as the log of the time span covered increases. However, Watson (1988) used six different time frames for mood ratings and found independence between positive and negative affect in each case. The issue is therefore undecided, although it does appear that high levels of positive and negative affect are unlikely to be experienced simultaneously.

Others have argued that even two factors are insufficient to account for variation in mood. For example, Matthews, Jones, and Chamberlain (1990) believe that two factor solutions have arisen from incorrect use of factor analysis. They have proposed a three factor solution: energetic arousal, tense arousal and hedonic tone, which roughly correspond to positive affect, negative affect, and pleasantness. It is curious to note that this is the same solution Wilhelm Wundt (cited in Miller, 1988) found from personal introspection. Moreover, Wundt's method was based on a temporally defined stimulus. Specifically, Wundt recorded the feelings that he felt in
response to different patterns of auditory clicks from a metronome: A faster series of auditory clicks induced excitement (energetic arousal), intervals between clicks induced tension (tense arousal), and regular clicks induced pleasant feelings (hedonic tone).

Causal relations. Another argument for treating positive and negative affect as independent factors is that they appear to have different relations with other variables (e.g., Dua, 1993). For example, it has been suggested that positive affect is primarily influenced by the environment whereas negative affect has a genetic component (Baker, Cesa, Gatz, & Mellins, 1992), that positive affect is controlled by the right hemisphere and negative affect by the left hemisphere (e.g., Burke, Brief, George, Roberson, & Webster, 1989), that positive affect is related to extraversion and negative affect to neuroticism (e.g., Larsen & Ketelaar, 1991), and that positive affect is related to social activity but negative affect is not (e.g., Clark & Watson, 1988).

These examples consider affect as an outcome variable, meaning that it is influenced by other variables. However, affect also has its own effects on other variables. For example, mood can affect attribution of blame (Forgas, 1994), perception of others (Forgas & Bower, 1987), partner choice (Forgas, 1991) and prosocial behaviour (e.g., George & Brief, 1992). There are various explanations for these types of effect. For example, it has been suggested that people use their affective state as a source of information for making various types of judgement and for directing them to particular types of information (Schwarz & Clore, 1983). Affective state may also influence cognitive processing style. For example, depressed moods have been associated with a more analytic style of reasoning (e.g., Schwarz and Bless, 1991). Alternatively, affective state may activate material of similar affective tone in memory. This effect is known as mood congruence (e.g., Singer & Salovey, 1988).

Many researchers have treated affect as either a dependent or an independent variable depending on their research interest. However, it is clear from the above studies that affect can function as both an input and an output. One of the problems of categorising affect as an input or an output is that it encourages an approach in which
the dependent measure is collected only once following an experimental manipulation. This ignores the possible effects of the passage of time. Sedikides (1994), for example, has shown that subjects describe themselves negatively immediately following induction of a sad mood (mood congruent effect) but describe themselves more positively (mood incongruent) over time. The next section demonstrates that a richer conception is emerging from studies that are investigating the ways in which affect unfolds over time. These studies, which have adopted what Larsen (1989) refers to as a process approach, are concerned with finding consistent patterns of change over time.

Affective change

Stability. A number of studies have shown that people have a stable baseline or characteristic level of mood, even though their moods vary over time. This baseline varies from person to person but in general it is usually mildly positive. For example, a study that collected over 3000 mood reports from 133 subjects over a two week period, found that pleasant affect was reported on 87% of occasions but the maximum level of positive affect was reported on only 1% of occasions (Diener, Fujita & Sandvik, 1994). Other studies of daily mood have also found that people experience more pleasant affect than unpleasant affect (see Veenhoven, 1991). Most of the hundreds of surveys of happiness, conducted in many countries, have also reported a general level of mild happiness in participants. However, the results of these studies could partly reflect the fact that people like to present themselves in a positive or socially desirable way (Schwarz & Strack, 1991).

Variability. Variability in mood over time also appears to be a stable personal characteristic (e.g., Penner, Shiffman, Paty, & Fritzche, 1994). For example, Cooper and McConville (1990) found that individual differences accounted for 25% of the total variability in mood scores over time. In other words, variability in mood depends not only on the situations that people encounter but also on their personal characteristics. A number of studies have shown that mood variability is related to
specific personality traits. For example, Hepburn and Eysenck (1989) found that extraversion was related to greater variability of positive affect, and that neuroticism was related to greater variability of negative affect. However, mood variability is also influenced by a person’s general state of well-being. For example, Slavney, Breitner and Rabins (1977) showed that women who were more depressed had greater lability in their mood.

Changeability. One way to look at the changeability, or speed of change, of mood is to investigate how mood changes in relation to stressful events or daily hassles. Marco and Suls (1993) found that mood was worse in response to a stressful event if the prior time had been problem free. They also found that most stressful events had short-term effects on mood that did not last more than 24 hours; although, the effects of events on mood were more likely to spillover to the next day if people had high negative affectivity. Other studies have also shown that the effects of daily events on mood don’t persist for more than a day (e.g., Stone & Neale, 1984) and that mood may even be better than usual the following day (e.g., DeLongis, Folkman, & Lazarus, 1988). When stressful events persist for a number of days, emotional habituation seems to occur by the second day for all daily stressors except interpersonal conflicts (Bolger, DeLongis, Kessler, & Schilling, 1989).

Extrinsic factors can affect the endurance of moods. For example, Caspi, Bolger and Eckenrode (1987) found that chronic ecologic stress, in the form of people’s perceptions of the quality of their neighbourhood, increased the likelihood of daily events having an enduring effect on next day mood. Previous exposure to major life events decreased the impact of daily events, and social support mitigated the enduring effects of events on next day mood.

Other evidence suggests that undesirable events may have a more enduring effect on physical symptoms than on mood. For example, an increase in symptoms of infectious illness, such as colds and flu, has been found as much as four days after the occurrence of daily stressors (Stone, Reed, & Neale, 1987).
Larson, Csikszentmihalyi, and Graef (1980) found that adolescents' moods changed more quickly than adults' moods: On average, adolescents' positive moods diminished by two thirds within 30 minutes whereas adults' moods were still at half-strength two hours later. The adolescents also experienced worse mood and wider mood swings but these appeared to be related to the types of activity that they engaged in rather than inner turmoil or maladjustment. Indeed, there is some evidence that emotionally unstable people are more likely to spend longer in a negative or positive mood (Brandstatter, 1994).

A consistent change in mood over the course of a day is sometimes referred to as diurnal variation (DV). DV is often associated with worst mood in the morning and best mood in the evening but the reverse pattern is also possible. Wood and Magnello (1992) found that positive affect was significantly better between 10 and 12 am than on rising or retiring, but they also found that negative affect showed no diurnal variation. Robbins and Tanck (1987) found that the majority of a group of undergraduates reported some type of diurnal mood swing during a 10-day period, and that an increase in depressed mood from morning to evening was the most common pattern. Students who exhibited diurnal variation in mood experienced lower levels of symptoms and greater pleasure in social interaction.

There is some evidence that diurnal variation changes with age. For example, Templer, Ruff, Ayers and Beshai (1981) found that young adults reported better mood in the evening whereas older adults tended to report better mood in the morning. However, this could be due to the pleasure derived from different activities at different times of day.

Unpredictability. Most studies of affective change have assumed that affect changes in proportion to the magnitude of an event. The same event will therefore always have the same impact on affect and the change will be linear. However, there is increasing evidence that many natural systems change in a nonlinear fashion.

In a nonlinear system, the system's history of states is important in determining its behaviour. The system can react differently to the same event at different stages of
Nonlinear systems can also produce aperiodic or chaotic behaviour. Chaotic behaviour arises from deterministic or rule-based systems and therefore although the behaviour is complex it is not random. See Barton (1994) for a review of the application of nonlinear dynamics and chaos theory to psychological systems.

A number of researchers have begun to investigate nonlinearity in mood. For example, Möller and Leitner (1987) developed a nonlinear model for analysing mood curves which they used to identify differences in the mood changes of different clinical groups. Another study is underway (Heiby, 1994) to test for a chaotic pattern of mood change during depression by collecting sadness ratings from a nondepressed and a depressed individual every 20 minutes for up to a year. Chapter 17 of this thesis also presents an investigation of nonlinear changes in affect and performance.

Affect regulation

Many of the affective changes described in the last section probably occur automatically in response to external events. However, some of the changes may be the consequence of affect regulation. Affect regulation refers to the nonconscious and conscious processes by which people evaluate and change or maintain their moods. These processes enable people to bring about deliberate changes in their future well-being. There is evidence, for example, that people's beliefs or expectancies concerning negative mood regulation predicts the rate at which they recover from undesirable events such as the end of a romantic relationship (Catanzaro & Mearns, 1990; Mearns, 1991).

The ability to affect one's own psychological processes has been termed mental control (see Wegner & Pennebaker, 1993). One aspect of mental control is the capacity to monitor feelings and use them to guide future actions. Salovey and colleagues (1993) refer to this ability as emotional intelligence. Emotional intelligence includes the ability to evaluate and regulate one's own mood. In Mayer and Stevens' (1994) framework, evaluation of feelings includes clarity, acceptance, novelty, and influence, and regulation of feelings includes repair, maintenance, and dampening.
However, other researchers have produced different theories and categories of mood regulation (e.g., Thayer, Newman, & McClain, 1994; Westen, 1994).

For example, Westen (1994) believes that people regulate their affect by selecting those mental and behavioural responses that have proved effective in regulating a similar affective state in the past. Consequently, different regulation strategies are associated with different types of feeling and with different intensities of feeling. Westen has found that people who feel emotions more intensely are more likely to use “hot” rather than “cold” coping responses. Hot coping alters feelings directly and quickly, for example by venting feelings or seeking social support. In contrast, cold coping alters feelings less directly and more slowly, for example by rational thinking or positive thinking.

From a temporal perspective, one of the hallmarks of affect regulation is that it is not instantaneous. Many of the strategies for changing affect are indirect. For example, people use behavioural strategies such as exercise, listening to music, and shopping to change their mood (e.g., Thayer, Newman, & McClain, 1994). It therefore usually takes time to bring about a desired change in mood and not all attempts to change mood are successful. Affect regulation therefore requires an ability to dynamically monitor and evaluate affective state in comparison to a desired state, and an ability to use different regulation strategies at different times if necessary.

The effectiveness of regulation strategies may also depend on the time-frame considered. For example, it has been found that avoidant coping strategies are more beneficial to health than non-avoidant strategies in the short-term but not in the long-term (see Filipp & Klauer, 1991).

Affective Disorder

This chapter has provided evidence that well-being has a number of temporal characteristics. If these characteristics are important to the integrity of well-being, then it would be expected that they would be altered in some way when well-being is disturbed. This final part of the chapter therefore considers the evidence that temporal
factors have a role in the chronically disturbed well-being of affective disorders. In particular, it describes what is known about body time and experiential time during affective disorders.

**Body time**

Diurnal variation (DV) in mood, usually with worse mood in the morning, is recognised as a symptom of endogenous depression. However, as already described, DV has also been found in healthy individuals and some researchers have cast doubt on the validity of DV as a diagnostic marker of depression. For example, there does not appear to be an association between diurnal variation in mood and severity of depression (e.g., Ede, Kravitz and Templer, 1976; Leibenluft, Noonan, & Wehr, 1992). Diurnal variation does, however, often disappear during extreme depression. There is some evidence that DV may predict response to certain types of chronobiological treatment. For example, patients with low mood in the morning show a greater antidepressant response to sleep deprivation (Haug, 1992). It is therefore possible that chronobiological treatments will only be effective during the milder stages of depression when DV is present. The relation between diurnal variation and depressed mood is investigated further in chapter 16.

Diurnal variation in mood has also been associated with seasonal affective disorder (SAD), which usually takes the form of winter depression. Graw, Krauchi, Wirz-Justice and Poldinger (1991) found that about 75% of SAD patients showed worse mood in the morning. Their study showed that, although diurnal variation did not predict response to phototherapy, patients without diurnal variation were more likely to relapse within a week of treatment.

Haug and Wirz-Justice (1993) suggest that diurnal variation may reflect an underlying circadian rhythm of mood that is normally masked by exogenous factors but that is unmasked during depression because of reduced responsiveness to external events. Indeed, there is a wealth of research suggesting that the circadian system may be involved in depression (see Healy & Waterhouse, 1990). Some treatments for
depression, such as phototherapy and sleep deprivation, are thought to be successful because of their influence on circadian phenomena (e.g., Wehr, Wirz-Justice, Goodwin, Duncan, & Gillin, 1979; Wirz-Justice & Anderson, 1990).

However, the exact mechanisms involved are not understood. For example, it has been proposed that depression is a consequence of desynchronised, advanced, delayed or unstable circadian rhythms (see Volz, Mackert, Stieglitz & Müller-Oerlinghausen, 1991). Healy and Waterhouse (1995) believe that altered rhythms during depression are due to changes in lifestyle rather than due to disturbance of an endogenous circadian clock. In support of this view, it has been shown that social circadian rhythms are commonly disturbed during depression (e.g., Szuba, Yager, Guze, Allen, & Baxter, 1992).

Healy and Waterhouse (1995) liken depression to shiftwork maladaptation. Shiftwork maladaptation is the consequence of a mismatch between lifestyle and circadian organisation and produces a range of symptoms that are similar to those of depression, such as dysphoria, fatigue, sleep disturbance and anxiety. Healy and Waterhouse believe that endogenous depression, like shiftwork maladaptation, is triggered by environmental disruption. There is some evidence that this is true. For example, isolation can sometimes trigger depression (see Kripke, Drennan, & Elliot, 1992). This may be due to disturbance of circadian rhythms or due to social factors such as loneliness.

It is also possible that periodic illnesses such as cyclic psychosis and manic-depression are due to disturbed biological rhythms. Studies of monkeys have shown that experimental stresses can induce psychotic or neurotic symptoms that are accompanied by different abnormal rhythms in temperature and behaviour (see Gaer Luce, 1973). However, the timing of psychotic and manic attacks in humans is often irregular. Ehlers (1995) believes that patients with bipolar disorder may be particularly sensitive to social factors that disrupt their biological rhythms. She describes therapies for manic-depression that attempt to stabilise social rhythms using behavioural and cognitive techniques.
Affective disorders are often accompanied by characteristic distortions of subjective time (see Edlund, 1987). For example, depression is typically characterised by a slowing of the passage of time and a time perspective in which the future is blocked. In contrast, mania is characterised by a speeding up of the passage of time, although time estimation often remains very accurate.

Melges and Fougerousse (1966) evaluated 50 psychiatric patients for changes in time sense. He found that patients who had greater levels of unpleasant affect also tended to experience greater distortions of time sense. The most marked distortions of time sense were found in patients with poor reality testing, including psychotic, schizophrenic, and delusional patients. Temporal disorganisation or fragmentation of time is a common experience during schizophrenia. For example, time sometimes seems to move both backward and forward during schizophrenia so that events that happened long ago seem as though they just happened or that they will never happen. Schizophrenic patients also sometimes experience time as standing still and a discrepancy between true and stated age is not uncommon.

Temporal perspective can also be affected during affective disorders. According to Rappaport (1990) many clinical disorders, including affective disorders, reflect a temporal imbalance between the past, present and future. For example, he argued that addiction reflects a desire to heighten the present because of a dread of the future, and the "yuppie" syndrome reflects a desire to compress goals into the near future. Rappaport believes that treatment of these types of disorder should therefore focus on the dimension of time. However, Rappaport also points out that the temporal imbalance of individuals sometimes reflects historical and cultural conflicts concerning time. For example, he believes that western society has shifted to a present-centredness in recent decades because rapid change has made the past more meaningless and the future more uncertain. Temporal balance may therefore be fundamental to the well-being of societies as well as individuals.
This section has shown that some of the temporal characteristics of body time and experiential time are altered during some affective disorders. It is not known whether these temporal changes are the symptom or the cause of the disorder. This problem will not be tackled in this thesis. For this thesis, it is sufficient to know that time and well-being show consistent relations during abnormal as well as normal conditions.

Summary

This chapter has described the main components and theories of well-being. It has briefly reviewed the stability, determinants and effects of well-being and has described the structure of affect and affective change. The chapter has also considered affect regulation and affective disorders. The focus throughout the chapter has been on temporal issues and the review has demonstrated that there are a number of temporal dimensions to well-being.

The next chapter will set out the research agenda and approach of this thesis. The research that has been described in this chapter and the last will help that task. In particular, the review presented in this chapter will help conceptualise and operationalise measures of well-being for investigation in subsequent chapters.
4

Approach

Theoretical Framework and Method

In people's lives, in yours and mine, there are linear time sequences, with and without beginnings and endings. Conditions and epochs that appear with or without warning, only to pass and never come round again. And there are repetitions, cycles: ups and downs, hope and despair, love and rejection, rearing up and dying away and returning again and again. And there are blackouts, time-lags. And spurts of time. And sudden delays. There is an overwhelmingly powerful tendency, when people are gathered together, to create a common time.

- Peter Høeg

Borderliners (1995)

The previous two chapters brought together some diverse strands of psychological research to show that there is already good evidence that time has multiple influences on well-being. This chapter uses this evidence to distil a theoretical framework that will guide the research investigations reported in this thesis. The framework is developed following an examination of related theories and general issues of theory development. The investigations that will examine various parts of the framework are then described. Methodological issues are discussed and a method for research is outlined.
Theoretical Development

Background

The chapter on time suggested that people are influenced by time both through the sensations that accompany their body time and through their temporal experience of time. Both body time and experiential time were shown to be influenced by the temporal constraints of the external or social world. Hence, the extreme changes in time that arise from social conditions such as shiftwork and unemployment can cause disturbances to body time and experiential time, which manifest themselves in reduced well-being. The chapter on well-being showed that well-being reveals itself through a range of temporal characteristics, such as changeability and diurnal variation, and that these characteristics are affected during disorders of well-being. Just as the chapter on time reached forward to show that disturbances to body time and experiential time can influence well-being, so the chapter on well-being reached back to show that disturbed well-being is commonly associated (the causal direction is unclear) with disturbed body time and experiential time.

Theoretical criteria. It is proposed that a temporal model of well-being should include reference to the following:

1) Temporal events that are external to the person (social time).
2) Temporal events that are internal to the person, below consciousness, and dynamically interact with 1 (body time).
3) Temporal events that are internal to the person, available to consciousness, and dynamically interact with both 1 and 2 (experiential time).
4) Temporal interactions between social time, body time and experiential time that influence well-being.
5) States of well-being whose development depends on the dynamic history of interactions described in 4.

The next section will examine some of the theories that guided the research described in the previous two chapters and will then evaluate those theories against the theoretical criteria described above.
Theories

Many of the studies described in the previous two chapters were based on an empirical rather than a rational approach to theory building (see Mackay, 1988). An empirical approach develops theories from an accumulation of empirical facts. Investigations in this approach are not designed to test relationships between theoretical constructs. Instead, their aim is to collect and use empirical data to answer narrowly defined research questions. Consequently, theory frequently remains implicit within these investigations. However, very little of the research described in the previous two chapters was based on a theory, implicit or explicit, that had temporal factors at its core. This is in spite of the fact that all the research had a temporal concern.

Of the research described in the previous two chapters, one area that should have developed a strong understanding of temporality is shiftwork research, because its major point of departure from other areas of occupational psychology is its temporal nature. Theories in shiftwork research have mainly been shaped by concepts of stress from work psychology and experimental findings from chronobiology. However, it is rare to find a research programme in shiftwork research that is driven by a detailed theoretical framework. The theories are usually implicit, pragmatic and non-temporal.

Psychological theories of stress have generally divided into those based on the concept that stress arises from external events and those based on the concept that stress arises from transactions between the person and the environment (Briner, 1994). Shiftwork research has generally favoured the former type of theory. The stress and strain model of shiftwork (Colquhoun & Rutenfranz, 1980), for example, distinguished between the external stress that comes from the shift system itself and the internal strain that develops in shiftworkers as they attempt to cope with the shift system. A number of variations on this model have appeared. The models vary according to the mediating and moderating variables proposed to intervene between the input from the shift system and the outcomes produced in the shiftworker (Akerstedt & Froberg,
These models have usually proposed a causal order between variables. The causal order is normally described by means of box and arrow diagrams. Surprisingly, time only ever enters these models as a box labelled rhythms or something similar. In other words, time is collapsed to a summary term for body rhythms.

Destabilization theory (Kundi, 1989) is an interesting exception to the stress-strain models of shiftwork, and is based on hypotheses concerning time. The theory states that, "A dynamic equilibrium between the degree of adaptation to the working sphere, the social sphere and the recreation sphere is a necessary condition for the preservation of health, and that shiftwork, by its direct impact on all these activity spheres, tends to disturb the equilibrium, thus leading either directly or by increasing risk factors to diminished well-being and health". Using a crude algorithm for destabilisation, Kundi showed that destabilisation was higher in a group of shiftworkers than dayworkers and that the amount of destabilisation predicted health impairment. Unfortunately the theory has not had a wide impact.

Studies of shiftwork that have adopted chronobiological concepts, such as rhythms and entrainment, can generally be characterised as having taken a transactional view. The most explicit transactional theory that has been applied to shiftwork is the social entrainment model (McGrath & Kelly, 1986), which was described in chapter 2. Put simply, this model suggests that temporal patterns of behaviour are produced by the entrainment of rhythms under the influence of external pacer events.

There is also one example of an adaptation model of shiftwork (Kieswetter, 1990). Adaptation theories assume that systems adapt in response to changes in the environment in an attempt to become better suited to that environment. However, the changes are not always immediate and not always successful. It can be said, for example, that the human circadian system is adaptive for a diurnal routine but not a nocturnal routine. Adaptation models have also appeared in research on stress (e.g., Hockey, 1986) and well-being (see Diener & Fujita, 1995).
Evaluation. The theories described above can be evaluated against the theoretical criteria specified for a temporal model of well-being.

1) Social time. The stress-strain, destabilisation, entrainment, and adaptation theories all include reference to external temporal events, which is usually the shift system in the case of shiftwork.

2) Body time. All the theories except the destabilisation model also include reference to internal temporal events, usually in the form of body rhythms.

3) Experiential time. The destabilisation model includes the experience of competing demands on time, and the stress-strain models usually include reference to experiential variables that can influence internal events, such as coping. However, in the main, the experience of time is given little consideration by most of the theories.

4) Well-being. Most of the models include well-being or health as outcomes, but the only outcome from the entrainment model is behaviour.

5) History. The stress-strain models have no historical or developmental aspect. The domains of the destabilisation model are interactive and the model also includes life stages. Time in the entrainment model is said to be developmental, but no feedback processes are specified. Finally, the systems in adaptation models respond as a function of both their history and environmental demands.

Current theories are therefore unable to meet all the criteria that have been set and an alternative framework is required. However, theoretical frameworks do not only differ in the relationships that are hypothesised to exist between constructs. Theories in the same research area are developed with different aims and hence the theoretical constructs chosen also differ. For example, Briner (1994) distinguishes two general approaches to theory development in stress research. The first approach involves the development of frameworks, usually in the form of flow diagrams with variables in boxes and arrows that specify assumed causal relationships between variables. Stress-strain models are usually of this type. Unfortunately these frameworks are usually descriptive rather than explanatory. The second approach involves the development of frameworks that provide a paradigm for research. Transactional
models are usually of this type. Unfortunately these frameworks are often abstract and difficult to operationalise.

**Theoretical framework**

The aim in this chapter is to develop a theoretical framework that provides a paradigm for research. The framework will be used to test specific hypotheses in subsequent chapters. However, the framework is also intended to meet the additional requirements that theories should be broad in scope but detailed enough to facilitate the development of methodology (Briner, 1994).

The theoretical framework that will be described here represents the minimal version of a theory of temporal aspects of well-being. It is minimal in the sense that it proposes a set of relationships between constructs of time and well-being but makes minimal assumptions about how those relationships are brought about. The empirical investigations described in subsequent chapters are intended to establish the validity of the minimal theory. A reformulated version of the theory will then be described in the final chapter of the thesis. This will make much stronger hypotheses about the status of the relationships between time and well-being. The reformulated theory is partial and speculative but will be justified and supported using recent research. The reformulated theory has arisen subsequent to and partly as a consequence of the empirical investigations of this thesis and will therefore be described at the end of the thesis.

**Description.** The following is a simple statement of the minimal theory of the temporal aspects of well-being:

A person's well-being is dynamically influenced by the temporal characteristics of his or her social world, body and experience.

The conceptual framework for this theory is illustrated in Figure 4.1 This framework has been developed to meet the criteria set out above. Three domains of time are specified: social, body and experiential. Social time includes all characteristics
of time that are external to the person and impinge on the person. Most of these characteristics are products of human relations, such as work time, but also include characteristics of the environment, such as the light-dark cycle. Body time includes those characteristics of time that are generated within the person but are below consciousness, such as circadian rhythms. Experiential time includes those characteristics of time that are generated within the person, are available to consciousness, and depend on prior experience, such as awareness and perspective.

Well-being includes all states of affect. This includes moods, emotions, symptoms and satisfaction. The three domains of time in the framework have reciprocal influences. The relations between the domains of time influence well-being. States of well-being change dynamically over time, meaning that they have temporal characteristics that depend on previous states of well-being. Well-being therefore depends on (and can influence) the history of reciprocal influences between the three domains of time.

Figure 4.1 deliberately leaves out direct relations between each time domain and well-being because it is proposed that any influence on well-being requires the involvement of at least two of the domains. For example, the circadian body clock (body time) influences well-being when activity is scheduled out of phase with the body clock, due to shiftwork for example (social time), and its effects may depend on the decision to exert effort (experiential time). Similarly, the recollection of episodic memories (experiential time) influences well-being by being interpreted in relation to current events (social time), and may also depend on the person’s current level of activation (body time). In other words, the effects of each domain only have meaning with reference to the other domains.
Aims. Based on this theoretical framework, the aims of this thesis are to show broadly that:

Well-being is influenced by temporal characteristics.

Well-being is influenced by relations between the domains of time.

Well-being is influenced by history.

However, it is also intended that the thesis should investigate unanswered empirical questions concerning specific temporal aspects of well-being. The thesis therefore tries to strike a balance between meeting broad and specific aims.

Design. Two studies will be used to meet the aims. The first study investigates what happens to well-being as a consequence of changing body time and experiential time by disrupting social time with shiftwork. The second study investigates the relations between body time, experiential time and well-being without the disturbances caused by shiftwork. The second study also investigates the influence of history on well-being.

There will be a number of separate investigations within each of the studies. Each investigation will examine a specific research question and illustrate the effects on
well-being of a different temporal characteristic. Chapter 2 demonstrated that there is probably not a definitive set of basic temporal characteristics, so a number of possible characteristics have been selected. The investigations from the first study will show the effects of timing, order, duration, synchronisation, and latency respectively. The investigations from the second study will show the effects of latency, tempo, anticipation, repetition and direction respectively. The time-frames chosen for the investigations range from two hours to four weeks with particular focus on daily changes.

The rest of this chapter examines methodological issues in order to select a research method that will meet the theoretical aims and design requirements of the two studies.

Methodology

Time and method

Strategy. Research methodologies differ in their treatment of time and hence the choice of methodology for this thesis is very important. Runkel and McGrath (1972) have identified eight types of research strategy or setting: Field studies, field experiments, experimental simulations, laboratory experiments, judgement studies, surveys, formal theories, and computer simulations. These strategies treat time differently (McGrath & Kelly, 1986). Only field studies and field experiments take place in real time and only field studies leave the order of events undisturbed. Experimental simulations and laboratory experiments take place in experimental time. Time is often controlled in these types of study, for example by counterbalancing presentation order. Judgement studies and surveys usually remove time completely, although the order of survey questions is sometimes counterbalanced and questions sometimes refer to periods of time. Time is only conceptual in formal theories. Computer simulations preserve temporal relations but within their own time frame.

To meet the aims described above it will be necessary to use a strategy that can examine processes as they unfold in real time. The order of events is hypothesised to
be an important influence in determining outcomes and hence the strategy must preserve the natural order of events. Field studies are therefore the strategy of choice for this thesis.

**Design.** The design of a study should enable valid conclusions to be made about causal relations, so that other potential explanations are ruled out. Temporal factors threaten the validity of many designs (McGrath & Kelly, 1986). For example, many field studies have used measurements at two time points to enable comparisons to be made before and after some event. However, any change that takes place during the interval may be due to interference from factors other than the intervening event.

A common solution is to include a control group. However, this can still lead to spurious conclusions. For example, if the process being studied is cyclic then the times at which measures are taken may catch the groups at different points in the cycle. This may lead to the erroneous conclusion that the experimental and control groups differ in their response to the event. This can be avoided by using a time-series design with frequently repeated measurements. However, even then it is necessary to combine a longitudinal time-series design with a cross-sectional design to rule out other threats to internal validity, such as the effects of history and reactivity. In other words, a design that measures many variables on many occasions from many people enables stronger inferences to be made about causal relations. This is therefore the design chosen for this thesis.

**Approach.** The use of this type of design for examining patterns of change within individuals over time has been termed a process approach (Larsen, 1989). The process approach integrates fixed and fluid approaches to personality. The fixed approach focuses on finding fundamental traits of personality; these traits are averaged tendencies that individuals exhibit with some consistency. The fluid approach focuses on dynamic processes of personality. This involves comparing individuals with themselves at different points in time rather than comparing individuals with each other at the same point in time.
The process approach combines the fixed and fluid approaches by focusing on stable but nonstatic processes of personality. Temporal patterns are identified within individuals and compared between individuals to find consistent patterns of change. The regular temporal pattern of change is referred to as a second order consistency and can be used to describe differences between people. The process approach acknowledges, "that the subjects of our investigations are embedded within time, that time is fundamentally important to life as it is lived, and that personality processes take place over time" (Larsen, 1989). This is therefore the methodological approach chosen for this thesis.

Research method

The method of taking frequent repeated measurements of people's experiences has been called intensive time-sampling. The number of studies employing an intensive time-sampling method has increased rapidly in the last decade (Temmen, Suls, & Affleck, 1991). These studies are sometimes referred to as diary studies. This term implies daily reporting but it is also used to refer to different frequencies of measurement.

Technique. There are three main techniques used for intensive time-sampling: interval-, signal- and event-contingent recording (Wheeler and Reiss, 1991). Interval-contingent recording requires participants to report their experiences at fixed predetermined time intervals. The advantages of this method are that all events and experiences can be covered and the data are amenable to time-series analysis. The disadvantage is that the time of recording may occur some time after the events or experiences.

Signal-contingent recording requires participants to report their current experiences whenever prompted by an agreed signal, such as an alarm. This method is also known as experience sampling (e.g., Csikszentmihalyi & Larson, 1987). The signals are usually presented at quasi-random intervals. The advantages of this method are that participants report their current experiences rather than relying on memory,
and specific events are sampled rather than aggregated. The disadvantage is that many events may be missed.

Event-contingent recording requires participants to report their experiences in response to the occurrence of specific events. This method is less intrusive but is also less suitable for studying the unfolding of processes. This makes event-contingent recording unsuitable for this thesis. The studies in this thesis use an interval-contingent recording method. However, the studies also use a signal to prompt participants and some of the variables in the second study refer to current experiences rather than experiences during the interval. There is therefore some overlap with signal-contingent recording.

Instrument. There are a number of different instruments available for signalling participants and recording data. Paper and pencil recording is the simplest method. This requires participants to record their experiences in response booklets at specified times. Radiopagers, programmable watches, and programmable calculators can be used to signal the participant to complete their responses. The main disadvantages of this method are that participants can review earlier responses and can complete their responses at the wrong times without the researcher’s knowledge.

Telephone interviewing is an alternative method. This may improve both the quality of data and compliance because the researcher can clarify problems and prompt for more information, but it is a practically demanding method and can encourage self-presentation effects. Another alternative, and the one used in this thesis, is to use a computerised diary. A computerised diary avoids all of the above problems but may cause anxiety in the participant if it is difficult to use. The development of software for a computerised diary is described in the next chapter.

Design and conduct. The issues surrounding the design and conduct of intensive time-sampling studies are discussed in detail by Stone, Kessler, and Haythornthwaite (1991) but a number of their key points will be repeated here. When designing the study, the researcher must carefully consider the size of the sample, the length of the study, the frequency of measurement, the number of measures, and the
time it takes to complete measures. The choice of these parameters will depend on considerations of statistical power, causal processes, and potential threats to internal validity such as reactivity and attrition.

Statistical power depends on both the number of participants and the number of observations (timepoints), but each additional person adds more power than each additional observation. The frequency of measurement partly depends on the temporal characteristics of the causal process. For example, if the frequency is too low then important changes may be missed and distortions due to inadequate sampling of cyclic effects may occur. Low frequency sampling will also increase the participants' reliance on memory. However, high frequency sampling will increase intrusiveness and hence reactivity, meaning that the act of measurement is likely to alter the participants' experiences.

The demands put on the participants by the length of study, frequency of measurement, and the time needed to complete the measures will increase the likelihood that they will drop out of the study (attrition), that their response rate will decay over time, and that they will miss responses. This can be offset to some extent by instituting good procedures of conduct. For example, proper training of the participants at the outset of the study and regular contact with the participants during the study can help maintain their interest. The details of the samples, design parameters and procedures chosen for the studies in this thesis are provided in chapters 6 and 12.

Measures. A number of types of measure can be used for measuring well-being. These include subjective measures such as self-reports, objective measures such as informant reports, and indirect measures such as physiological and performance measures. Sandvik, Diener, and Seidtitz (1993) examined the validity of self-report measures of well-being and compared them with non self-report measures including informant reports, a written interview, and memory for positive and negative events. A single construct underlay all the measures, and the self-report measures correlated highly with the non self-report measures, and showed good convergent and discriminant validity.
This thesis will operationalise well-being using mainly self-report measures but will supplement these with cognitive performance measures. Self-reports of mood, satisfaction, symptoms, and hassles will be used. The cognitive performance measures will be used as indirect indicators of the general adjustment of the person to the situation. More specifically, the performance measures will be used in the first study to indicate the activation level of the person, and in the second study as a comparative measure of state related change.

Self-reports can be collected using a number of formats. These include open-ended questions, event checklists, and response scales. The advantages of open-ended responses are that the participants can pick events that have meaning for them and can use their own language to describe their responses, whereas event checklists and response scales may focus on events that are not salient for the participants and may be misinterpreted. However, open-ended responses are difficult to categorise and compare. This thesis will therefore use a visual analogue scale format for most of the self-reports. Full details of the measures are provided in chapters 6 and 12.

**Analysing temporal data**

*Missing data.* Intensive time-sampling studies generally require a lot of effort and time from participants. Missing data is therefore a common problem. Standard procedures for dealing with missing data, such as listwise and pairwise deletion, are unfortunately not feasible with diary data because they would drastically reduce the dataset. Similarly, imputation techniques have yet to be introduced in this area (Stone et al., 1991). Analysis techniques that allow for missing data must therefore be used. However, a cut-off point for inclusion of data may also be necessary if response rates begin to decay rapidly.

*Non-independence.* The main problem in analysing temporal data is that the observations from each participant are not independent and therefore do not meet the assumptions of standard statistical techniques such as analysis of variance and multiple regression. There are three types of non-independence: Trend, cycle, and serial
dependency. Trend refers to a systematic change over time due to factors such as response habituation and practice. Cycle refers to a rhythm or repetition in the data, for example due to day of week effects. Serial dependency, also known as autocorrelation, refers to the fact that adjacent observations are more likely to be correlated than observations at greater intervals. In some cases these temporal effects will be of interest but otherwise they need to be removed from the data using standard techniques of residualisation.

Techniques. Although it is possible to aggregate temporal data by using a within-subjects summary statistic for each time-series, such as the mean or the standard deviation, this does not take full advantage of their temporal nature and can therefore be misleading (e.g., Larsen, 1987). Alternatives to aggregation include time-series methods and structural equation models. West and Hepworth (1991) have reviewed these techniques for analysing temporal data.

Time-series methods include those in the frequency domain and those in the time domain. Time-domain models, such as the Box-Jenkins autoregressive integrated moving average (ARIMA) model, attempt to fit a statistical model to time-series and can be used to forecast ahead using weightings on previous observations. In practice, the forecasting aspect of time-domain models is rarely used in psychology. Frequency-domain models, such as spectral analysis and cosinor, fit periodic (rhythmic) functions to time-series. There are a range of bivariate and multivariate techniques, such as cross-spectral analysis and multiple regression, that can be used to examine the relationship between time-series (see Larsen, 1989).

Structural equation models are most suitable when there are few time points but many participants, whereas time-series methods are most suitable when there are many time points (> 50) but few participants. However, many intensive time-sampling studies, including those in this thesis, have fewer time points than the number required by conventional time-series analysis but more than is practical for structural equation modelling.
Pooled time-series methods, such as regression with dummy variables and random coefficient models, are suitable for this type of dataset. These methods remove differences in the dataset attributable to differences between participants so that the whole dataset can then be analysed as though it were the time-series of an aggregate person. Pooled time-series is the general analysis technique used in this thesis. However, a number of other techniques including structural equation modelling, within-subject correlation, cosinor analysis, and nonlinear analysis are also used. These will be described in later chapters.

This chapter has described the theoretical framework and methodology that will be used in this thesis. However, in order to implement the methodology a research instrument is required. The next chapter will describe the development and validation of this instrument.
5

Instrument

Development of an instrument for intensive time-sampling

Some say it is best not to go near the centre of time. Life is a vessel of sadness, but it is noble to live life, and without time there is no life. Others disagree. They would rather have an eternity of contentment, even if that eternity were fixed and frozen, like a butterfly mounted in a case.

- Alan Lightman

_Einstein's Dreams_ (1994)

Many research methods in psychology seem to purge time from life, proceeding as if psychological experience can be frozen and mounted in a case. This thesis has adopted the alternative position, namely that psychological experience depends on time. The previous chapter described how this stance requires a research method that enables the researcher to study processes as they unfold over time. In particular, a research instrument that can collect frequent repeated measures of affect and performance is required.

The author has therefore developed such an instrument, in the form of software programs for a pocket computer. The development and validation of this instrument will be described in this chapter. All of the empirical investigations described in subsequent chapters make use of this research instrument. The instrument is therefore not only a contribution to research methodology but it is also vital to the research reported in this thesis.
Researchers who collect time-series data from individuals appear, at present, to divide into social psychologists with a primary interest in everyday changes in affective experience (e.g., Bolger, Delongis, Kieessler, & Schilling, 1989; DeLongis, Folkman, & Lazarus, 1988), and chronopsychologists with a primary interest in diurnal changes in psychological performance (e.g., Folkard, 1977; Naitoh, 1982). This separation of interests is probably exacerbated by the limitations of current instruments for the combined measurement of affect and performance in situ.

The last chapter described how studies of affective change have normally used paper-based diaries for collecting data. Technological instruments such as radiopagers, watches and calculators have sometimes been used to signal the respondent to complete the diary but they have rarely been used to record responses. However, Barr-Taylor, Fried and Kenardy (1990) have used a programmable pocket computer in their diary studies for recording as well as signalling responses. Their development of the instrument is very similar to that described here but it does not include objective measures of cognitive performance.

Most of the chronopsychological studies of cognitive performance have been investigations of circadian and time-of-day effects (Folkard, 1990; Monk, 1990). Alongside the relatively numerous laboratory based investigations of circadian performance (Folkard & Monk, 1985), there have been a number of field studies that have used on-job measures of performance, and a few field studies that have been able to apply standard laboratory measures of cognitive performance (Monk & Folkard, 1985). These latter studies have normally relied on paper and pencil tests either administered infrequently by the investigator (e.g., Wojczak-Jaroszowa, Makowska, Rzepecki, Banaszkiewicz, & Romejko, 1978) or by the participants themselves using stopwatches to time their own responses (e.g., Folkard & Haines, 1977; Monk & Embrey, 1981). The reliability of data obtained in this latter fashion must be questionable.
Performance tests that run on personal computers (PCs; e.g., Rosa & Colligan, 1988) are likely to be more reliable but they are difficult to administer in field studies of this type. The size and cost of PCs mean that participants normally have to be tested on the same PC in series - i.e. not at the same time of day - and often with an operator present. This is likely to present problems when testing is required at all times of day and night, for example in studies of shiftwork, and may act to restrict the number of times of day at which testing takes place (e.g., Dalbokova & Kolev, 1991). It is also disruptive to the worker's routine and virtually rules out obtaining measures during the worker's leisure time.

**Functional requirements**

The functional requirements for an instrument that can be used in field studies to collect repeated measures of both affect and cognitive performance are that it should:

1) Be portable. The participant should be able to carry the instrument at all times.
2) Be inexpensive. Ideally each participant should keep the instrument for the duration of the study.
3) Signal the participant to respond without the intervention of the investigator.
4) Record the time at which the participant responds. This is particularly important in time-of-day studies.
5) Accurately record elapsed time. This is essential for cognitive performance measures such as reaction time.
6) Have sufficient display size to allow presentation of tasks.
7) Have sufficient memory for program and data storage.
8) Allow downloading of data to PC for subsequent analysis. This eliminates the need for a separate data coding stage.
A suite of programs for a programmable pocket computer was therefore developed to satisfy the above requirements. The usability of the instrument will clearly also be a key factor but such an instrument could in fact motivate participant compliance given proper instruction on its use, a good user interface, a safe user environment, and reliable performance.

Since development, the programs have been used successfully in a number of field and laboratory studies. This chapter concentrates on the instrument itself - hardware, software and usability - rather than on the substantive results of those studies. However, a few results from these studies are described to illustrate the utility of the instrument.

**Design of Instrument**

**Hardware**

The pocket computer chosen was a Psion Organiser II: Model LZ; which is advertised as an electronic personal organiser, and costs approximately £135. Its weight is 250 g without batteries and its dimensions with protective case closed are 142 x 78 x 29 mm. The LZ model has 64K ROM and 32K RAM but this can be expanded by inserting either EPROM datapaks up to 128K, or the newer flash datapaks which start at 128K. The LZ model has a four line by 20 character LCD screen. The keyboard is alphabetic and not QWERTY. The Psion Organiser has its own programming language OPL, and programs can either be developed on the Psion Organiser itself or using the Psion Organiser Developer software on a PC and then downloaded to the Psion Organiser. Data can be transferred from the Psion Organiser to a PC or Macintosh using a Comms Link (approximate cost £60).

Current preference is to use a 128K flash datapak (approximate cost £70) for the programs and a 128K flash datapak for the datafiles. The advantages are: separation of programs and data, programs and data are safe in the event of power failure, and ability to use the Mk III Datapak Copier. The Mk III Copier (approximate...
cost £995) enables programs to be simultaneously copied from a master datapak to up to 8 datapaks, and also enables simultaneous transfer of files from up to 8 datapaks to a PC. A datapak formatter is required to erase the contents of an EPROM datapak, this is a separate device and costs approximately £45. The newer flash datapaks can be erased on the Psion Organiser using a separate flash datapak.

The Psion Organiser has an in-built clock and calendar which can be used for setting alarms and time-stamping events. Elapsed time can be calculated by reading the Psion Organiser's frame counter which increments every 50 msec. This sets the upper limit on accuracy for a single reaction time measure.

Alarms

Although the Psion Organiser provides in-built alarm functions, these were not felt to be sufficiently flexible and hence programs were developed that enable the investigator to schedule alarms which signal the participant to respond at scheduled intervals. Because of a particular interest in time of day effects, the programs set fixed intervals between alarms. The interval can, however, be set to change within or between days. It is also possible to randomise the time of the signal within the interval, for example for an experience sampling study.

Before commencing a study the investigator runs a program that helps to create a master alarms file; this file can then be copied onto the datapaks that will store the data. Each record on the alarms file specifies the date and time of the first alarm, the interval in minutes between alarms, the number of alarms required, and the number of consecutive days for which this should apply. When the alarm sounds, it beeps, pauses for 10 seconds and then beeps every 2 seconds for up to a minute unless the user presses a key. Unfortunately there is only one volume level available on the Psion Organiser and it is not very loud.

Participants in studies (users) can turn the alarms off for the duration of their sleep by answering a question which asks, at the start of each set of tests, whether or
not they are going to sleep in the next interval. On waking the user completes a sleep diary on the pocket computer and this has the effect of automatically resetting the alarms for the day. The users can also override the alarms by selecting a menu option which allows them to turn off either the next or all alarms. If they choose to turn off all the alarms, then they can later reinstate the alarms by selecting another menu option.

**User environment**

The programs have been designed to run within a program shell. This protects the user from the other functions of the Psion Organiser and improves the security of the data. An escape route is provided in the shell to allow the investigator to stop the program. Only through this escape route or by removing and replacing the battery can someone access either the alarms schedule or the recorded data.

When the users turn the pocket computer on, they are first prompted for an identification (ID) number. They then see a menu of options which might include: a sleep diary, a nap diary, an alarms option, and a test option. If they choose the test option, they will then be taken through a set of selected tasks. Quit points are provided between tasks in case the user does not have sufficient time to continue. There is no means of backtracking once the user has selected an option or entered a response.

The programs have been developed as a set of modules, one for each task. Advantages of the modular design are that tasks can undergo a number of iterations in their development without affecting other tasks, and new tasks can easily be added. By editing the program files for the menu options and the test option, the investigator can easily choose which tasks to present and in which order to present them. The investigator can also decide whether or not to include procedure names in the test file that have the effect of giving feedback to users on their performance.
Datafiles

Modularity is also maintained in the datafiles, with each task module creating and updating its own file. Whenever a task is executed, a new record is created in the file with new values in each of the record fields. The first field in every record is a time-stamp of the current date, hour, minute and second. The filename indicates the task and the user ID number.

The modularity of the datafiles makes it possible to select subsets of the data for analysis. However, it has the disadvantage that the time-stamps have to be matched when the files are merged for analysis. But given that the Psion Organiser has a 16 fields per record maximum, one large datafile was not viable.

A range of task programs have been developed for the pocket computer including:

Rating scales

These are 20 point self-report rating scales. A number of scales for alertness, mood and task load (NASA Task Load Index: Hart & Staveland, 1988) have been programmed. However, it is easy for investigators to construct their own scales simply by supplying the label for a scale item as an argument to one of two program procedures. The two procedures construct either monopolar or bipolar scales. Figure 5.1 shows an example of each.

```
  Cheerful
  - ============ +
     +
     +
```

```
  Back Pain
  0 ============ ++
     +
```

*Figure 5.1. Presentation of a bipolar and a monopolar rating scale.*
To complete a scale users must move the cursor, shown here as an asterisk, up onto the horizontal line using the arrow keys, then move the cursor again to the desired position along the line and finally press a specific key to indicate that they are satisfied with the cursor's position. The date and time of completion as well as the column position of the cursor (1-20) are recorded.

Sleep diary

The user would normally be required to complete this on waking from a main sleep in each 24 hr period. The diary prompts users for answers to a number of questions about the sleep that they have just finished. The following data are recorded:

- Time of going to bed (hours:minutes)
- Time of starting to try to sleep (hours:minutes)
- Number of minutes to fall asleep
- Number of times of waking up
- Number of minutes sleep lost in total
- Time of waking up (hours:minutes)
- Time of getting up (hours:minutes)
- Quality of sleep (scale 1-20)
- Time of starting work (hours:minutes)

Serial choice reaction time

Reaction time has been shown to be sensitive to many factors including fatigue and sleep loss (Wilkinson, 1964) and time of day (Gillooly, 1990) and so is a relevant measure for this kind of study. Reaction time can be assessed in a number of ways, for example simple, unprepared, or choice. The serial choice reaction time task that was implemented has been shown to be sensitive to a range of stresses (Broadbent, 1963).

In the current version of this commonly used task, an asterisk symbol appears on the display in one of 4 positions. These positions correspond to the relative positioning of the M, T, W and R keys on the Psion Organiser's keyboard (Figure
5.2). The user is required to press the corresponding key as quickly as possible. The next stimulus is presented immediately.

```
Display
*      *
*      *
M      R
T      W
```

Keyboard

*Figure 5.2. Presentation of serial 4-choice RT task.*

Users are instructed to use the second and first fingers of their left hand for the M and T keys respectively and the first and second fingers of their right hand for the W and R keys respectively. There is a fixation point in the middle of the display which the user is asked to gaze at between stimuli. Trials on which the user fails to respond within a set amount of time, usually set at 1 second, are excluded from the RT and accuracy measures but are not replaced. These trials are known as *gaps*, and the percentage of gaps is recorded.

There are 2 task lengths: the full length which uses 5 blocks of 80 stimuli each, and the restricted length which uses just 2 blocks of 80 stimuli each. Each set of 8 trials within a block of 80 has 2 stimuli in each of the 4 positions; the order is random apart from this constraint. Data is recorded for each block. This causes a small (approx. 1 second) interrupt between blocks. The Psion Organiser's 50 msec limit on the resolution of timings, means that a single RT measure may not be reliable and hence the RTs are summed over blocks. The following data are recorded:
There is another programmed version of the task which incorporates both 2 and 4 choice but which has a fixed interval between stimuli. An advantage, however, of using the task without an interval is that the number of user responses per unit time is maximised.

Memory search task

This task is based on Sternberg's (1969) paradigm and is very similar to the STRES (AGARD, 1989) implementation of the task. The task is particularly useful for differentiating between factors which affect response processes and those which affect central memory scanning processes.

The user is required to memorise a set of letters which appear simultaneously across the display. The number of letters in the memory set can be changed by the investigator to alter the memory load. The user presses a key to indicate that the set has been memorised. A fixed number of "probe" letters then appear one at a time in the middle of the display. The user presses the T key if the letter was in the memory set and the F key if it wasn't.

The memory set letters are randomly selected but without repetition, without vowels and without the response key letters T and F. Negative probes have the additional constraint that they shouldn't be a member of the memory set. Positive probes are equally likely to match any of the memory set letters. Each probe has an
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equal chance of being or not being in the memory set. If the user fails to respond to a probe within five seconds the results are ignored and the next probe is displayed but the probe is not replaced. The following data are recorded:

- Date and time of completion
- Size of memory set (1, 3, 5 or 7)
- Number of memory sets (default 1)
- Number of probes per set (default 20 or 40)
- Time taken to memorise set in seconds
- Number of true positives
- Mean RT for true positives in seconds
- Number of false negatives
- Mean RT for false negatives in seconds
- Number of true negatives
- Mean RT for true negatives in seconds
- Number of false positives
- Mean RT for false positives in seconds
- Number of probes not responded to within 5 secs

**Search and memory (SAM)**

This task, like its predecessor MAST, was originally devised as a paper and pencil task for time-of-day studies (e.g. Folkard, Knauth, Monk, & Rutenfranz, 1976). Circadian performance rhythms on this task have been shown to vary with memory load (Folkard, Wever, & Wildgruber, 1983). The user is required to memorise a set of letters. The size of the set, either 1, 3 or 5 target, can be changed by the investigator to alter the memory load. When the user presses a key to indicate that the list is memorised, 2 lines of 20 letters appear on the display. Users scan the lines from left to right and press a specific key each time they see one of the memorised letters. When they have finished the search they must press another key. Another target set then appears for them to memorise. The target set is selected at random but without vowels and without repetition. The targets are positioned at random in the stimulus set and there is an equal probability of 0, 1, 2, 3 or 4 targets appearing.

The main drawback with this implementation of the task is that one cannot
assess whether or not users have detected a valid target when they respond. Consequently the memory search task has been used in preference to SAM in the studies reported in this thesis. However, SAM and not memory search was used in two of the studies used to validate the instrument.

Other performance tasks

A number of other cognitive performance tasks have been programmed for the instrument but will not be described here because they are not used in the studies reported in this thesis.

Validation of Instrument

Compliance

Participants’ use of the instrument will be illustrated with data from a study (Study A) of university site security workers. The job of these workers was to monitor the university’s premises from a central control room. There were 12 male workers, grouped in four teams of three, providing 24 hour cover on a weekly backward rotating shift system with 8 hour shifts. Of the 12 workers, 1 was on holiday during most of the study, 2 declined to take part for personal reasons (a second job, and distrust of the purpose of the study), and another was unable to continue because the pocket computer’s display malfunctioned.

The remaining 8 participants were asked to carry the pocket computer for the 28 days of their shift cycle; all starting on the same calendar date. They completed tests every two hours while awake on the even hour, during both work and leisure time. The tests which took approximately 6 minutes to complete included: alertness, mood and disruption scales, 5-target SAM and a 4-choice reaction time task. The participants were given the option of discontinuing the test at the end of the rating scales, and encouraged to take this option if they were very busy. The participants were also asked to complete a sleep diary each day.
There was a "teething" problem in the software which enabled one participant to break out of the user environment and accidentally reset the clock (to local time in Tahiti!). However, the participant continued with the study despite this problem and so his compliance to the tests is included in the following table of results.

Table 5.1
Test Compliance of 8 Site Security Workers during 28 Day Study

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>(SD)</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of 2 hrly responses</td>
<td>112.4</td>
<td>(61.1)</td>
<td>33-227</td>
</tr>
<tr>
<td>Number of SAM tests completed</td>
<td>97.5</td>
<td>(61.8)</td>
<td>28-212</td>
</tr>
<tr>
<td>Number of sleep diary entries</td>
<td>21.4</td>
<td>(7.4)</td>
<td>5-28</td>
</tr>
<tr>
<td>Days 1-14 On shift responses</td>
<td>28.8</td>
<td>(9.1)</td>
<td></td>
</tr>
<tr>
<td>Days 1-14 Off shift responses</td>
<td>39.4</td>
<td>(21.6)</td>
<td></td>
</tr>
<tr>
<td>Days 15-28 On shift responses</td>
<td>23</td>
<td>(15.9)</td>
<td></td>
</tr>
<tr>
<td>Days 15-28 Off shift responses</td>
<td>21.3</td>
<td>(21.3)</td>
<td></td>
</tr>
</tbody>
</table>

Compliance figures for the study are shown in Table 5.1. Assuming a sleep average of 8 hrs, a maximum of 8 two-hourly tests per day per participant for the 28 days could be expected. This gives a compliance rate of 50.2% to the 2 hourly tests, 43.5% to the SAM tests (representing a dropoff of 6.7% due to lack of time), and 76.4% to the daily sleep diary.

A maximum of 4 on-shift readings and 4 off-shift readings in each working day per participant and an average of 3.5 days holiday per participant each fortnight can be assumed. In the first half of the study the on-shift compliance was therefore 68.6%, dropping to 54.8% in the second half of the study. And the off-shift compliance in the first half of the study was 56.3%, dropping to 30.4% in the second half.

These figures can be compared with those from a similar study, part of which is reported in Folkard, Arendt and Clark (1990), which used pencil-and-paper measures to assess the sleep, mood and performance of twenty police officers over a 28 day shift cycle. Compliance to the daily sleep diary used in this study was 78.4%.
which is similar to the figure from the pocket computer study. Although compliance
to 2 hourly ratings of alertness was 66.5%, the participants were only asked to record
alertness on 12 days and so the best comparison figures from the pocket computer
study are those from the first half of the study, which are similar. Compliance to the
pencil-and-paper SAM tasks was 63.5%, but the participants were only asked to
complete tests once a day on 12 days in contrast to the 8 times a day for 28 days
asked of participants in the pocket computer study. The pencil-and-paper compliance
figures may also be inflated because there is no possible check on when the ratings
and tasks were actually completed.

Of the total of 899 two-hourly tests completed in Study A, 19% commenced
before an alarm was due, 63% commenced within 10 minutes of an alarm, and 18%
commenced over 10 minutes after an alarm. This suggests that participants did make
use of the programmed alarms.

Usability
At the end of Study A, and at the end of two other field studies of
shiftworkers (Study B and Study C), participants were asked to complete a simple
questionnaire to assess their feelings about the usability of the instrument.

Study B was a study of 23 power plant workers (see Smith, Totterdell &
Folkard, 1995 for substantive results of this study). The workers were on one of two
shift systems, depending on whether they were engineers or operators/craftworkers.
The participants kept the pocket computer for a shift cycle, which was 5 weeks on
both systems, but they were asked to complete 2 hourly tests on only 8 specific days
of the cycle. The tasks in the 2 hourly test were: an alertness scale, task load index
scales, 4 choice RT, and SAM 5. The tasks took approximately 6 minutes to complete
in all.

Study C was a study of 17 air traffic controllers who worked a rapid forward
rotating shift system with 8 hour shifts. On average they were on duty for 90 minutes
between breaks. The participants kept the pocket computer for 20 days and completed tests at the start of a shift, in their breaks, and at the end of a shift. The tasks in the breaks were: workload ratings, response to workload ratings, mood ratings, a visual spatialisation task, and memory search 1- and 5-target. The tasks took approximately 5 minutes to complete.

The usability results are summarised in Table 5.2. Mean levels of agreement to each question are represented graphically in Figure 5.3.

Table 5.2
Usability evaluation of the research instrument

<table>
<thead>
<tr>
<th>Study A: 8 Site Security Workers (6 completed questionnaire)</th>
<th>Disagree</th>
<th>Neither</th>
<th>Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1. Enjoyed using Organiser</td>
<td>0</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Q2. Prefer to pen &amp; paper</td>
<td>2</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Q3. Easy to carry around</td>
<td>2</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Q4. Organiser easy to use</td>
<td>0</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Q5. Tests didn't interfere with work</td>
<td>4</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Study B: 23 Power Plant Workers (18 completed questionnaire)</th>
<th>Disagree</th>
<th>Neither</th>
<th>Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1. Enjoyed using Organiser</td>
<td>1</td>
<td>5</td>
<td>12</td>
</tr>
<tr>
<td>Q2. Prefer to pen &amp; paper</td>
<td>1</td>
<td>2</td>
<td>15</td>
</tr>
<tr>
<td>Q3. Easy to carry around</td>
<td>3</td>
<td>2</td>
<td>13</td>
</tr>
<tr>
<td>Q4. Organiser easy to use</td>
<td>1</td>
<td>2</td>
<td>15</td>
</tr>
<tr>
<td>Q5. Tests didn't interfere with work</td>
<td>5</td>
<td>8</td>
<td>5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Study C: 17 Air Traffic Controllers (16 completed questionnaire)</th>
<th>Disagree</th>
<th>Neither</th>
<th>Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1. Enjoyed using Organiser</td>
<td>1</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Q2. Prefer to pen &amp; paper</td>
<td>1</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>Q3. Easy to carry around</td>
<td>2</td>
<td>3</td>
<td>11</td>
</tr>
<tr>
<td>Q4. Organiser easy to use</td>
<td>0</td>
<td>2</td>
<td>14</td>
</tr>
<tr>
<td>Q5. Tests didn't interfere with work</td>
<td>2</td>
<td>2</td>
<td>12</td>
</tr>
</tbody>
</table>

In Study A, the compliance rates of the 3 participants who reported enjoying using the pocket computer were higher than those of the 3 participants who were indifferent, suggesting that evaluative reactions to the pocket computer may also be reflected in behaviour.
Validity, reliability and sensitivity of tasks

In Study D, the pocket computers were used to collect data from 3 participants every two hours while awake for a total of 26 days. The participants spent the last 15 days in a temporal isolation unit on a 30 hour sleep-wake schedule. The mean 4-choice RT of one participant was 380 msecs, excluding gaps (RTs > 1 sec). Woodworth and Schlosberg (1954) quote a figure of 364 msec for 3-choice and 434 msec for 4-choice, probably including gaps. This suggests that response time measurement in the current implementation of the task corresponds satisfactorily with previous implementations.

In many studies, it would be possible to compare the results of the first half of the study with those of the second half in order to assess the reliability of the measures. However, this is not possible in shiftwork studies because of the confounding factor of the shift cycle. Results from shiftwork studies depend on the position of the shiftworker within the shift cycle. The two halves of a shiftwork study are not likely to be symmetrical with respect to this factor. Figure 5.4 shows the
average daily on-shift and rest-day SAM-5 results of a participant from Study A. It shows quite clearly that response time was slower when the participant was working night shifts. This suggests that SAM is sensitive to time-of-day effects.

**Figure 5.4.** Mean SAM-5 time-per-trial results of a security worker over a 28 day shift cycle.

Practice effects also affect reliability. Figure 5.5 shows how the practice effect for the 4 choice serial RT results of the participant in Study D persisted throughout the course of the study. This suggests that practice effects in performance are unlikely to be eliminated and must therefore be taken into account during analysis.

**Figure 5.5.** Practice effect for 4-choice serial reaction time (n=1)
Figure 5.6 demonstrates the sensitivity of the reaction time task to endogenous and exogenous rhythms by showing the power spectrum of 4-choice serial RT for a participant from Study D. This is based on the time series of 88 2-hourly measures obtained during the last ten days of the study. Cosine curves varying from 20 hr to 32 hr in 0.2 hour increments were fitted by a least squares method in order to assess the power of the rhythm at different periods. The figure shows quite clearly that there is a circa 25 hour, a circa 30 hour and possibly a circa 21 hour performance rhythm on this task. Similar but less powerful rhythms have been obtained for SAM RT-5 and memory search RT-1 and -5 (see Folkard, Totterdell, Minors, & Waterhouse, 1991).

Figure 5.6. Power spectrum of 4-choice serial reaction time (n=1)

Performance of pocket computer

There have been very few hardware or software problems with the pocket computer. Apart from the display malfunction in Study A, there were also 2 non-diagnosable software errors in Study B which were rectified by resetting the pocket computer.
The number of sampling points that can be recorded on the pocket computer depends both on the capacity of the datapak and on the number and combination of tasks used. However, as a rough guide, the most compliant participant in Study A completed 227 two-hourly tests and 28 sleep diary entries. Each two-hourly test recorded a total of 32 fields of information and each sleep diary entry 10 fields, giving a grand total of 7544 datapoints for this participant. This occupied 61K of the datapak. A warning to contact the investigator would have been displayed had the datapak reached within 2K of its maximum. A warning is also displayed if the battery is low, but in this case one long-life battery was sufficient.

Another aspect of the performance of the pocket computer which is clearly critical to use of the instrument is the reliability of the timer and associated software procedures. To check the timer's reliability, the choice RT module was altered so that it did not empty the key buffer before starting the timer. By keeping a recognised key continually depressed to stock the key buffer, it was possible to check whether the module recorded a response time of 0 seconds for each stimulus. Of 8000 responses, 7170 were recorded as 0 seconds and 830 were recorded as 0.05 seconds. Therefore, assuming an average overestimate of 0.05 seconds on 10.38% of trials, the average overestimate of mean RT on a block of 40 serial choice stimuli will be +0.0052 seconds.

Discussion

The pocket computer has proved itself to be an invaluable and practical instrument for repeated measures of self-reported affect and cognitive performance in field studies. It allows the investigator to: Cue the participant to respond without the investigator being present; collect data at all times of day and night in all locations without direct intervention or excessive disruption; objectively record when a task is completed; obtain objective measures of response time; automatically code data and hence speed analysis and eliminate human coding errors
Participants in the initial field studies described here responded favourably to using the pocket computer. Only 2 out of 40 participants reported that they had not enjoyed using the pocket computer, and only 1 participant reported difficulty in using the instrument.

The compliance rate of 50.2% to the 2 hourly tests in Study 1 was not spectacular. However, given that the study lasted for 28 days and that the tasks took approximately 6 minutes to complete, the participants were being expected to give up over 22 hours of their time to the study with no incentive, financial or otherwise. It is interesting to note that compliance was higher during work hours and that leisure time readings dropped off considerably in the second half of the study. Subsequent studies, including those reported in this thesis, have therefore been more judicious in the length and number of tests, particularly in the number of leisure time measures requested. This has also been prudent in view of the sheer amount of data generated by this type of study.

The major limitation of using the pocket computer in the way described is that the investigator has no control or knowledge of the conditions under which a test is completed. Ambient conditions such as light and noise are likely to vary considerably. Interruptions during tests and social inhibitory factors may also vary. Hand and finger positioning and the eye to display distance are also likely to change, despite instructions to the contrary at the start of a study. The act of faith on the part of the investigator is that these variations will not change or swamp the phenomena under investigation.

Another problem, but one which is also common to all measuring instruments, is that the pocket computer may interfere with the participant’s daily life and hence may alter the constructs being measured. The extent of the problem is, however, difficult to assess because there is no acceptable “yardstick” currently available that is not also subject to the same criticism. The best one can hope to do is look for discrepancies between results obtained using different instruments.
Although it is suggested that the pocket computer will prove most useful in field studies which need to measure multiple variables of affect and cognitive performance on many occasions for each participant, clearly there are many other situations in which it would be beneficial. For example, Barr-Taylor, Fried and Kenardy (1990) relate that they are already finding such instruments useful for therapeutic interventions. Similarly, the instrument can be cost effective in cross sectional laboratory studies simply because it is possible to use many pocket computers in parallel.

These applications plus the potential for simultaneous measures of affect and cognition, and for viable comparisons between laboratory and field results, make the pocket computer an exciting practical addition to the psychologist’s toolbox. More specifically for this thesis, the instrument is suitable for investigating the temporal aspects of well-being.
6

Study One

Design of Shiftwork in Nursing Study (SIN)

I thought shift-work would work,
But it has good as broken us apart.
Lights flash over me, twenty four hour bulb.
I'm just home for tea, but she's in work mode.

Shift-work you've let me down,
Gave me a hard heart.
You've just cracked my mind,
You split us apart.

- C. Scanlon & M. E. Smith

Shift-work (1991)

This chapter describes the first of the two main studies reported in this thesis. The study was an intensive time-sampling study of shiftworking nurses using the pocket computer described in the last chapter. The context and method of the study are described in this chapter. Subsequent chapters will describe the specific investigations that were based on the dataset from this study.

The original data were collected as part of a larger research project conducted by a team of five researchers on night and shiftwork in nursing and midwifery. This larger project was a three year programme of research commissioned by the Department of Health. The aim of the project was to identify those forms of shift system currently in use in nursing and midwifery in England and Wales that minimize the individual's shiftwork related problems.

There were three phases to the project. The first phase was a survey and classification of the most common shift systems in use in general hospitals with more
than 400 beds. The second phase was a survey of over 1500 nurses and midwives to determine the nature and extent of their shiftwork related problems. The third phase was an intensive time-sampling study of a subsample of over 60 nurses. This final phase is the basis of the first study and associated investigations reported in this thesis. The author of this thesis was solely responsible for designing, analysing, and reporting the investigations allied to this phase of the project. The software programs for data collection and the resulting dataset for this phase of the project were also prepared solely by the author. However, the co-researchers helped enormously with data collection and provided invaluable feedback.

The survey of nursing shift systems conducted in the first phase of the project found little variation between the shift systems for the start times and lengths of particular types of shift. The shift systems were therefore classified along two main dimensions: degree of flexibility and organization of night shift cover (Barton, Spelten, Smith, Totterdell, & Folkard, 1993b). The majority (65%) of the systems were classified as "flexible" meaning that the nurses were consulted before the duty roster was drawn up. However, 18% of the systems were "regular" meaning that there was a fixed cycle of shifts and 17% were "irregular" meaning that the roster did not repeat in a regular manner and did not take individual preferences into account. To cover the night period, the majority of systems (61%) used a permanent night shift in which the nurses only worked at night, 27% used a system of fast internal rotation in which nurses worked a few nights each month, and 12% used slow internal rotation in which nurses worked a few blocks of night shifts each year. Daytime hours on the rotating shift systems were normally covered by "early" and "late" shifts: Early shifts start in the morning and late shifts start in the afternoon. In these rotating shift systems, the night shifts were generally kept separate from the night shifts by rest days. Combining the two dimensions produced nine possible types of shift system. However, there were no incidences of regular slowly rotating shift systems.

In the second phase of the project over 1500 nurses and midwives that worked the eight types of shift system were surveyed using the Standard Shiftwork Index.
(SSI), which is a battery of questionnaires designed to assess a range of problems associated with shiftwork (see Barton, Spelten, Smith, Totterdell, Folkard & Costa, 1995 for a description of the SSI measures). The results of this survey are reported elsewhere (Barton, Spelten, Smith, Totterdell, & Folkard, 1993a).

The rest of this chapter explains the design, procedure and measures used in the intensive time-sampling study. The preparation of data and general analytical procedures used are also explained. The sample is compared against the larger sample of nurses to evaluate its representativeness. Descriptive statistics concerning the sample and compliance to the protocol are also provided.

Method

Design

Based on experience in previous phases of the project, it was decided that the study sample should be selected to maximise representation of certain factors.

The criteria for selection were:

- Permanent Nights (P) or Fast Rotating (R) Shift System
- Provincial (Pr) or Teaching (T) Hospital
- Negative or Positive Health Disturbance

The Permanent Nights group were further subdivided into:

- Regular (Re) or Non-Regular (NR) Shift System
- Full (FT) or Part-time (PT)

The Rotating group were further subdivided into:

- Irregular (I) or Flexible (F) Shift System

A crossed factorial design was used to select 64 nurses so that, for example, half of the 64 nurses were on Permanent Nights, half of these were at a Provincial Hospital, half of these had a Negative Health Disturbance, half of these were Full-time, and half of these were on a Regular system. The full design is shown in Figure 6.1.
Figure 6.1. Factorial design for sample.
The Non-regular classification included both Irregular and Flexible systems. The classification of hospitals into Provincial or Teaching was done by a member of the nursing panel that acted as advisors to the project. The health disturbance factor was formed from the average of: two standardised (Z) scores of the GHQ-12 measure of well being from the Standard Shiftwork Index (SSI) and follow-up questionnaire, and a standardised score of Chronic Fatigue from the SSI.

At the end of the SSI there was a question that asked the respondents whether they were prepared to take part in an in-depth study. Those nurses that answered affirmatively to this question were taken as the basis for the sample. Nurses not meeting the above selection criteria for the design were then excluded and the remainder were classified into the various cells of the design. The remaining 230 nurses were then potential candidates for a specific cell of the design until the required number for each cell (2 or 4) had been recruited. The potential number of candidates for a cell ranged from 2 to 22.

Procedure

Recruitment to the study took place in a number of stages over a one year period. A pilot study was conducted using eight nurses from the Sheffield district. It was reasoned that any problems occurring could be more easily dealt with if the nurses were relatively local. These nurses were subsequently incorporated into the main sample. Nurses were then recruited in stages from different areas: Greater London and Bristol, the North West, the North East, and miscellaneous places, until all cells were filled. The resulting sample came from 34 hospitals and 22 towns or cities across England and Wales.

Potential participants were contacted over the telephone. Details of the study and what would be required of them as participants were explained. If the nurses were willing to participate then, provided that they could get clearance at work to take part and that they were still working on the same shift system at the same hospital, an appointment was made to visit them at work to explain how to use the pocket
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computer. The main reasons for non-recruitment were: change of shift system or hospital, illness, on training courses or holiday.

The appointment between nurse and researcher (five researchers shared the training of participants) lasted up to 30 minutes. The nurse was asked to practice the tasks for at least a day before commencing the study. The nurse was asked to use the recording instrument - a pocket computer - for 28 days, and then post it back in a prepaid envelope along with a form detailing the shifts worked during that period. The nurse was given a set of written instructions and a contact telephone number in case of problems. Nearly all participants were contacted over the phone at some stage during the 28 days, either to check on progress or in response to a reported problem. Apart from minor misunderstandings, the main reported problems were computer “Trap” errors and alarms not working. Both types of problem were relatively rare and difficult to diagnose, but fortunately could normally be rectified over the phone. Only in one case did the pocket computer have to be replaced. At the end of the study, the nurses were sent a surprise gift voucher as a gesture of thanks.

The measures were presented and all data recorded on the pocket computer - a Psion Organiser - that the nurses carried with them for 28 days. This instrument has been used and validated in previous studies of shiftworkers (see chapter 5). An auditory reminder facility was programmed into the pocket computer to prompt the nurse to complete a set of programmed tasks, every 2-hr on the even hour during shifts. The auditory reminder facility was turned on by the nurse at the start of a shift, and turned off after completing the final set of tasks for the shift. There was also a manual override for the reminder facility. The tasks took up to 5 minutes to complete.

The nurses were also asked to use the pocket computer to complete a set of self-rating scales about the day just passed before every main sleep and a sleep diary after every main sleep on both work and rest days. The nurses were also asked to use the pocket computer to record the start and end times of any naps taken, and the onset date of a menstrual period if it occurred during the study (but not if taking an oral contraceptive).
On-shift measures

Every 2-hr on the even hour during shifts, the nurses were required to complete a series of self-ratings of their mood and workload, and to complete a reaction time task (not included in pilot study) and a memory search task.

Mood. Self-ratings of current mood were measured using a series of bipolar 20 point visual analogue scales labelled -ve and +ve at the two ends, with the mood adjective centred above the scale. The mood adjectives chosen were: alertness, cheerfulness, and calmness. These items were selected from the three dimensions of mood identified in the UWIST Mood Adjective Checklist (Matthew, Jones, & Chamberlain, 1990): energetic arousal (alertness), hedonic tone (cheerfulness), and tense arousal (calmness). All of these items loaded greater than .5 on the relevant dimension and less than .3 on any of the other dimensions.

Work satisfaction. This was measured using a single bipolar self-rating scale of current work satisfaction.

Task workload. Six self-rating scales were adopted from the NASA Task Load Index (Hart & Staveland, 1988). The scales were unipolar - labelled 0 at one end and ++ at the other. The items were: mental workload, physical workload, time pressure, frustration, effort and effectiveness. The nurses were asked to rate each of these with respect to their current work tasks.

Serial choice reaction time. For this task, participants had to press one of four keys corresponding to the position of an asterisk symbol that appeared on the display. The next symbol then appeared immediately. There were two consecutive blocks of 80 stimuli. Participants were instructed to work quickly but accurately and at the end of the task they were given feedback on their speed and accuracy. Further details of the implementation of this task are described in chapter 5. Three summary measures were derived: mean response time, percentage incorrect, and percentage responses over 1 second (known as gaps). These long response delays are referred to as gaps, but they have also been termed blocks or lapses (e.g., Dinges, 1992). The mean response time excluded gaps.
Memory search task. A 5-target version of the memory search task based on that of Sternberg (1969) was used. On each of 40 trials, participants had to decide whether a letter was one of the five letters that they memorised at the start of the task, and press one of two keys accordingly. Participants were instructed to work quickly but accurately and at the end of the task they were given feedback on their speed and accuracy. Further details of the implementation of this task are described in chapter 5. Four summary measures were derived: memorisation time, mean response time (RT), \(d^\prime\) and efficiency \((d^\prime/\sqrt{RT})\). The \(d^\prime\) measure is a standard indicator of signal detection sensitivity and measures the distance between the means of the signal-plus-noise and the noise distribution (Green & Swets, 1966).

Start-of-day measures

Sleep diary. After each period of sleep, participants were asked to recall: time they went to bed, time they tried to sleep, time taken to fall asleep, number of awakenings, amount of lost sleep, time they awoke, whether they woke naturally, and time they got up. They also completed a bipolar self-rating scale of quality of sleep. Although subjective records of sleep are not as reliable as polysomnographic records, subjective estimates of sleep length have been shown to correlate highly with polysomnographic estimates (Tepas & Mahan, 1989) and self-rated sleep quality has been shown to correlate negatively with activity during sleep (Dirkx & Verhaegen, 1990). Three summary measures were used: duration of sleep (taking into account estimated time to fall asleep), latency (time to fall asleep), and self-rated quality of sleep.

End-of-day measures

Before going to sleep, participants were required to complete a series of self-rating scales concerning their feelings about the day just passed. These included:

Mood. This was measured using bipolar scales for alertness, cheerfulness, and calmness.
Personal effectiveness. This was measured using a single bipolar scale.

Symptoms. These were measured using unipolar scales for abdominal pain, back pain, mood swings, and feeling irritable adopted from the physical discomfort and dysphoric mood factors of the Daily Ratings Form of premenstrual changes (Endicott, Nee, Cohen, and Halbreich, 1986).

Social satisfaction. This was measured using unipolar scales for satisfaction with social life, and satisfaction with home life. These scales were not included in the pilot study.

Work and Non-work Conflict. This was measured using unipolar scales for worried by work when not at work, and worried by non-work when at work (the latter completed on work days only). These scales were not included in the pilot study.

Shift times. Participants also entered their shift start and end times on work days, and indicated if they had been off work sick.

Preparation of data and analysis procedures

All on-shift data were sorted on time of response into time-bins of 2 hr: 1 hr either side of the even hour. For example, if a nurse completed the psion tasks at 02:15, then this data would be put into the time bin that was centred at 02:00 and covered the period 01:00-02:59. For some analyses a time-into-shift variable was required; this was calculated by subtracting the start time for the shift from the time of response, before sorting the data into 2-hr time-into-shift bins. For example, if the above nurse started the shift at 20:45 then the elapsed time on completing the tasks would be 5.5-hr and this would be put into the time-into-shift bin that was centred at 6-hr and covered the period 5.00 - 6.99 hr.

Sometimes the feature of interest involved a comparison between sub-groups: for example, rotating vs permanent nights. This involved using analysis of covariance (ANCOVA), in which cases were subjects rather than observations. This therefore required averaging the observations for each subject prior to analysis. Age and
experience of shift work were used as covariates in these analyses because of differences between sub-groups on these variables (see below).

In most of the analyses, however, the feature of interest was a pattern of change within the shift cycle: for example, fatigue effects over a shift or over a series of shifts or rest days. Most of these analyses were made separately on the rotating, permanent night full-time and permanent night part-time nurses because of expected differences between these groups. The cases for this type of analysis were observations rather than subjects. A pooled time-series analysis was used for this purpose. This involved using either analysis of covariance (ANCOVA) or multiple regression. See West and Hepworth (1991) for details on this type of analysis.

Pooled time-series methods are most appropriate for designs with a moderate number of subjects and a moderate number of time points (< 50). Before analysing time-series data it is usually necessary to remove any trend, cyclicity and serial dependency from the series. Pooling time series from different subjects causes additional problems, the most important of which is the between-subjects effect, specifically the differences in intercepts and slopes of the subjects' time series. This problem is usually addressed using either a least squares with dummy variables approach or a random coefficients model. In the present study the former approach was used to address this problem as well as the problems of trend, cyclicity and serial dependency.

For an ANCOVA, each subject was represented by a dummy variable in the covariate list to remove the effect of between-subject differences. The covariate list also included a dummy variable for each day of the week and a variable for the number of days into the study, to remove day-of-week effects and linear practice effects respectively. Multiple regression was used if the independent variable was continuous rather than categorical. For a multiple regression, the same variables used in the covariate list for an ANCOVA were simultaneously entered into the regression equation before entering the independent variable. The lag of the dependent variable was also
entered before entering the independent variable to partial out possible autocorrelation effects.

The first rest day following a night shift could be considered to start either on the same calendar day that the shift ends or on the next calendar day. The common nursing convention that the first rest day after a night shift commences on the same calendar day was adopted. The nurses usually slept immediately after the night shift, and therefore the end-of-day measures for the first rest day following a night shift were considered to be those completed before the second sleep period after the end of the shift. Similarly, the sleep measures for the first rest day following a night shift were those completed following the first sleep after the end of the shift.

Study Descriptives

Sample characteristics

The average age of the participants was 33.55 years (SD = 8.25), ranging from 22 to 51 years; their average length of experience of shift work was 13.68 years (SD = 7.9), ranging from 7 months to 33 years; and the average time the nurses had been in their current job was 5.91 years (SD = 5.93), ranging from 1 to 25 years.

Comparison with larger sample

Because the present sample was selected from a much larger sample of shiftworking nurses, the representativeness of the present (psion) sample could be tested against the larger (main) sample. The permanent night nurses and the rotating shift nurses in each sample were compared on demographic and health and well-being variables from the SSI.

The following demographic variables were compared: gender, age, domestic situation, number of dependent persons, years of experience in shiftwork, in work in general and in their present shift system, hours worked and the regularity of the shift system. The only significant demographic difference was that the permanent night
nurses in the psion sample had worked in shiftwork longer, $M=18.96$ years ($SD = 7.76$), than permanent night nurses in the main sample, $M=15.28$ years ($SD = 7.96$).

The following health and well-being variables from the SSI (Barton et al., 1995) were compared: GHQ-12, chronic fatigue, sleep disturbance on early, late and night shifts and on rest days, cardiovascular complaints, digestive complaints, cognitive and somatic anxiety, social and domestic problems, neuroticism, extraversion, languidness, flexibility, morningness, job satisfaction, and sleep duration on early, late and night shifts and on rest days. The results are presented in Table 6.1 (courtesy of Evelien Spelten who made these comparisons).

The rotating shift nurses varied significantly on two well-being variables: The psion sample tended to sleep less before the first early shift and on rest days. No significant differences for health and well-being measures were found between the permanent night groups. The very few significant differences that were found between the two groups indicate that the psion sample was sufficiently representative of the larger sample.
Table 6.1
Comparison of the sample using the pocket computer (Psion) and the main sample on health and well-being measures

<table>
<thead>
<tr>
<th></th>
<th>Rotating Shifts</th>
<th>Permanent Nights</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Main sample</td>
<td>Psion sample</td>
</tr>
<tr>
<td></td>
<td>Main sample</td>
<td>Psion sample</td>
</tr>
<tr>
<td>General Health Questionnaire</td>
<td>12.88</td>
<td>13.77</td>
</tr>
<tr>
<td></td>
<td>11.54</td>
<td>12.07</td>
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<tr>
<td>Chronic Fatigue</td>
<td>25.68</td>
<td>24.96</td>
</tr>
<tr>
<td></td>
<td>24.06</td>
<td>25.41</td>
</tr>
<tr>
<td>Sleep quality night shift</td>
<td>20.15</td>
<td>19.26</td>
</tr>
<tr>
<td></td>
<td>17.62</td>
<td>16.80</td>
</tr>
<tr>
<td>Sleep quality rest days</td>
<td>12.48</td>
<td>12.51</td>
</tr>
<tr>
<td></td>
<td>14.73</td>
<td>13.84</td>
</tr>
<tr>
<td>Sleep quality early shifts</td>
<td>17.97</td>
<td>17.97</td>
</tr>
<tr>
<td></td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Sleep quality late shifts</td>
<td>15.22</td>
<td>14.52</td>
</tr>
<tr>
<td></td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Cardiovascular complaints</td>
<td>10.23</td>
<td>10.48</td>
</tr>
<tr>
<td></td>
<td>10.20</td>
<td>10.55</td>
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<tr>
<td>Digestive complaints</td>
<td>14.26</td>
<td>14.77</td>
</tr>
<tr>
<td></td>
<td>13.46</td>
<td>13.75</td>
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<tr>
<td>Cognitive anxiety</td>
<td>13.04</td>
<td>14.03</td>
</tr>
<tr>
<td></td>
<td>11.74</td>
<td>12.86</td>
</tr>
<tr>
<td>Somatic anxiety</td>
<td>13.78</td>
<td>14.77</td>
</tr>
<tr>
<td></td>
<td>12.41</td>
<td>13.43</td>
</tr>
<tr>
<td>Social problems</td>
<td>3.32</td>
<td>3.52</td>
</tr>
<tr>
<td></td>
<td>2.80</td>
<td>2.93</td>
</tr>
<tr>
<td>Domestic problems</td>
<td>2.69</td>
<td>2.55</td>
</tr>
<tr>
<td></td>
<td>2.55</td>
<td>2.41</td>
</tr>
<tr>
<td>Non-domestic problems</td>
<td>2.66</td>
<td>2.58</td>
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<td></td>
<td>2.33</td>
<td>2.31</td>
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<tr>
<td>Neuroticism</td>
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<td>13.55</td>
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<td></td>
<td>12.44</td>
<td>12.73</td>
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<td>Extraversion</td>
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<td>17.70</td>
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<td></td>
<td>17.51</td>
<td>17.41</td>
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<td>Languidness</td>
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<td>33.23</td>
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<td></td>
<td>29.88</td>
<td>30.83</td>
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<td>Flexibility</td>
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<td>29.46</td>
<td>28.50</td>
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<td></td>
<td>34.35</td>
<td>33.50</td>
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<tr>
<td>Job satisfaction</td>
<td>16.96</td>
<td>17.07</td>
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<td></td>
<td>17.04</td>
<td>15.29</td>
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<tr>
<td>Sleep duration:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>before first early shift</td>
<td>6.88</td>
<td>6.53*</td>
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<tr>
<td></td>
<td>6.92</td>
<td>-----</td>
</tr>
<tr>
<td>after last early shift</td>
<td>9.15</td>
<td>8.86</td>
</tr>
<tr>
<td></td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Sleep duration:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>before first late shift</td>
<td>9.42</td>
<td>9.32</td>
</tr>
<tr>
<td></td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>between two late shifts</td>
<td>9.31</td>
<td>8.98</td>
</tr>
<tr>
<td></td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>after last late shift</td>
<td>8.76</td>
<td>8.12</td>
</tr>
<tr>
<td></td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Sleep duration:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>before first night shift</td>
<td>8.94</td>
<td>8.27</td>
</tr>
<tr>
<td></td>
<td>7.18</td>
<td>6.91</td>
</tr>
<tr>
<td>between two night shifts</td>
<td>7.11</td>
<td>7.21</td>
</tr>
<tr>
<td></td>
<td>6.48</td>
<td>6.86</td>
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<td>after last night shift</td>
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<td></td>
<td>5.23</td>
<td>4.86</td>
</tr>
<tr>
<td>Sleep duration:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>before first rest day</td>
<td>9.40</td>
<td>8.92</td>
</tr>
<tr>
<td></td>
<td>7.05</td>
<td>6.17</td>
</tr>
<tr>
<td>between two rest days</td>
<td>9.39</td>
<td>8.93**</td>
</tr>
<tr>
<td></td>
<td>8.76</td>
<td>8.37</td>
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<tr>
<td>after last rest day</td>
<td>9.07</td>
<td>8.60</td>
</tr>
<tr>
<td></td>
<td>8.21</td>
<td>7.36</td>
</tr>
</tbody>
</table>

Note: * p < .05    ** p < .01

Comparison of age and shiftwork experience of sub-groups

The sub-groups within each factor of the design (see Figure 6.1) were compared for both age and experience of shift work using a series of t-tests. The results are shown in Table 6.2. The permanent night nurses were significantly older ($t(58) = 5.77, p < .001$) and significantly more shift work experienced ($t(57) = 6.19, p<.001$) than the rotating shift nurses. No other differences were significant.
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Table 6.2
T-tests comparing the age and shiftwork experience of the sub-groups within each factor of the sample

<table>
<thead>
<tr>
<th></th>
<th>Age (yrs)</th>
<th>Experience of shiftwork (months)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n Mean SD</td>
<td>t</td>
<td>n Mean  SD t</td>
</tr>
<tr>
<td>Perm Night</td>
<td>29 38.66  7.63</td>
<td>5.77***</td>
<td>27 229.07 84.72</td>
</tr>
<tr>
<td>Rotating</td>
<td>31 28.77  5.54</td>
<td>32 109.41</td>
<td>63.63</td>
</tr>
<tr>
<td>Full-time</td>
<td>14 37.00  8.51</td>
<td>1.13</td>
<td>14 216.71 97.87</td>
</tr>
<tr>
<td>Part-time</td>
<td>15 40.20  6.63</td>
<td>13 242.38</td>
<td>69.32</td>
</tr>
<tr>
<td>Provincial</td>
<td>30 34.53  8.48</td>
<td>0.92</td>
<td>29 180.48 102.58</td>
</tr>
<tr>
<td>Teaching</td>
<td>30 32.57  8.02</td>
<td>30 148.40</td>
<td>85.51</td>
</tr>
<tr>
<td>-ve disturbance</td>
<td>28 33.61  7.73</td>
<td>0.05</td>
<td>29 162.45 83.71</td>
</tr>
<tr>
<td>+ve disturbance</td>
<td>32 33.50  8.80</td>
<td>30 165.83</td>
<td>105.94</td>
</tr>
<tr>
<td>Irregular</td>
<td>17 29.53  6.89</td>
<td>0.83</td>
<td>17 114.71 76.39</td>
</tr>
<tr>
<td>Flexible</td>
<td>21 27.85  3.26</td>
<td>15 103.40</td>
<td>47.15</td>
</tr>
<tr>
<td>Regular</td>
<td>13 39.54  8.52</td>
<td>0.55</td>
<td>12 220.00 89.65</td>
</tr>
<tr>
<td>Non-regular</td>
<td>16 37.94  7.03</td>
<td>15 236.33</td>
<td>83.00</td>
</tr>
</tbody>
</table>

Note: *** p<.001

Compliance to tasks

Of the 64 nurses in the original sample, 61 provided usable data. The reasons for the three sample drop-outs were: sickness, on training course, and insufficient data (< 5 days). The span of days provided by the 61 participants ranged from 16 to 51 days with an average of 30 (SD = 5.38) and a median of 29. The number of recorded end of day entries (including practice entries) ranged from 6 to 45 with an average of 25.84 (SD = 6.91) and a median of 27. The total number (excluding practice entries) of unique end of day mood measures was 1449, which assuming an anticipated 28 days for 61 nurses, represented a compliance rate of 85%. Using the same formula, the compliance rate for sleep diaries was 91%.

The on-shift measures were sorted by time of response into time bins of 2-hr (1-hr on either side of the even hour), with only one entry allowed per bin per day. The resulting number of valid on-shift mood measures for any single scale was 3363.
Given that the number of recorded shift start times was 768, this represented an average of 4.4 mood measures per shift. Using the same formula, an average of 4.1 memory search tasks were completed per shift.

A chi-square test comparing rotating, permanent full-time, and permanent part-time nurses on end of day compliance was not significant, which suggests that the groups were equally committed to the study.

Missing data are a problem in diary studies. In the present study, the use of dummy variables to control for the mean level of subjects may distort the results if subjects are missing from one or more cells in the design. This will occur if a nurse systematically provides data at some time points but not at others, because of workload for example. A difference that is due to a treatment will then be attributed to a subject, and will result in an overly conservative estimate of the treatment effect. A series of tests were therefore made to determine whether specific rest days or shifts were associated with different compliance rates. A series of chi-square tests were used to assess compliance with daily measures and then on-shift alertness measures across consecutive rest days (up to 4) and across consecutive shifts (up to 4) separately for each shift system and each type of shift. Compliance was lower for on-shift measures on first night shifts than on subsequent night shifts for the part-time, \( \chi^2(3, N = 1580) = 10.20, p < .05 \), and full-time, \( \chi^2(3, N = 1717) = 13.05, p < .01 \), permanent night nurses. However, there were no other significant differences. This does not, however, preclude the possibility that the nurses chose not to provide data at different time points in a way that balanced the compliance rates on different rest days and shifts.

**Hours of work**

Over the four weeks, the mean hours worked per week by the rotating shift nurses was 36.02 \( (SD = 15.78) \), ranging from 8 hr to 77 hr; by the full-time permanent night nurses were 42.95 \( (SD = 20.72) \), ranging from 10.5 hr to 84.25 hr; and by the part-time permanent night nurses were 32.13 \( (SD = 14.41) \), ranging from 8.25 hr to 66.25 hr. The mean start times of the shifts were: 07:40 for the early shift (\( SD = 37- \)),
min), 13:22 for the late shift ($SD = 38$-min), and 20:47 for the night shift ($SD = 25$-min). The mean lengths of shifts were: 8.26-hr for the early shift ($SD = 2.07$), 7.9-hr for the late shift ($SD = 1.18$), and 11.03-hr for the night shift ($SD = 0.61$). The mean number of consecutive work shifts and rest days are shown in Table 6.3. For the rotating shift nurses, the mean number of consecutive shifts of the same type (i.e., early only, late only, or night only) is also shown. The rotating shift nurses worked 43% early shifts, 30% late shifts, and 27% night shifts.

Table 6.3
Mean number of consecutive shifts and rest days

<table>
<thead>
<tr>
<th>Shift</th>
<th>No. of sub-cycles</th>
<th>Mean consecutive days</th>
<th>SD</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perm Full-time - Night</td>
<td>45</td>
<td>3.73</td>
<td>2.24</td>
<td>9</td>
</tr>
<tr>
<td>Perm Full-time - Rest</td>
<td>41</td>
<td>3.88</td>
<td>2.60</td>
<td>11</td>
</tr>
<tr>
<td>Perm Part-time - Night</td>
<td>49</td>
<td>2.73</td>
<td>1.56</td>
<td>7</td>
</tr>
<tr>
<td>Perm Part-time - Rest</td>
<td>53</td>
<td>4.30</td>
<td>2.89</td>
<td>14</td>
</tr>
<tr>
<td>Rotating - Early</td>
<td>45</td>
<td>1.76</td>
<td>1.17</td>
<td>5</td>
</tr>
<tr>
<td>Rotating - Late</td>
<td>65</td>
<td>1.20</td>
<td>0.40</td>
<td>2</td>
</tr>
<tr>
<td>Rotating - Night</td>
<td>25</td>
<td>4.16</td>
<td>2.12</td>
<td>9</td>
</tr>
<tr>
<td>Rotating - Any shift</td>
<td>137</td>
<td>3.48</td>
<td>2.08</td>
<td>10</td>
</tr>
<tr>
<td>Rotating - Rest</td>
<td>47</td>
<td>2.43</td>
<td>1.89</td>
<td>14</td>
</tr>
<tr>
<td>Total sample - Shifts</td>
<td>243</td>
<td>3.29</td>
<td>2.07</td>
<td>10</td>
</tr>
</tbody>
</table>

Overview of Investigations

The next five chapters will describe investigations based on this dataset. The investigations will explore acute changes in the nurses' sleep, affect, and performance over time as a consequence of the temporal interference of shiftwork. The first three investigations will explore different aspects of the temporal structure of the shift system. In particular, the investigations will examine the effects on well-being of the timing of shifts (chapter 7), the order of shifts (chapter 8), and the duration of rest periods (chapter 9). The next investigation (chapter 10) will explore the effects on well-being of the potential interaction between the shift cycle and the menstrual cycle.
Finally, a structural model will be developed to test the temporal associations between well-being variables over the course of a “shiftworking” day (chapter 11).
Temporal Schedule

Effects of the timing of work shifts on aspects of well-being

Being up all night two days a week threw my schedule off for the rest of the time .... The anchoring ports that used to keep my days even were all lost to what seemed like a constant need for sleep .... Between my apartment and my job, I was living out of place and out of time. And I started to get depressed again. One afternoon after working security the night before, I couldn't remember what day it was ... and I had this twilight-zone sensation in which I almost couldn't figure out if I was in my own bed, my own room, my own head. It was like having a hangover without the alcohol.

- Elizabeth Wurtzel

Prozac Nation (1994)

The next three chapters will investigate the effects of the timing, order, and duration of work shifts and rest days on specific aspects of well-being. The motivation for these investigations is the belief that not all times are the same for people's well-being. In particular, it is hypothesised that the scheduling of work has predictable effects on how people feel. This chapter will investigate how the schedule or timing of work within a 24 hour day over a number of days affects well-being. This will include comparing different shift systems, and comparing shifts worked at different times of day.

There is still a strong debate about the relative merits of rotating and permanent night shift systems (e.g., Folkard, 1992; Wedderburn, 1992; Wilkinson 1992). The argument for rapidly rotating shift systems, in which the shiftworker works only a few
shifts of the same type before changing to another type, is that they minimise circadian and social disruption. Conversely, the argument for permanent night systems is that they maximise adjustment to a nocturnal routine. In this investigation an intensive method is used to examine the effects of working rotating shifts and permanent nights on acute measures of sleep, mood, personal disruption, workload, and cognitive performance in nurses.

A recent review of nursing shift systems (U.S. Congress Office of Technology Assessment, 1991), which relied heavily on a study conducted at the National Institute of Occupational Safety and Health, reported that rotating shift nurses suffered greater sleep disturbance, mood disturbance, social disruption, and dissatisfaction with work performance. Studies have also shown that nurses on rotating shifts report higher levels of job-related stress (Coffey, Skipper, & Jung, 1988), more health complaints (Verhaegen et al., 1987), and less sleep (Lee, 1992), but sometimes also more sleep (Escriba, Perez-Hoyos, & Bolumar, 1992), than nurses on permanent nights. Unfortunately most of the comparisons of sleep duration have failed to take account of differences in sleep duration between different combinations of shifts over the whole shift cycle.

Although there have not been any direct comparisons of performance on rotating shifts and permanent nights, Gold et al. (1992) did find that rotating shift nurses, but not permanent night nurses, had a significantly higher risk of reported accidents. A number of studies have compared the use of 8- and 12-hr shifts in nursing. These studies have generally shown no performance difference between the two types of shift (e.g., Washburn, 1991) but some have shown increased fatigue on the 12-hr shift (e.g., Todd, Reid, & Robinson, 1991) especially at night (e.g., Fields & Loveridge, 1988). This is important given that night shifts in excess of 10-hr are common in nursing (Barton, Spelten, Smith, Totterdell, & Folkard, 1993).

The comparison between rotating shifts and permanent nights is complicated by the fact that the night shift is not the only shift that causes problems. For example, Folkard, Arendt, and Clark (1990) found that the early shift and not the night shift was
the most problematic shift in terms of sleep duration and mood disturbance for a group of police officers. Similarly, Bauer (1993) has shown that an early start to the morning shift puts nurses under considerable stress. Folkard and Barton (1993) found that the truncation of nurses' sleep before the early shift may depend on a number of factors including the forbidden zone for sleep onset, social pressures, and time of leaving home.

Most of the above studies of subjective factors have used cross-sectional retrospective questionnaire designs, and not longitudinal momentary self-reports which are less susceptible to stereotyped responding and better able to assess finer-grained changes both during and between shifts. Likewise very few field studies have used interpolated standard performance tasks because of the difficulty of administering them.

This investigation therefore compares the effects of rotating, full-time and part-time permanent night shift systems, and compares the effects of different types of shift, by collecting both momentary self-reports and interpolated performance data on a pocket computer every 2-hr during nurses' shifts. Possible confounding factors are examined, including age, shiftwork experience, workload, number of consecutive shifts, and length of shift.

Method

The investigation was based on data from the 61 nurses that took part in the intensive time-sampling study of shiftwork in nursing. See chapter 6 for a complete description of the sample, procedure, measures and analyses. The complete set of measures described in chapter 6 were used in this investigation.

Two types of analysis were conducted. The first type of analysis involved making between-subject comparisons between groups working on different shift systems. For this purpose, the 28 days of data from each nurse, including rest days, were averaged so that each nurse provided one data point per measure for the analysis. Analysis of covariance (ANCOVA) was then conducted on the aggregated data. The
second type of analysis involved making within-subject comparisons between different types of shift. A pooled time-series method using ANCOVA with dummy variables was used for this purpose. The covariate list included dummy variables for each subject and for each day of the week and a variable for the number of days into the study, to control for between subject differences, day-of-week effects, and linear practice effects respectively.

Results

Comparison between groups (shift systems)

All days: Start- and end-of-day measures. A comparison was made between those nurses on a rotating shift system, those on permanent nights full-time, and those on permanent nights part-time. An ANCOVA was made on each start- and end-of-day measure using the aggregated data. Orthogonal contrasts were specified between rotating and permanent systems, and between permanent full-time and permanent part-time systems.

Initially these analyses did not control for age and experience of shift work, in order to determine what differences might actually exist between these systems in hospitals. The rotating shift nurses slept significantly more ($M = 7.58$ hr) than the full-time ($M = 7.17$ hr) and part-time ($M = 7.01$ hr) permanent night nurses ($F(2, 58) = 3.16, p < .05$) but the permanent night nurses had fewer worries about non-work when at work ($F(2,50) = 4.91, p < .05$). However, controlling for differences in age and experience of shift work there was only a significant difference for effectiveness ($F(2, 56) = 3.9, p < .05$). Figure 7.1 shows that the permanent night nurses had higher ratings of self-effectiveness.

Shift days: On-shift measures. The analysis was repeated using the on-shift measures. Without controlling for age and experience, there were two significant effects for choice reaction time ($F(2, 50) = 5.27, p < .01$) and choice reaction errors ($F(2, 50) = 4.11, p < .05$). Inspection of the means shows that the permanent night nurses were slower but more accurate on this task. However, these effects were not
significant after controlling for age and experience; but there were differences for physical demand \( F(2, 56) = 3.98, p < .05 \) and work satisfaction \( F(2, 56) = 3.47, p < .05 \). Figure 7.1 shows that ratings of these measures were higher on permanent nights.

**Figure 7.1.** Comparison of self-ratings on different shift systems.

**Night shifts: all measures.** The analyses for the different systems were repeated but using night shifts only, and controlling for age and experience. Quality of sleep \( F(2, 49) = 3.63, p < .05 \), daily alertness \( F(2, 47) = 3.82, p < .05 \), on-shift alertness \( F(2, 49) = 3.85, p < .05 \), on-shift cheerfulness \( F(2, 49) = 4.96, p < .05 \) and work satisfaction \( F(2, 49) = 3.37, p < .05 \) were all rated higher on the night shift by the permanent nights group. This is shown for on-shift alertness and cheerfulness in Figure 7.2. The analysis was repeated twice for these last two measures: the first time restricting the analysis to three or less consecutive night shifts in case the differences were due to the number of consecutive shifts worked, and the second time controlling for mental and physical demand and time pressure in case the differences were due to workload. Each time the differences remained significant.
Comparisons within groups (between shifts)

Shift days vs rest days: start- and end-of-day measures. For each start and end-of-day measure, an ANCOVA with dummy variables was undertaken to assess the impact of different shifts compared to rest days. The analyses were performed separately for rotating shift nurses, permanent full-time, and permanent part-time nurses because of the previously identified differences between these groups. For the rotating shift nurses, separate contrasts between each shift and rest days were specified. The results are shown in Table 7.1.

For the rotating shift nurses, sleep length was significantly reduced on night shifts ($M = 7.6$ hr for the rotating shift nurses), but it was even shorter on early shifts ($M = 6.37$ hr). The early shift was also associated with a significant reduction in cheerfulness and calmness, and a significant increase in back pain, irritability, and worries about work when not at work. Satisfaction with home life and social life were significantly reduced on all shifts. The permanent night nurses also showed significantly reduced satisfaction with home and social life on nights.
Table 7.1
ANCOVA of start and end of day measures on different shifts and rest days

<table>
<thead>
<tr>
<th>Rotate</th>
<th>Perm Night</th>
<th>Full</th>
<th>Perm Night</th>
<th>Part</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>E</td>
<td>L</td>
<td>N</td>
<td>R</td>
</tr>
<tr>
<td>Sleep Length (hr)</td>
<td>6.37</td>
<td>8.24</td>
<td>7.61</td>
<td>8.06</td>
</tr>
<tr>
<td>Sleep Quality</td>
<td>13.17</td>
<td>13.48</td>
<td>12.81</td>
<td>13.91</td>
</tr>
<tr>
<td>Sleep Latency (min)</td>
<td>13.38</td>
<td>14.13</td>
<td>10.73</td>
<td>14.68</td>
</tr>
<tr>
<td>Alertness</td>
<td>14.31</td>
<td>14.67</td>
<td>13.15</td>
<td>13.74</td>
</tr>
<tr>
<td>Cheerfulness</td>
<td>13.19</td>
<td>13.53</td>
<td>12.73</td>
<td>14.03</td>
</tr>
<tr>
<td>Calmness</td>
<td>13.13</td>
<td>13.29</td>
<td>13.65</td>
<td>14.15</td>
</tr>
<tr>
<td>Back pain</td>
<td>3.74</td>
<td>3.21</td>
<td>3.97</td>
<td>2.90</td>
</tr>
<tr>
<td>Abdominal pain</td>
<td>3.02</td>
<td>3.29</td>
<td>3.48</td>
<td>2.92</td>
</tr>
<tr>
<td>Mood swings</td>
<td>5.39</td>
<td>4.92</td>
<td>4.78</td>
<td>4.82</td>
</tr>
<tr>
<td>Irritable</td>
<td>6.35</td>
<td>5.88</td>
<td>5.42</td>
<td>5.43</td>
</tr>
<tr>
<td>Effectiveness</td>
<td>13.25</td>
<td>13.44</td>
<td>13.50</td>
<td>13.21</td>
</tr>
<tr>
<td>Satisfied with home life</td>
<td>11.48</td>
<td>11.32</td>
<td>10.63</td>
<td>12.8</td>
</tr>
<tr>
<td>Satisfied with social life</td>
<td>10.92</td>
<td>9.00</td>
<td>7.13</td>
<td>12.09</td>
</tr>
<tr>
<td>Worried by work</td>
<td>4.85</td>
<td>4.11</td>
<td>3.56</td>
<td>3.45</td>
</tr>
<tr>
<td>Worried by non-work</td>
<td>5.29</td>
<td>6.04</td>
<td>6.8</td>
<td>-2,351</td>
</tr>
</tbody>
</table>

*Note. Table shows adjusted means; E = Early, L = Late; N = Night, R = Rest; *** = p < .001, ** = p < .01, * = p < .05
Different shift days: On-shift measures. The analyses for the on-shift measures were similar but included time-into-shift (0, 2, 4, 6 and 8 hr) as an independent variable, and specified orthogonal contrasts between early and late shifts, and between day (early and late) shifts and night shifts.

For the mood measures, there was a significant interaction between type of shift and time-into-shift for alertness ($F(8, 1413) = 7.73, p < .001$) and cheerfulness ($F(8, 1413) = 2.74, p < .01$). Figure 7.3 shows that both alertness and cheerfulness were lower on a night shift and decreased over the course of a night shift.

For the workload measures, there were significant interactions for time pressure ($F(8, 1413) = 3.98, p < .001$), effectiveness ($F(8, 1413) = 2.37, p < .05$), effort ($F(8, 1413) = 2.67, p < .01$), and physical demand ($F(8, 1413) = 2.18, p < .05$). Perceived mental demand, frustration, and work satisfaction showed main effects for type of shift and time-into-shift. The workload effects are illustrated by time pressure in Figure 7.3, which shows that time pressure was lower on a night shift; with levels decreasing over the course of both early and night shifts.

Figure 7.3. Self-rated mood and time pressure of rotating shift nurses during different shifts.
For the performance tasks, there was a significant interaction for choice reaction time ($F(8, 1129) = 2.47, p < .05$). Figure 7.4 shows that reaction times were slower on the night shift and became slower over the course of both an early and a night shift. Gaps (responses > 1 sec) on the choice reaction task were significantly lower on a night shift ($F(2, 1129) = 3.54, p < .05$) but tended to increase over the course of a night shift. Efficiency on the 5-target memory search task showed a main effect for time-into-shift ($F(4, 1268) = 3.15, p < .05$) due to a peak in efficiency 4-hr into a shift. Response time on the memory search task increased over the course of a night shift ($F(5, 434), = 5.13, p < .001$).

![Figure 7.4: Choice reaction time of rotating shift nurses during different shifts.](image)

The analyses were repeated but this time controlling for perceived workload by including mental demand, physical demand, and time pressure as covariates. Mostly the results were unchanged but there were three exceptions. For calmness, there was now a significant main effect for shift ($F(2, 1401) = 6.51, p < .01$) and for time-into-shift ($F(4, 1401)=2.65, p < .05$). A contrast comparison showed that calmness was now significantly lower on a night shift compared to a day shift. On controlling for workload, the main effect of shift on frustration, and the shift and time-into-shift interaction and main effect of shift on effort were no longer significant.
Discussion

This investigation used a battery of 2-hrly on-shift and start and end of day measures collected over a 28 day period to compare rotating and permanent night shift nurses, and to compare the effects of different shifts on sleep, mood, personal disruption, workload, and performance.

The nurses on rotating shift systems appeared to get more sleep and to be faster on a choice reaction time task than the permanent night nurses. However, they were also younger and had less experience of shiftwork, and controlling for these differences eliminated the sleep and reaction time differences but highlighted other differences between the systems. The rotating shift nurses now had lower ratings of work satisfaction, effectiveness, and physical demand, and on night shifts their sleep quality and mood ratings were lower than those of the permanent night nurses. These results are in accordance with those of previous studies of nursing shift systems (e.g., U.S. Congress Office of Technology Assessment, 1991) which have shown that the permanent night system offers some advantages.

A possible explanation is that nurses on permanent night systems are more likely to have chosen to work at night and may therefore be more committed to their schedule (e.g., Alward & Monk, 1990; Barton, Smith, Totterdell, Spelten, & Folkard, 1993). However, unlike previous studies (e.g., Barton & Folkard, 1991; Folkard, Monk, & Lobban, 1978), this investigation did not find that the full-time permanent night nurses experienced fewer problems than the part-time night nurses. Another explanation is that the rotating shift nurses experienced greater circadian and social disturbance because they usually worked their night shifts in blocks and actually worked more consecutive night shifts on average than the permanent night nurses. There is some agreement that weekly rotating systems are worse than rapidly rotating or permanent systems (e.g., Folkard, 1992). However, the rotating shift group in the current study showed worse mood on night shifts even when the analysis was restricted to under four consecutive nights.
The results suggest that the early shift as well as the night shift causes problems. The sleep length of the rotating shift nurses was shortest on early shifts (6.4 hr) and the early shift was also associated with lower end-of-day mood, increased back pain, and worries about work. Satisfaction with home and social life were lower on all shifts compared to rest days, but were less impaired on early shifts. These findings are similar to those of Folkard et al. (1990) who found that, with the exception of social disruption, the early shift was the most problematic for a group of police officers. However, the start time of the early shift was considerably earlier (06:00) in that study, and therefore the problems were probably more greatly influenced by circadian factors. Another contributory factor could be workload, which is unevenly distributed between shifts and is often highest on the early shift.

Alertness and reaction times were worse at the end of each shift compared to the start of the subsequent shift, implying that those coming on shift were less fatigued than those going off shift. There were significant interactions between type of shift and time-into-shift for a number of measures including alertness, cheerfulness, and choice reaction time. The general pattern was that the measures were similar at the start of different shifts but the ratings decreased and the reaction times increased more dramatically over the course of the night shift compared to the other shifts. This pattern could be attributable either to circadian phase or to length of time awake or to time on shift. Previous studies of shiftworkers have also found decrements in alertness and increased reaction time at night (e.g., Parkes, 1993; Rosa & Colligan, 1992). Daniel and Potasova (1989) only found an increase in memory search times at night on a 12-hr shift, and not on an 8-hr shift. The night shift therefore appears to be the shift most likely to cause adverse effects when it is extended and yet in nursing shift systems it is often the longest shift. The night shifts in this study were 11-hr long on average, whereas the other shifts were only 8-hr.

However, this seeming cause for concern over the night shift was somewhat mitigated by two other results. The percentage of gaps (responses > 1 sec), which may correspond to attention lapses, was actually lower on the night shift than on other
Temporal Schedule

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shifts, although it did tend to increase over the course of a night shift. It was also found that ratings of workload tended to be lower on the night shift. Controlling for workload did not eliminate the difference in the frequency of gaps on different shifts, but it is still possible that the lower frequency of gaps on the night shift may be a reflection of fewer extraneous distractions at night. Controlling for differences in workload between shifts did, however, suggest that the higher workload on day shifts reduces calmness to night shift levels and increases frustration and effort compared to the night shift.

In summary, it was found that permanent night nurses were no worse off and for some measures were actually better off than rotating shift nurses after controlling for differences in age and shiftwork experience. The night shift was problematic for rotating shift nurses but so was the early shift. Some mood and performance measures got worse over the course of a night shift but extra long performance responses were less likely and rated workload was lower on the night shift. The relatively large number of consecutive night shifts worked by the rotating shift nurses, the uneven distribution of workload between shifts, and the long night shift may have contributed to these results.

In terms of the theoretical framework of this thesis, the results show very clearly that the timing of events, in this case work shifts, had acute effects on aspects of people’s well-being. Different work shifts were reliably associated with different sleep, mood, symptom, satisfaction, and performance outcomes. However, it was not only the timing of work within a day but also the timing of work over an extended period that had effects on well-being. This was demonstrated by the fact that the permanent night shift system seemed to offer some advantages for well-being compared to the rotating shift system (even when the analysis was restricted to a comparison of night shifts). This suggests that the effects of a particular work shift also depend on the timing of other work shifts. The next investigation will therefore examine whether different sequences or temporal orders of work shifts have different effects on well-being.
8 Temporal Sequence

Effects of the order of work shifts on aspects of well-being

If we cannot change the rate of flow of time, we can at least impose a deliberate structure on the way events are packaged within the confines of the time we find at our disposal.

- J. Michon & J. Jackson

Time, Mind, and Behavior (1995)

Tomorrow is today's pupil. This proverb implies that how a person fills time today will affect her or his psychological experience tomorrow. The previous chapter demonstrated that the timing of events can affect the experience of those events. For example, a work shift in the morning was associated with different psychological effects than a work shift at night. This chapter extends those findings by examining whether the ordering of events in time alters their psychological effects. In particular, an investigation is made of the effects of putting different types of work shift in different orders. Or to put it another way, it is proposed that the effects of working a particular type of shift depends in part on the previous shift.

Nurses on rotating shift systems frequently work a sequence of shifts that is made up of early and late shifts; and this sequence is often preceded and followed by a rest day. Only a limited number of shift changes are therefore possible in these sequences: An early shift (E), a late shift (L) and a rest day (R) can be preceded by an early shift, a late shift or a rest day, making a total of nine possible changes. An investigation was therefore undertaken to determine whether some of these changes are more desirable than others in terms of their psychological effects.

Previous studies have shown that one of the main problems of working an early shift is the fatigue that results from truncated sleep prior to the shift (e.g., Folkard,
Arendt, & Clark, 1990). Although shiftworkers have to wake up earlier than normal before an early shift, they do not generally compensate by going to sleep sufficiently earlier. This may be due to social pressures to stay up late but it may also be a consequence of not being able to sleep earlier if the shiftworkers are in a “forbidden zone” for sleep due to the phase of their body clock (Folkard & Barton, 1993). These results make it possible to speculate on the likely effects of working different shifts before an early shift.

A late shift worked before an early shift (LE) has three likely effects. First, the shiftworkers will probably have attempted to sleep much earlier before the early shift than they did before the late shift: Advancing sleep in this way is harder than delaying sleep because the natural circa 25 hr period of the body clock encourages a delay. Second, there will be very little time off between shifts (usually the duration of the night shift) and consequently very little time for the shiftworker to unwind before sleeping: This type of shift change is often referred to as a quick changeover or quick return. Barton and Folkard (1993) have demonstrated that advancing shift systems cause more disturbance than delaying shift systems, especially if the advancing system incorporates a quick return. Knauth (1993) recommends that quick changeovers must be avoided in the design of shift systems. Third, the shiftworker will have no time available for social or family activities before the early shift.

Working an early shift before an early shift (EE) avoids the above three problems but is likely to exacerbate fatigue because the shiftworker will probably have two truncated sleeps in succession and hence accumulate a “sleep debt”. The sequence with the least associated disturbance is likely to be a rest day before an early shift (RE).

Late shifts do not cause physiological disruption but they are associated with disturbance of social and family life. Leisure activities generally have low temporal flexibility, meaning that they can only be done at certain times and usually this is during the evening (McGrath & Kelly, 1986). Shiftworkers on the late shift are therefore deprived of the socially preferred time for leisure activity. Workers on fixed afternoon shifts express concern about lack of contact with their children, loss of valuable time
with their partners, and inability to participate in social activities (see Colligan & Rosa, 1990).

Working two late shifts in succession (LL) is therefore likely to exacerbate the problem of social and family disturbance. In contrast, an early shift before a late shift (EL) will provide some time for social and family activity. The change from an early to a late shift also allows sufficient time for sleep between shifts and is a delaying rather than an advancing sequence; both these factors should minimise sleep and fatigue related effects. However, again the sequence which minimises disturbance is likely to be a rest day before a late shift (RL).

Previous research has shown that flexible shift schedules that allow shiftworkers some choice over the shifts that they work can reduce shiftwork related disturbance (e.g., Barton, Smith, Totterdell, Spelten, & Folkard, 1993). It is conceivable that the shiftworkers are able to reduce their personal disturbance by using their own experience to choose sequences of shifts that they know cause them the least disruption. Alternatively, the shiftworkers' choice of shifts might be influenced by their desire to maximise a specific facet of their lives, such as the amount of time available for social life. This investigation therefore includes an examination of the frequency of actual shift sequences on flexible and non-flexible shift systems relative to the disturbance caused by those sequences.

Method

The investigation was based on data from the 61 nurses that took part in the intensive time-sampling study of shiftwork in nursing. See chapter 6 for a complete description of the sample, procedure, measures and analyses. This investigation was confined to the 32 nurses that worked on a rotating shift system. Half of these nurses worked on flexible shift systems where they had some choice over the shifts that they worked. Data from night shifts and from shifts that were preceded by a night shift were not used in this investigation. The complete set of measures described in chapter 6 were used in this investigation.
An analysis of covariance (ANCOVA) was performed on each of the daily measures using two factors: Today and Previous day. Each factor had three levels: Early shift, Late shift, and Rest day. The covariates included dummy variables for the participants, a variable for the day of the study and dummy variables for the days of the week. The purpose of including these covariates was to remove between-subjects effects, linear practice effects, and day of week effects respectively. Day of week was partialled out because otherwise the disturbance caused by a shift that was scheduled very frequently on a day such as Saturday or Sunday could be due more to the undesirability of working at weekends than to the shift itself.

A similar analysis with the same covariates was made using the on-shift measures, except that the Today factor had only two levels: Early and Late shift, because there were no on-shift measures on a rest day. A Time-into-shift factor was also included for the on-shift measures, using 0, 2, 4, 6 and 8 hr as the levels. The effects of interest in this investigation involve previous day either as a main effect or as part of an interaction.

Results

The means of each measure for different shift changes, adjusted for between-subjects, day of study and day of week effects, are shown in Table 8.1.
There were only three significant effects involving previous day. There was a significant interaction between previous day and today for end-of-day alertness ($F(4, 455) = 3.45, p < .01$). Figure 8.1 shows that alertness was lower on the day of an early shift when it was preceded by an early shift, and that it was lower on a rest day when the rest day was preceded by a late shift. There was a significant main effect of previous day for physical demand ($F(2, 858) = 6.08, p < .01$) and time pressure ($F(2,
Figure 8.1 shows that both physical demand and time pressure were rated lower if the previous day was a rest day.

Figure 8.1. Effect of previous day on the next day’s end-of-day alertness ratings for rotating shift nurses.

Figure 8.2. Effect of previous day on the next day’s on-shift ratings of physical demand and time pressure for rotating shift nurses.

Although very few of the results reached significance, the shift changes which caused the greatest and least problems appeared to be somewhat consistent across the
measures. To test for this trend, the means for the shift changes were ranked 1-6 for each measure where 1 was least disturbance and 6 was most disturbance. Kendall's coefficient of concordance showed there to be significant agreement on the rankings across the measures ($\chi^2 (5, n = 32), p < .01$).

The mean rankings were therefore converted to standard Z-scores to form a summary measure of disturbance on the various shift changes. Then the relative frequencies with which the shift changes were actually worked by the rotating shift nurses, and by the flexible and non-flexible sub-groups were also expressed as Z-scores. Figure 8.3 shows these Z-scores plotted together. If shift changes that cause the most disturbance are scheduled less frequently and shift changes that cause the least disturbance are scheduled more frequently, then the disturbance and frequency columns should be seen on opposite sides of the X axis. Only EL, which was associated with low disturbance, and LL, which was associated with high disturbance, showed this pattern.

![Diagram](image)

**Figure 8.3.** Summary measure of disturbance on early and late shifts preceded by early (E), late (L), or rest (R) days, compared to the relative frequency with which those combinations were scheduled.

Inspection of the problem domains within Table 8.1 shows that EE was mainly associated with mood disturbance, LE with sleep and performance deficits and physical symptoms, and LL with social disruption and workload problems. Figure 8.4 shows
the fit between just one measure, social satisfaction, on different shift changes and the relative frequency with which those changes were scheduled. It shows, that the least frequently scheduled shift change, LL, was associated with the greatest social disruption.

![Graph showing social satisfaction on shift changes compared to relative frequency of occurrence of those shift changes.](image)

*Figure 8.4.* Social satisfaction on shift changes compared to relative frequency of occurrence of those shift changes.

**Discussion**

The results give some support to the hypothesis that changing the sequence of events can change the psychological impact of those events on well-being. Specifically, the effects on a group of nurses of working an early or a late shift depended to some extent on the type of shift that they had worked the previous day.

Nine shift changes were identified: an early shift, a late shift and a rest day each preceded by an early shift, a late shift and a rest day. These shift changes were compared for their effects on sleep, mood, symptoms, social satisfaction, workload and cognitive performance. Alertness was lower on the day of an early shift when it was preceded by an early shift rather than a late shift or rest day, and was lower on a rest day when the rest day was preceded by a late shift rather than an early shift or rest day. Very few of the other individual measures showed significant differences between the shift changes. However, there was a consistent trend across the measures.
A summary measure of disturbance was therefore calculated from all the measures. Unexpectedly, this measure showed that changing from an early shift to another early shift (EE) was associated with greater disturbance than a quick changeover from a late shift to an early shift (LE). However, as expected an early shift preceded by a rest day (RE) caused the least disturbance. Also, as expected an early shift before a late shift (EL) caused less disturbance than a late shift before a late shift (LL), and was even slightly better than a rest day before a late shift (RL).

The shift changes also seemed to differ in their specific effects. For example, as expected, the quick changeover (LE) mainly affected sleep and performance, and changing from a late to a late (LL) affected social satisfaction. Surprisingly, the problematic change from an early to an early shift (EE) seemed to affect mood rather than sleep.

It would be hoped that those shift changes that were associated with the greatest disturbance would be scheduled least often, and those associated with the least disturbance scheduled most often. In practice, almost the reverse happened. In particular, an early shift preceded by an early shift (EE) appeared to be associated with the most disturbance and yet it was also the second most frequent sequence; similarly, an early shift preceded by a rest day had the least associated disturbance and yet it was the second least frequent sequence.

The flexible sub-group - those nurses that had some choice over their shifts - had relatively fewer of the early-early (EE) sequences than the non flexible sub-group. This suggests that nurses may know to avoid this shift change. However, an alternative interpretation is that the disturbance was greater on the early-early sequence because it was mostly worked by the non flexible sub-group, who show greater disturbance than the flexible sub-group for reasons other than shift changes. This could not be tested because of the small number of early-early shifts worked by the flexible sub-group.

It has been assumed that combining the individual measures forms a balanced assessment of disturbance. Although the measures covered a number of likely problem areas, the number of measures from each domain were neither equal nor designed to
prioritise problem areas. For example, there was a large number of mood related
measures and these were the measures that were most sensitive to the EE change.
There was also a reasonably good fit between the frequency of the shift changes and
satisfaction with social life. In particular, the least frequently scheduled sequence (LL)
was associated with the most social disruption. Shifts might therefore have been
sequenced to fit social needs because these needs were viewed as a priority by the
nurses.

A practical outcome of this investigation could be to provide shift schedule
managers with information about desirable and undesirable shift changes from a
psychological perspective. However, the results contain contradictions for scheduling.
For example, consider the task of finding a desirable five shift sequence: A rest day
followed by an early shift (RE) and an early shift before a late shift (EL) minimised
disturbance, so a sequence of \( RELEL \) seems desirable, but it contains a quick
changeover from a late to an early (LE) which is not desirable. Compromises would
therefore be necessary to produce a final schedule. It should also be recognised that
longer sequences may have more complex effects than the sum of the short sequences
that they contain. Future research could therefore investigate the effects of longer
sequences of shifts.

These results do, however, suggest that it may be advisable when sequencing
early and late shifts to not follow an early shift with another early shift, to follow a rest
day with an early shift, and to follow an early shift with a late shift where possible.
This may help minimise the overall disturbance to the shiftworker. Unfortunately, it
appears that at present the early-early combination is one of the most frequent, and the
rest-early combination one of the least frequent shift sequences scheduled in nursing
shift systems.

The general conclusion from this investigation is that the psychological effects
of events can depend on their temporal relations to other events. So the latent effects
of the previous time period and, as will be demonstrated in a later chapter, the next
time period should be considered when examining the psychological effects of events on well-being.
9

Temporal Duration

Effects of the amount of time between work shifts on aspects of well-being

A change is as good as a rest.

Time is the healer.

- Proverbs

If a change is as good as a rest, then a single rest day following a number of work shifts ought to be as good for psychological recovery as two or more rest days. Alternatively, if time is the healer then any psychological deficits accrued through work may require longer than one rest day to wear off. This investigation examines the question of whether increasing the number of rest days between spans of work shifts increases psychological recovery and hence improves well-being on subsequent work days. It also examines the related issue of the effect of increasing the number of consecutive shifts on well-being.

Most countries have regulations concerning hours of work for night workers and shift workers. It is usual for a minimum weekly rest period to be specified within these regulations. For example, a study of 49 countries showed that 42 have national regulations for minimum weekly rest (U.S. Congress, Office of Technology Assessment, 1991). Most of these 42 countries require a weekly minimum of about one rest day (sometimes specified in hours), and often specify a particular day for rest at the weekend.

Agreements on hours of work - and hence rest - also exist among countries. The International Labor Organization, for example, has adopted two conventions on weekly rest (Conventions 14 and 106) which have been ratified by 104 and 52 respectively of its 150 member countries (U.S. Congress, Office of Technology Assessment, 1991). The proposed European Community Directive on Working Time (Commission of the European Communities, 1991) also contains legislation for the
minimum duration and frequency of rest periods. In particular, Article 3 of the directive requires a minimum daily rest period of 12-hr per 24-hr and Article 4 requires a minimum of one rest day in every seven day period. This would limit the number of consecutive shifts worked to six, and would limit the number of hours worked per week to 72. Night workers could be further limited to 48-hr per week because of Article 7 which requires that hours of work for night workers should on average be no longer than 8-hr per 24-hr calculated over a reference period of 14 days.

An underlying assumption of all these regulations on working-time is that time spent working can have negative consequences for the well-being of the individual concerned. This assumption extends back at least as far as Marx, who proposed that labor is alienating for the worker (Kamenka, 1985). Proponents of the alienation hypothesis argue that feelings of alienation generated by work spill over to non-work (see Seeman, 1971). Alternative conceptions of work and non-work also exist (Kabanoff, 1980, 1982). For example, the compensatory view proposes that individuals use leisure to compensate for work, the segmentalist view proposes that work and non-work are psychologically separate spheres, and the task-based view proposes that there are a number of possible relationships between work and non-work depending on the attributes of each.

All of the regulations concerning working-time also make additional assumptions, namely, that working too many hours is detrimental to an employee, that employees require sufficient time to recover from undesirable side effects arising from work, and that particular days of the week are of higher value to the employee for leisure. The theories of work and non-work, referred to above, generally posit either a uniform response to work and non-work or a response that depends on the individual's experience of work and non-work. This does not seem to include a response to work and non-work that changes over time and that could therefore encompass the influence of temporal factors, such as psychological recovery and valuation of time, which are implicitly assumed in regulations of work-time. Although there is good general evidence to support these assumptions, some of which is reviewed below, there is a
paucity of theory and empirical evidence relating to the specific time parameters
chosen in the regulations. For example, little is known about how recovery takes place
over rest days and hence how much rest is required. Similarly, little is known about the
cumulative effects of consecutive work shifts.

Psychological recovery refers to the period of time that an individual requires
to return to a normal or prestressor level of functioning following the termination of a
stressor (Craig & Cooper, 1992). Unfortunately, relatively little research has been
conducted on the time course of the aftereffects of stressors, even though it has been
suggested that the time required to recover from a stressor may be a better measure of
the severity of stress and a better predictor of the likelihood of long-term chronic
effects than the immediate response to a stressor (e.g., Depue & Monroe, 1986).

Much of the research on the aftereffects of stressors has focused on changes in
performance immediately following termination of a limited number of stressors, such
as task load and noise (e.g., Rotton, Olszewski, Charleton, & Soler, 1978). Cohen
(1980) suggested that most of the theories in this area derive from the adaptive-cost
hypothesis, which predicts that the severity of performance aftereffects is a function of
the effort required to adapt to aversive events.

One of the costs of adaptation may be evident in increased feelings of fatigue.
It has been extremely difficult, however, to demonstrate performance differences
between fatigued and rested individuals. For example, Chiles' study showed that
individuals asked to perform a task to the point of exhaustion were able to maintain
performance on a separate test task (as cited in Craig & Cooper, 1992). Holding
(1983) suggested three reasons to explain this general failure to find fatigue
aftereffects: the novelty of changing to the test task, the ability of individuals to
compensate for deficits in the short term, and the wrong choice of test tasks. Holding
also pointed out that a number of studies have demonstrated that fatigued individuals
show less inclination to exert effort on tasks.

The aftereffects of stressors may also have consequences for affect, social
behaviour and physiological responses. Some studies have shown that the effect of
daily stressors on mood is confined to the day of occurrence (e.g., Stone & Neale, 1984), whereas other studies have shown that mood is actually better on days following a stressful event (e.g., Bolger, DeLongis, Kessler, & Schilling, 1989). Marco and Suls (1993) found that individuals scoring high on negative affectivity recovered more slowly from stressful events that occurred the previous day. It has also been shown that the availability of social support can buffer the impact of stressful daily events on mood the following day (Caspi, Bolger, & Eckenrode, 1987). A study of air traffic controllers found that high workload days are associated with increased social withdrawal and expressed anger after work, and that these associations are facilitated by high spouse-support and are independent of self-reported fatigue (Repetti, 1989).

Studies of physiological unwinding following work have shown that a return to physiological and neuroendocrine baselines is slowed by repetitive, uncontrollable work (Frankenhaeuser, 1986). Individuals with a rapid adrenaline decrease following high mental load show better psychological adjustment. For example, a group of industrial workers showed higher well-being and a higher proportion of rapid adrenaline decreases following a vacation (Johansson, 1976). Complementary to this finding, a group of insurance clerks working up to 15-hr a week overtime over a period of months showed increased adrenaline excretion both at work and at home, as well as increased irritability and fatigue at home (Frankenhaeuser, 1980).

Recommendations for the design of shift systems sometimes include the requirement for sufficient time for recovery. For example, Knauth (1993) recommended that "instead of only single days off or one and a half days off (after a night shift), every shift system should include some free weekends with at least two consecutive days off" (p. 21). The evidence for the positioning of free time within a shift schedule is more compelling than that for the amount of free time required. A number of studies, for example, have shown that shiftworkers place a higher value on weekday evenings and weekends for leisure (e.g., Hornberger & Knauth, 1993; Wedderburn, 1981). By using spectral analysis, Nachreiner, Baer, Diekmann, and Ernst...
(1984) showed that some shift systems interfere more with the weekly utility of time, but they pointed out that the utility of time at a given hour also depends on the availability of the hours before and after.

No systematic study of the process of psychological recovery on rest days following work shifts has been conducted but there is some indirect evidence. Meijmann, van der Meer, and van Dormolen (1993), for example, found that short-term memory performance was more impaired by a cycling task 32-hr after four night shifts than at baseline in comparison with a group tested 17- or 25-hr after four day shifts. In another study, two days of rest following a 60-hr work-week were sufficient to improve performance on a battery of cognitive tasks, except on motor tasks (Rosa & Colligan, 1988).

Colligan and Rosa (1990) pointed out that the effective use of free time may be curtailed by carryover effects associated with a variable schedule. In support of this viewpoint, Fischer et al. (1993) found that the frequency of activities associated with recovery, such as rest and naps, was higher on a schedule with two rest days than on a schedule with 4 rest days. Patkai and Dahlgren (1981) also found that satisfaction was higher on a system that included 3-5 rest days, but fewer holidays, compared with one that had 2 rest days. In addition, Nicholson, Jackson, and Howes (1978) showed that workers on a 6-on, 2-off shift system sometimes extend the duration of rest days by taking uncertified absence either immediately before or after rest days.

A likely corollary of extending rest periods without a reduction in total working-time would be a longer series of consecutive shifts. Apart from the possibility of an increase in accumulated fatigue in all types of shift, this may have particular implications for night shifts, because the circadian system may have increased time for adjustment to a nocturnal routine but equally may require longer to reentrain to a diurnal routine on days off. Most studies of the circadian rhythms of shift workers have shown that most adjustment takes place over the first few nights (probably because of exogenous effects rather than adjustment of the endogenous pacemaker) but that full adjustment does not occur even after many night shifts (Åkerstedt, 1990).
Moog and Hildebrandt (1989) reported phase shifts of approximately 1-hr per day on night shifts but more rapid phase shifts of about 2-hr per day back to a daytime routine. On the basis of three experimental studies of shiftwork, Knauth, Rutenfranz, Hermann, and Poeppl (1978) estimated that reentrainment of the circadian rhythm of rectal temperature takes 2 days following 2 night shifts but 3-4 days following 21 night shifts.

Cooper (1992) conducted two studies of nurses' recovery between consecutive shifts and found recovery effects in only the second of these studies. This difference could be attributed either to an improved design or to the use of nurse learners in the second study. By using only those cases in which the nurse's negative affect at the end of a shift was higher than the nurse's median, Cooper found that an improvement by the start of the next day predicted less negative affect and lower emotional demands at the end of the next shift, independent of sleep quality. However, an improvement in positive affect predicted higher cognitive demands on the next shift, and non-recovery cases were not associated with more symptoms at the end of the subsequent shift.

Although the aforementioned studies provide evidence for the existence and impact of psychological recovery following work, they were not designed to systematically investigate the effects of different amounts of time off between work shifts. For example, it has not yet been demonstrated that two consecutive rest days can be of greater benefit than a single rest day. Likewise, it has not been demonstrated that the benefits of extended rest carryover to subsequent work days. The present investigation examines changes in nurses' self-reports of sleep, mood, symptoms and social satisfaction over consecutive rest days following day and night shifts, and cognitive performance and self-reports on subsequent blocks of day and night shifts. Changes over consecutive day and night shifts are also investigated. Adopting the adaptive-cost theory, it is assumed that work has adaptive-costs that are recovered on rest days. It is further assumed that adaptation to night work and back to a daytime routine has higher costs. It is, therefore, hypothesised (H) that:
H 1. The first rest day following work shifts will show greater deficits than subsequent rest days.

H 2. The first rest day following night shifts will show greater deficits than the first rest day following day shifts.

H 3. Day shifts will show greater deficits when they follow fewer rest days.

H 4. Night shifts will show greater deficits when they follow more rest days.

It has been assumed here that more rest days increase the adjustment required to work on nights again, however it is recognised that more rest days could also reduce fatigue.

H 5. Deficits will increase over consecutive day shifts.

H 6. Deficits will decrease over consecutive night shifts. It has been assumed here that adjustment to a nocturnal routine reduces costs faster than accumulated work fatigue increases them.

H 7. Longer working weeks will be associated with greater deficits.

Method

The investigation was based on data from the 61 nurses that took part in the intensive time-sampling study of shiftwork in nursing. See chapter 6 for a complete description of the sample, procedure, measures and analyses. The subset of variables used in this investigation were: daily sleep duration and quality; daily mood, symptom and satisfaction ratings; on-shift mood and workload ratings; on-shift serial reaction time and proportion of errors and gaps (the proportion scores were transformed to the arcsine of their square root to approximate the normal distribution); and on-shift memory search response time, d', and efficiency.

The on-shift workload ratings were combined into a composite measure of perceived workload (alpha = .86) to reduce the number of variables and improve reliability. For the same reasons, the symptom and social satisfaction ratings were factor analysed: Subject, day of week, day of study, and previous day effects were removed from the ratings by using multiple regression (see chapter 6 for more detail), so that the residual scores could then be analysed using principal components factor
Temporal Duration

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analysis with varimax rotation. An interpretable three factor solution resulted: mood symptoms (mood swings, feeling irritable) explained 32% of the variance, Cronbach's alpha = .70; physical symptoms (abdominal pain, back pain) explained 18% of the variance, alpha = .29; social satisfaction (satisfaction with social life, satisfaction with home life) explained 21% of the variance, alpha = .66. All items loaded above .70 on a principal factor and no higher than .20 on both of the other two factors. Physical symptoms was dropped because of its low reliability.

The correlations between all measures are shown in Table 9.1. No correlation exceeded .60 apart from that between d' and memory search efficiency. This last measure was therefore dropped.

Table 9.1
Intercorrelations of dependent variables

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<td>.05</td>
<td>.01</td>
<td>.01</td>
<td>.04</td>
<td>-.10</td>
<td>-.12</td>
<td>-.16</td>
<td>-.43</td>
<td>.98</td>
<td>-</td>
</tr>
</tbody>
</table>

Note. All scores were residualised prior to correlation to remove the effects of the control variables used in subsequent analyses.
The analyses tested for significant changes over consecutive days: for example, changes in mood over a series of shifts or rest days. A within-subject approach was used for all analyses. A pooled time-series analysis was used for this purpose. This involved using either multiple analysis of covariance (ANCOVA) or multiple regression with dummy variables. Bonferroni corrections were made to the alpha levels to take account of the number of tests conducted. The alpha was therefore set at $p = .007$ for the seven daily measures, and $p = .005$ for the 10 on-shift measures.

**Results**

**Recovery on rest days**

Changes over consecutive rest days. An ANCOVA was used on each daily measure from the rotating shift nurses, to test changes over three rest days following a shift. The number of rest days (1-3) and the type of previous shift (early, late, or night) were used as variables in the analyses. The first three rest days were chosen to give sufficient cell sizes (> 8). The results, including effect sizes, are shown in Table 9.2. The largest effect size, estimated using partial $\eta^2$, was .153 for the sleep length interaction. Sleep length, sleep quality, alertness, and calmness were all significantly worse on rest days that followed a night shift. The main effects for the number of rest days did not reach significance, but all of the measures except sleep quality were better on the the second and third rest day than on the first rest day. Figure 9.1 illustrates this pattern with alertness.
Table 9.2

ANCOVA of daily measures for rotating shift nurses across 3 rest days following 3 types of shift

<table>
<thead>
<tr>
<th>Variable</th>
<th>Rest days: R 1-3</th>
<th>Last shift: S</th>
<th>R x S</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Parti $\eta^2$</td>
<td>df</td>
<td>F</td>
</tr>
<tr>
<td>Sleep length</td>
<td>.024, 2, 152</td>
<td>1.87</td>
<td>.118, 2, 152</td>
</tr>
<tr>
<td>Sleep quality</td>
<td>.017, 2, 152</td>
<td>1.32</td>
<td>.069, 2, 152</td>
</tr>
<tr>
<td>Alertness</td>
<td>.057, 2, 147</td>
<td>4.43</td>
<td>.095, 2, 147</td>
</tr>
<tr>
<td>Cheerfulness</td>
<td>.058, 2, 147</td>
<td>4.51</td>
<td>.032, 2, 147</td>
</tr>
<tr>
<td>Calmness</td>
<td>.028, 2, 147</td>
<td>2.12</td>
<td>.074, 2, 147</td>
</tr>
<tr>
<td>Mood symptoms</td>
<td>.023, 2, 145</td>
<td>1.68</td>
<td>.019, 2, 145</td>
</tr>
<tr>
<td>Social satisfaction</td>
<td>.026, 2, 131</td>
<td>1.75</td>
<td>.029, 2, 131</td>
</tr>
</tbody>
</table>

Note. Last shift (S) before rest days had 3 levels: early, late, and night shift
* $p < .007$ (with Bonferroni correction); Parti. = partial

Figure 9.1. Alertness of rotating shift nurses on consecutive rest days following different types of shift.

Comparison of rest days and work days. It was tested whether the measures on rest days represented deficits or improvements as compared with measures on work days. Paired contrasts were used to compare the daily measures on the first and second rest days following day (early and late) shifts with the daily measures on day shifts. The results are shown in Table 9.3.
Table 9.3
Contrasts between daily measures at the end of a day shift and at the end of rest days following a day shift, and between daily measures at the end of a night shift and at the end of rest days following a night shift for rotating shift nurses

<table>
<thead>
<tr>
<th>Variable</th>
<th>D R1 R2</th>
<th>DvrR1</th>
<th>DvrR2</th>
<th>N R1 R2</th>
<th>NvrR1</th>
<th>NvrR2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>adj.means</td>
<td>n</td>
<td>η² t</td>
<td>n</td>
<td>η² t</td>
<td>adj.means</td>
</tr>
<tr>
<td>Sleep length (hr)</td>
<td>7.10 8.46 8.02 462</td>
<td>.10 7.26*</td>
<td>.03 3.78*</td>
<td>7.57 6.02 8.14 151</td>
<td>.08 3.66*</td>
<td>.01 1.34</td>
</tr>
<tr>
<td>Sleep quality</td>
<td>13.39 14.51 14.52 462</td>
<td>.01 2.56</td>
<td>.01 1.97</td>
<td>12.64 12.84 12.64 151</td>
<td>.00 0.22</td>
<td>.00 0.00</td>
</tr>
<tr>
<td>Alertness</td>
<td>14.50 13.66 14.54 434</td>
<td>.01 2.24</td>
<td>.00 0.09</td>
<td>13.34 11.08 14.06 137</td>
<td>.07 3.18*</td>
<td>.01 0.92</td>
</tr>
<tr>
<td>Cheerfulness</td>
<td>13.32 13.90 14.59 434</td>
<td>.00 1.44</td>
<td>.01 2.43</td>
<td>12.91 12.00 15.03 137</td>
<td>.01 1.32</td>
<td>.05 2.81</td>
</tr>
<tr>
<td>Calmness</td>
<td>13.10 14.10 14.88 434</td>
<td>.02 2.58</td>
<td>.03 3.52*</td>
<td>13.80 13.33 13.86 137</td>
<td>.00 0.71</td>
<td>.00 0.08</td>
</tr>
<tr>
<td>Mood symptoms</td>
<td>5.83 5.24 4.57 433</td>
<td>.00 1.39</td>
<td>.01 2.30</td>
<td>5.05 5.70 4.52 137</td>
<td>.01 0.86</td>
<td>.00 0.64</td>
</tr>
<tr>
<td>Social satisfaction</td>
<td>10.70 12.47 12.44 398</td>
<td>.03 3.70*</td>
<td>.02 2.77</td>
<td>9.25 10.73 13.11 114</td>
<td>.04 2.31</td>
<td>.20 5.28*</td>
</tr>
</tbody>
</table>

Note. D = day shift, N = night shift, R1 = first rest day, R2 = second rest day; * p < .003 (with Bonferroni correction)
Alertness was worse, but not significantly, on the first rest day as compared with day shifts. However, all 13 of the other contrasts showed a trend, 4 of which were significant, in which the measures were better on rest days than on day shifts. When the analyses were repeated with night shifts, 9 of the 14 contrasts showed the same trend. Social satisfaction was significantly higher on the second rest day than on night shifts. The other 5 contrasts involved the first rest day and showed a trend in which the measures were worse on the first rest day as compared with night shifts. Two of these were significant: alertness and sleep duration. This pattern of results for rest days after day shifts and night shifts is illustrated for calmness in Figure 9.2.

![Calmness of rotating shift nurses on rest days and on shifts.](image)

**Figure 9.2.** Calmness of rotating shift nurses on rest days and on shifts.

*Recovery from night shifts.* Recovery from night shifts was then tested in greater detail, including the permanent night nurses as well as the rotating shift nurses. For each daily measure, an ANCOVA was used to examine potential changes in the measures over four rest days following a night shift. The analyses were made separately on the part- and full-time permanent night, and the rotating shift nurses. These results, including effect sizes, are shown in Table 9.4. The largest effect size was .335 for the part-time permanent night nurses' alertness. Only some of the individual measures reached significance. However, all of the measures, except sleep quality for the full- and part-time permanent night nurses and calmness for the rotating shift
nurses, showed a pattern in which the measures were at their worst on the first rest day following a night shift and were better on subsequent rest days. Figure 9.3 illustrates this pattern with cheerfulness.

Table 9.4

<table>
<thead>
<tr>
<th>Variable</th>
<th>Perm Full</th>
<th>Perm Part</th>
<th>Rotate after N</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Partl $\eta^2$</td>
<td>df</td>
<td>F</td>
</tr>
<tr>
<td>Sleep length</td>
<td>.120</td>
<td>3, 69</td>
<td>3.13</td>
</tr>
<tr>
<td>Sleep quality</td>
<td>.042</td>
<td>3, 69</td>
<td>1.00</td>
</tr>
<tr>
<td>Alertness</td>
<td>.257</td>
<td>3, 80</td>
<td>9.21*</td>
</tr>
<tr>
<td>Cheerfulness</td>
<td>.086</td>
<td>3, 80</td>
<td>2.51</td>
</tr>
<tr>
<td>Calmness</td>
<td>.087</td>
<td>3, 80</td>
<td>2.53</td>
</tr>
<tr>
<td>Mood symptoms</td>
<td>.056</td>
<td>3, 80</td>
<td>1.59</td>
</tr>
<tr>
<td>Social satisfaction</td>
<td>.132</td>
<td>3, 80</td>
<td>4.06</td>
</tr>
</tbody>
</table>

Note. * $p < .007$ (with Bonferroni correction)

Figure 9.3. Cheerfulness on consecutive rest days following a night shift.

These analyses were repeated for the whole sample, which was necessary to obtain a sufficient $N$, but the number of preceding night shifts (1-4) was used as an extra variable to determine whether the number of previous night shifts affected recovery. There were no significant interactions.
It was also possible that the measures would be affected by whether a rest day immediately preceded a work day. To test this, the analyses for night shifts were repeated again for the whole sample but this time with an extra variable for final rest day or not. There was a main effect of this factor on calmness, $\eta^2 = .047$, $F(1, 210) = 10.43$, $p < .007$. Examination of the adjusted means showed that calmness was higher when the rest day preceded a work day.

The finding that the first rest day following a night shift appeared to be associated with the greatest deficits was perhaps not surprising given that the day normally includes both the end of the shift and a daytime sleep. Therefore, the first set of analyses for the rotating shift nurses were repeated but this time the first rest day after the night shift was considered to be the day following the end of the night shift, and not the day on which the night shift ended. As a result, the significant effects for sleep duration and alertness disappeared.

These results give some support to the hypothesis (H1) that the first rest day shows greater deficits than subsequent rest days, and to the hypothesis (H2) that the first rest day following night shifts shows greater deficits than the first rest day following day shifts.

**The effects of rest days on subsequent work days**

*Day shifts following rest days.* By using those occasions when the rotating shift nurses had one or two rest days between early or late shifts, ANCOVA was performed on the daily measures for the three shifts that followed the rest days, with the number of rest days as the variable tested. The numbers of rest days and shifts were chosen to obtain reasonable sample sizes. Social satisfaction, $\eta^2 = .375$, $F(1, 25) = 14.99$, $p < .007$, was significantly higher after two rest days rather than one rest day. All of the other daily measures except sleep quality were also better after day shifts that followed two rest days but the effects did not reach significance. Some of these results are illustrated in Figure 9.4. Analyses of the on-shift measures with time into shift (0, 2, 4, 6, and 8-hr) as an additional variable produced no significant results. These results give
limited support to the hypothesis (H3) that day shifts show greater deficits when they follow fewer rest days.

![Bar chart showing means for first 3 days at work following 1 rest day vs. 2 rest days.]

* * p < .007

**Figure 9.4.** Self-report measures on three day shifts following 1 or 2 rest days.

**Night shifts following rest days.** For those occasions when the nurses had 2-5 rest days between night shifts, an ANCOVA was performed on the daily measures for the three shifts that followed the rest days. There were insufficient single rest days to include them in the analyses. Social satisfaction was significantly greater after more rest days, $\eta^2 = .271$, $F(3, 44) = 5.46, p < .007$. Sleep quality showed the same trend, but the other five measures were actually worse after night shifts that followed more than two rest days (12 of 15 comparisons).

Analyses of the on-shift measures with time into shift (2, 4, 6, 8 and 10- hr) as an additional factor, produced no significant results. However, choice reaction time and gaps showed consistent trends. Figure 9.5 shows that both measures were highest on night shifts that were preceded by four rest days.

These results give mixed support to the hypothesis (H4) that night shifts show greater deficits when they follow more rest days.
Temporal Duration

150

Figure 9.5. Trends for choice reaction time and percentage gaps on night shifts following 2, 3 or 4 rest days.

The effects of consecutive shifts

Analyses of the effects of consecutive shifts were confined to shift sequences of four consecutive shifts or fewer because there was an insufficient number of longer sequences, and the part-time permanent night nurses were excluded because they did not work enough sequences of three or four shifts. For the rotating shift nurses, there were not enough sequences of exclusively early or late shifts, so an early or late shift was included even when it was part of a sequence that included a different type of day shift.

Rotating shift nurses. For the rotating shift nurses, an ANCOVA was used for each daily measure with consecutive shift (1-4) and shift type (early, late, or night) as the variables. There was only one significant result involving consecutive shifts: a main effect of consecutive shift on sleep duration, $\eta^2 = .039$, $F(3, 300) = 4.01, p = .007$, which was due to longer sleeps before the first shift in a sequence.

The analyses were repeated for the on-shift measures but included time into shift (0, 2, 4, 6, and 8 hr) as an additional factor. There was a significant interaction between the number of consecutive shifts and type of shift for alertness, $\eta^2 = .029$, $F(6, 924) = 4.21, p < .005$. Alertness was lowest on the second night shift. There was
also a significant main effect of consecutive shifts for perceived workload, $\eta^2 = .015$, $F(3, 921) = 5.34, p < .005$. The effect sizes were very small, however. Figure 9.6 shows that perceived workload increased over consecutive shifts of any type.

![Figure 9.6. Perceived workload ratings of rotating shift nurses on consecutive shifts.](image)

These results give limited support to the hypothesis (H5) that deficits increase over consecutive day shifts.

**Permanent night nurses.** An ANCOVA of the full-time permanent night nurses' daily measures over four consecutive nights showed that sleep length, $\eta^2 = .362, F(3, 96) = 18.19, p < .007$, and sleep quality, $\eta^2 = .155, F(3, 96) = 5.85, p < .007$, decreased over consecutive night shifts. No other daily measures were significant.

Analyses of the on-shift measures were undertaken, including time into shift as an additional variable (0, 2, 4, 6, 8 and 10 hr). There was a main effect of consecutive shifts for choice reaction time, $\eta^2 = .036, F(3, 399) = 6.61, p < .005$. Figure 9.7 shows that both gaps (trend only) and reaction time decreased over consecutive night shifts.

These results, from both rotating and permanent night nurses, give mixed support to the hypothesis (H6) that deficits decrease over consecutive night shifts.
Hours worked per week

The hours that the nurses worked from week to week varied considerably to accommodate their shift rota. For example, 33 of the nurses worked at least one week in excess of 48-hr even though the average number of hours worked per week was 37. It was therefore possible to test whether longer work weeks were associated with adverse effects. The analysis was restricted to full-time nurses only, to avoid the problem that the length of the work week was confounded with type of employment: full-time or part-time.

Each daily measure was averaged for each complete week from each nurse, first by using data from all days and then by using data from work days only. The averaged measures were then regressed on the total number of hours worked for the week in a series of least squares regressions with dummy variables. Longer work weeks were associated with less social satisfaction, $\beta = -.32$, $R^2$ change $= .102$, $F(1, 109) = 32.42$, $p < .007$. These analyses were repeated with the on-shift measures but there were no significant effects. These results give minimal support to the hypothesis (H7) that longer working weeks are associated with greater deficits. However, this may simply reflect the parameters used in this investigation, such as the type of work,
the shift system, and the number of hours worked. Many of the measures also showed a pattern of deficits with longer working weeks, even though they did not reach significance.

Discussion

The results give some support to the view that work has adaptive costs for the worker and that the worker needs time to recover from these costs. The costs to the worker in this investigation were most evident on the first rest day following work shifts. The results also support the view that adjustment to a nocturnal routine is associated with additional costs that are evident on rest days following a night shift. An increase in the amount of time allowed for recovery was also shown to increase social satisfaction on subsequent work days, but some measures showed a tendency to be worse on night shifts that followed increased time off. This may reflect an increase in the cost of adjusting to a nocturnal routine following a longer period of adjustment to a diurnal routine. Although some measures changed for the worse across consecutive shifts, the results for night shifts also suggest an increase in adjustment across shifts. Longer work weeks were significantly associated only with reduced social satisfaction.

Some of the measures, such as self-reported mood symptoms and work satisfaction, and the memory search task, produced no significant results. It can, therefore, be assumed that no recovery is necessary for these measures, that recovery does not occur even after 3-4 rest days, that the measures are insensitive, or that the effects produced are too small to reach significance with the number of observations. A number of the analyses showed a consistent pattern of results across individual measures, even though the individual measures failed to reach significance. Therefore, applying Bonferroni corrections to the alpha levels to protect against inflated Type 1 errors from multiple tests might have erred on the conservative side. For example, an effect size of .23 for social satisfaction across four rest days following night shifts failed to reach significance at \( p < .007 \) but would have been significant at \( p < .05 \). However, many of the other nonsignificant effects were trivial in size.
The results showed that a number of measures of sleep, mood, and social satisfaction tended to be worse on the first rest day following work shifts as compared with subsequent rest days. This suggests that for these measures recovery from a shift did not occur by the end of the first rest day but might have occurred by the end of the second rest day. However, the individual effects were sometimes small and often failed to reach significance. Interestingly, some measures such as alertness and sleep duration were actually worse on the first rest day following night shifts than they were on the night shifts. This could mean that the nurses were expending effort to maintain their performance on the night shift, and that the costs of this effort were paid on the first rest day. Alternatively the shortened sleep duration may suggest either that the nurses were making themselves more tired so that they could sleep that night or that they were simply trying to make the most of their restricted rest day. A further possibility, however, is that the difference between these measures following night shifts and rest days partly reflects a circadian influence because the scales were completed at different times of day.

Some of the measures of well-being were worse on rest days that followed night shifts as compared with rest days that followed day shifts, especially on the first rest day. This indicates that night shifts cause additional costs for workers because they have to adjust to a nocturnal routine on night shifts and then readjust to a diurnal routine on days off. The number of rest days following night shifts accounted for more than 25% of the variance in alertness. It was somewhat surprising, however, that the number of previous night shifts was not a significant factor for any of the measures. It should also be noted that the elapsed times between the end of a shift and the data collection points on the subsequent rest day are shorter for a night shift than they are for a day shift because the night shift ends chronologically later. The results, therefore, could reflect a shortened time for recovery after night shifts. However, similar differences between early and late shifts could have been expected, because the early shift ends chronologically earlier, but no such differences were found.
The results suggest that the disparities between rest days that follow day shifts and those that follow night shifts are reduced by not counting the day on which the night shift ends as a rest day. This would be a simple rule to adopt within working time regulations. The International Labour Office make a similar recommendation for an extra long break when shift workers change from a night shift to a day shift (International Labour Office, 1988). The need for this extra long break may be even greater in jobs where workload is as great at night as it is during the day.

Social satisfaction was significantly better at the end of day shifts when the shifts were preceded by two rest days rather than one rest day. On night shifts, however, a number of measures showed a trend in which they were worse following more days off. For example, reaction time was slower and the percentage of gaps - which may reflect attention lapses - was higher during night shifts that followed four rather than two or three rest days. A possible explanation is that adjustment to a diurnal routine was more developed after four rest days, which increased the adjustment required for subsequent night shifts. However, most of the analyses for both day shifts and night shifts were not significant, hence a general effect cannot be claimed.

The results for rest days and subsequent shifts imply that where possible two consecutive rest days should be scheduled to enhance the benefit of the rest period. The only way to do this without shortening the work week would be to schedule slightly longer sequences of consecutive shifts. This seems a viable option given that the average number of consecutive shifts was 3.29 and that the analyses found few changes across four consecutive shifts.

Ratings of alertness increased, and reaction time decreased over four night shifts. This may suggest increasing adjustment to night shifts. However, workload ratings increased, and sleep measures such as duration and quality decreased over consecutive night shifts. This may imply that some adjustment takes place but at some cost in terms of effort. This interpretation is supported by the results of a study that compared a group of nurses working 1-4 nights with few days off with another group.
working 5-8 nights with many days off (Dirkx, 1993). Dirkx found no significant differences in subjective health or satisfaction but found that the many-nights group put more effort into coping with their schedule.

Although the analyses controlled for day of study, it is still possible that some of the results from the performance tasks reflect practice effects. The performance tasks were only completed on work days and therefore participants were less practiced following more rest days, and were more practiced at the end of longer sequences of consecutive shifts. However, this would be true for both day shifts and night shifts and, therefore, effects for consecutive day shifts as well as for consecutive night shifts would be expected.

The proposed European Community Directive on Working Time (Commission of the European Communities, 1991) would restrict a night worker to work a maximum of 48-hr per week. In the sample, a total of 47 weeks (21%) exceeded 48-hr. These 47 weeks originated from 33 (54%) of the nurses. The analyses showed that the length of the work week accounted for 10% of the nurses' social dissatisfaction. However, the length of work week was not significantly associated with any other measures.

The start of this chapter described some research that has demonstrated that the relationship between work and non-work is complex. For example, not all times of the week are equally valuable for leisure. It has also been shown that individual control over hours of work can influence tolerance of a work schedule (Burton, Smith, Totterdell, Spelten, & Folkard, 1993). Other studies have shown that shortening the work week may lead to an increase in personal maintenance activities, such as domestic chores, rather than to an increase in personal leisure (see Kabanoff, 1980). The results of this investigation additionally show that some days off are likely to be of lower quality because of the need for recovery. The amount of time needed for recovery from work seems to depend on the adaptive costs of the work. Night work, for example, seems to require additional time for recovery, and yet too much recovery time may have adverse consequences for readaptation to a nocturnal routine.
The growth of diverse work schedules (Kogi, 1991) and the emergence of computer-based design and assessment of work schedules (e.g., Nachreiner, Qin, Grzech-Sukalo, & Hedden, 1993; Schönfelder & Kauth, 1993) means that there is an increased need for empirical evidence to set parameters and limits for working time. This investigation has provided some such evidence with respect to the relationship between work shifts and rest days in nursing. The demands of other jobs, however, may provide a different picture of this relationship. Therefore more research with other occupational groups is required. The situation is further complicated by the fact that, in the future, changes in working time may focus on an intensification of the use of work time rather than, or alongside, changes in the duration of working time (Starkey, 1988). Intensification may lead to greater costs and hence the need for additional recovery. Starkey describes how a railworkers' dispute over the introduction of flexible rostering focused on the potential psychosocial effects of the more intense and less regular working pattern despite a reduction in total working hours.

Seymour and Buscherhof (1991) found that work schedules were the single greatest source of dissatisfaction in nursing, and quoted one nurse as saying that, "It is now more difficult to receive time off - especially consecutive time off. I'm tired". In this investigation, the deficits found on the first rest day after work shifts were small but they reinforce this need for consecutive time off. The initial proposition that time is a healer appears to be supported by the results. For night work, however, there may be hidden costs when the recovery is diurnally oriented.

This chapter and the previous two chapters have demonstrated that the timing, order, and duration of work shifts and rest periods can affect well-being. However, the results also suggest that the effects of these temporal characteristics cannot be studied in isolation. For example, the results of this investigation showed that the amount of time needed for recovery depended on the timing of previous work shifts (day or night) and that the effects of the amount of rest time depended on the timing of subsequent work shifts (day or night). The next investigation adds to this complexity by examining...
whether the effects of the timing of work on well-being also depends on the temporal state of the internal body rhythm of the menstrual cycle.
10

Temporal Interaction

Combined effects of unusual work hours and the menstrual cycle on aspects of well-being

In this world there are two times. There is mechanical time and there is body time. The first is as rigid and metallic as a massive pendulum of iron that swings back and forth, back and forth, back and forth. The second squirms and wriggles like a bluefish in a bay .... Where the two times meet, desperation. Where the two times go their separate ways contentment. For, miraculously, a barrister, a nurse, a baker can make a world in either time, but not in both times. Each time is true, but the truths are not the same.

- Alan Lightman

Einstein's Dreams (1994)

Does the change in daily rhythm enforced by nightwork affect changes in well-being associated with the menstrual cycle? Research on the menstrual cycle has shown that distress during the cycle may be related to the presence of external stressors, and also that reactivity to stressors may vary throughout the cycle (Ussher, 1992). This thesis has already described and shown that nightwork can act as an environmental temporal stressor with a range of deleterious effects on well-being. It is therefore plausible that nightwork may affect well-being during the menstrual cycle.

Menstrual cycle effects

Patkai (1985), in her review of menstrual cycle effects, concluded that the premenstrual and menstrual phases of the cycle are associated with some negative
moods and somatic complaints in a majority of women but that results are conflicting regarding the pattern, incidence and severity of symptoms. Retrospective questionnaires have generally produced more effects than prospective measures, possibly because retrospective accounts are more likely to reflect stereotypic beliefs about menstruation.

Studies based on objective measures of cognitive performance have generally failed to find decrements during particular phases of the cycle (Corbera & Grau, 1990; Sommer, 1973) and where differences have been found they have generally been found on single tests and not on batteries of tests (Ussher, 1992). However, Corbera and Grau (1990) suggest that diurnal and menstrual rhythms may have a common adrenergic effect on reaction time. They found that reaction times were faster in the evening when adrenaline peaks, and slower in the premenstrual phase when progesterone, which is thought to be anti-adrenergic, peaks.

According to Maueri's review (1990), retrospective self-report studies have suggested that women are commonly affected by sleep-related disturbances, such as lethargy, during premenstrual and menstrual phases. However, she makes the point that it is unclear whether these changes are mediated by sleep or are directly linked to hormonal changes, and shows that psychophysiological studies of sleep patterns during the menstrual cycle have failed to produce consistent results. A recent study by Lee, Shaver, Giblin, and Woods (1990) found a shorter REM latency during the post-ovulatory phase, and suggested that this may be a function of progesterone's thermogenic effect because of the known relationship between circadian temperature rhythm amplitude and REM latency.

Other studies have suggested a connection between the circadian timing system and the menstrual cycle. For example, a study of 810 probationer nurses found a daily rhythm in their onset of menstruation: onset was most likely in the early morning and menstruations beginning in the early morning were shorter (Málek, Gleich, & Malý, 1962). Appropriately timed bright light has been found to phase shift circadian rhythms, and has therefore been proposed as an intervention for shiftworkers.
(Eastman, 1990) and has also been used in treating menstrual dysfunction. In one study, a group of women with premenstrual syndrome were found to have a phase advance of their melatonin rhythm that responded to evening bright light (Parry et al., 1989). Weber and Adler (1979) found that in rats the persistent estrus induced by constant bright light could be delayed by the use of 24-hr cues, which led them to suggest that the oscillator regulating the menstrual cycle is maintained by time cues.

**Shiftwork and the menstrual cycle**

There have only been a few previous studies of the relationship between shiftwork and the menstrual cycle. In a survey of 2264 women, of which 1516 worked at night, Uehata and Sasakawa (1982) found higher rates of menstrual irregularity and painful menstruation in the nightworkers. Likewise, Nurminen (1989) found that more shiftworking women reported menstrual irregularities than non-shiftworking women. Cole et al. (1990) cited a report by Tasto et al. (1978) based on a study of 1199 nurses which found that rotating shift nurses suffered more symptoms at menstruation, longer menstrual periods and more clinic visits for menstrual problems compared to nurses on other shifts. Using retrospective ratings of discomfort for various shift type and menstrual cycle phase combinations from shiftworking women, Pokorski, Iskra-Golec, Czekaj, and Noworol (1990) found that the least favourable ratings were for the night shift during the premenstrual and menstrual phases of the cycle. However, 16% of the women reported no differences in their perception of discomfort for the different combinations. There is also evidence that the regularity of the work schedule may be an important factor. In a questionnaire study of slaughterhouse and cannery shiftworkers, none of whom worked nights, Messing, Saurel-Cubizolles, Bourgine, and Kaminski (1992) found that amenorrhea and long menstrual cycles were associated with schedule irregularity, whereas women on regular alternating morning and afternoon shifts did not show these associations.

There may be wider implications if shiftwork does affect the menstrual cycle. For example, the study by Uehata and Sasakawa (1982) that demonstrated that
nightworkers had a higher incidence of painful menstruation and irregular cycles than
dayworkers, also found that those nightworkers complaining of painful menstruation or
irregular cycles had lower rates of normal pregnancy than the other nightworkers. This
link is important because a number, but not all, of the studies that have investigated the
effects of work schedule on reproductive function have found shiftwork to be
associated with a higher risk of adverse pregnancy outcome including preterm birth,
low birth weight, and miscarriage (Scott & LaDou 1990; Infante-Rivard, David,
Gauthier, & Rivard, 1993). However, much more research is needed before it can be
concluded that there are causal links between nightwork, menstrual cycle irregularity,
and pregnancy outcome.

**Methodological problems**

Research on the menstrual cycle has been bedevilled by a range of conceptual
and methodological problems. Parlee (1988), for example, proposes that the lack of
consensus among studies is due to lack of analysis concerning the ways in which
women are embedded in social and biological contexts, and recommends that in future
the focus should be on the conditions associated with women's experience of the cycle.
Similarly, Ussher (1992) recommends a multifactorial approach with a focus on
identifying sources of stress that may alter women's experience of the menstrual cycle.
The present investigation focuses on one such source of external stress, namely
nightwork, and concentrates on possible interaction effects between that stressor and
menstrual cycle phase.

Previous studies of shiftwork and the menstrual cycle have relied on
retrospective reports and their results might therefore have been influenced by
stereotypic beliefs about the menstrual cycle. The present investigation uses
prospective ratings, including ratings made every 2-hr during work shifts as well as the
more commonly used daily ratings. Daily ratings, however, may still be influenced by
expectancies concerning the menstrual cycle. For example, symptoms may be
attributed to the cycle during the premenstrual phase but to environmental factors at
other times (Ussher, 1992). Some studies, but not all, have found that awareness of being in a menstrual cycle study increases symptom reporting during the premenstrual and menstrual phases (Gallant, Hamilton, Popiel, Morokoff, & Chakraborty, 1991). In the current investigation, the nurses were told accurately that the focus of the study was to investigate nursing shift patterns. The only explicit attention given to the menstrual cycle during the study was that the nurses were asked to provide an onset date for menstruation.

Other methodological problems found in the research on menstrual cycle effects include inconsistent definitions of menstrual cycle phase, selection bias towards regular cycles, and bias towards reporting only positive results (Sommer, 1973). The present investigation attempts to avoid these problems by picking commonly used definitions for the phases, by not selecting for cycle regularity, and by using and reporting the results from a battery of subjective and objective measures.

Method

The investigation was based on data from the 61 nurses that took part in the intensive time-sampling study of shiftwork in nursing. See chapter 6 for a complete description of the sample, procedure, measures and analyses. The investigation was confined to the 32 female nurses that worked on rotating shift systems.

The nurses were asked to provide the onset date of their menstrual period by selecting an option called period on the pocket computer’s menu when their period started. However, they were asked not to use this option if they were using an oral contraceptive because previous studies have shown differences in menstrual cycle symptomatology between women using and not using an oral contraceptive (Herrera, Gomez-Amor, Martinez-Silva, & Ato, 1990). Only 24 of the nurses gave an onset date for their menstrual period and could therefore be used in the analyses. It is assumed that the other nurses either did not experience a period during the study, or simply forgot or preferred not to indicate the start date of their period, or were using an oral contraceptive.
The sample was compared with nurses from the larger survey that also completed a separate questionnaire concerning their menstrual cycle. Nurses that were using a contraceptive pill, or were pregnant, or were menopausal were excluded from the comparisons. There were no significant differences between the groups on average duration of menstrual cycle, difference in average length of consecutive cycles, average duration of premenstrual problems, average duration of menstrual period, average duration of menstrual problems, or severity of menstrual problems. However, the present sample did report a greater severity of premenstrual problems ($t(388) = 2.43, p < .05$) on a 5-point Likert scale, but this difference disappeared on controlling for age using analysis of covariance.

The subset of variables used in this investigation were: daily sleep duration and sleep quality; daily symptom ratings (taken from the physical discomfort and dysphoric mood factors of premenstrual change identified by Endicott et al., 1986); on-shift mood and workload ratings; on-shift serial reaction time and proportion of errors and gaps (the proportion scores were transformed to the arcsine of their square root to approximate the normal distribution); and on-shift memory search response time and $d'$. Each dependent variable was analysed using a pooled time-series analysis. Analysis of covariance (ANCOVA) with dummy variables was used. Menstrual cycle phase, shift type and time into shift (for on-shift measures only) formed the variables in the analyses. The shift type variable for the daily measures included rest days. The covariate list included dummy variables for each subject and for each day of the week and a variable for the number of days into the study, to control for between subject differences, day-of-week effects, and linear practice effects respectively. See Gallant et al. (1991) for a comparison of day of week and menstrual cycle effects.

Three phases of the menstrual cycle were defined: the four days before onset of menstruation formed the premenstrual phase, the day of onset and the three days after formed the menstrual phase, and the following four days formed the postmenstrual phase. The postmenstrual phase was defined in this way because, firstly, other studies
have shown this to be the most stable period in the cycle because it avoids dysphoric changes that sometimes occur around ovulation (Endicott et al., 1986) and, secondly, it enabled approximately equal numbers of observations in the three phases.

Results

Start- and end-of-day measures

For each of the start- and end-of-day measures from the rotating shift nurses, an ANCOVA (see above) was undertaken using menstrual cycle phase and shift type as the two variables. The shift variable included early, late, night shifts and rest days. The results are shown in Table 10.1.

Table 10.1

<table>
<thead>
<tr>
<th>Variable</th>
<th>Cycle (C): Pre, Men, Post</th>
<th>C x Shift: E, L, N, R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sleep length</td>
<td>2, 218</td>
<td>6, 218</td>
</tr>
<tr>
<td>Sleep quality</td>
<td>2, 218</td>
<td>6, 218</td>
</tr>
<tr>
<td>Back pain</td>
<td>2, 203</td>
<td>6, 203</td>
</tr>
<tr>
<td>Abdominal pain</td>
<td>2, 203</td>
<td>6, 203</td>
</tr>
<tr>
<td>Mood swings</td>
<td>2, 203</td>
<td>6, 203</td>
</tr>
<tr>
<td>Feeling irritable</td>
<td>2, 203</td>
<td>6, 203</td>
</tr>
</tbody>
</table>

Note. ** p < .01, * p < .05

There were three significant interactions between shift type and phase of menstrual cycle; these are illustrated in Figure 10.1. Sleep quality between late shifts was lower during the premenstrual phase but higher during the menstrual phase compared to the postmenstrual phase. Irritability was lower on night shifts except during the premenstrual phase. Abdominal pains were generally higher during the
menstrual phase compared to the other phases but were also higher on night shifts during the premenstrual phase. There was one main effect of menstrual cycle phase for back pain: Back pains were higher during the menstrual phase, as shown in Figure 10.2. Sleep duration and mood swings did not show significant effects.

**Figure 10.1.** Sleep quality, abdominal pain, and irritability on different shifts during different phases of the menstrual cycle.

**Figure 10.2.** Back pain during different phases of the menstrual cycle.
An artifact of shift and phase definition could potentially explain the result for abdominal pains: Menstruation might have commenced before the end of a night shift but the end-of-day rating for that shift would be considered to be part of the premenstrual phase because the night shift started at the end of the previous day. Abdominal pains deriving from menstruation might therefore have elevated the premenstrual score on night shifts to some extent. To rule out this potential artifact the analysis was repeated but without the night shift rating prior to onset of menstruation. The interaction remained significant ($F(6,198) = 2.26, p < .05$).

**On-shift measures**

For each of the on-shift measures from the rotating shift nurses, an ANCOVA was undertaken using menstrual cycle phase, shift type, and time into shift (2, 4, 6 and 8 hr) as variables. The results are shown in Table 10.2.

<table>
<thead>
<tr>
<th>Variable</th>
<th>df</th>
<th>F</th>
<th>df</th>
<th>F</th>
<th>df</th>
<th>F</th>
<th>df</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alertness</td>
<td>2,365</td>
<td>1.06</td>
<td>4,365</td>
<td>3.82**</td>
<td>6,365</td>
<td>3.73**</td>
<td>12,365</td>
<td>1.63</td>
</tr>
<tr>
<td>Cheerfulness</td>
<td>2,365</td>
<td>8.58**</td>
<td>4,365</td>
<td>2.13</td>
<td>6,365</td>
<td>1.47</td>
<td>12,365</td>
<td>0.56</td>
</tr>
<tr>
<td>Calmness</td>
<td>2,365</td>
<td>5.47**</td>
<td>4,365</td>
<td>1.26</td>
<td>6,365</td>
<td>1.86</td>
<td>12,365</td>
<td>1.58</td>
</tr>
<tr>
<td>Time pressure</td>
<td>2,367</td>
<td>4.35*</td>
<td>4,367</td>
<td>0.29</td>
<td>6,367</td>
<td>0.38</td>
<td>12,367</td>
<td>0.88</td>
</tr>
<tr>
<td>Memory RT</td>
<td>2,329</td>
<td>0.57</td>
<td>4,329</td>
<td>0.18</td>
<td>6,329</td>
<td>1.42</td>
<td>12,329</td>
<td>1.30</td>
</tr>
<tr>
<td>Memory $d'$</td>
<td>2,329</td>
<td>2.47</td>
<td>4,329</td>
<td>0.43</td>
<td>6,329</td>
<td>0.60</td>
<td>12,329</td>
<td>0.48</td>
</tr>
<tr>
<td>Choice RT#</td>
<td>2,244</td>
<td>4.05*</td>
<td>4,244</td>
<td>0.20</td>
<td>4,244</td>
<td>0.94</td>
<td>8,244</td>
<td>1.28</td>
</tr>
<tr>
<td>Choice errors$^#$</td>
<td>2,244</td>
<td>0.07</td>
<td>4,244</td>
<td>0.41</td>
<td>4,244</td>
<td>0.75</td>
<td>8,244</td>
<td>0.33</td>
</tr>
<tr>
<td>Choice gaps$^#$</td>
<td>2,244</td>
<td>1.06</td>
<td>4,244</td>
<td>1.39</td>
<td>4,244</td>
<td>0.54</td>
<td>8,244</td>
<td>1.51</td>
</tr>
</tbody>
</table>

*Note. ** $p < .01$, * $p < .05$

$^\#$ Time into shift restricted to 2, 4 and 6 hr
Alertness showed a significant interaction between cycle phase and type of shift, and between cycle phase and time into shift. Figure 10.3 shows that alertness was lowest on the night shift during the premenstrual phase and dropped more over the course of a shift during the premenstrual phase.

![Figure 10.3: Alertness on different shifts during different phases of the menstrual cycle.](image)

There were also a number of main effects for menstrual phase. Cheerfulness and calmness were lower during the premenstrual phase. Time pressure was highest during the premenstrual phase, but lowest during the menstrual phase. These are shown in Figure 10.4. Figure 10.5 shows that choice reaction time was slower during the premenstrual phase ($M=486$ msec) than during the menstrual ($M=478$ msec) and postmenstrual ($M=472$ msec) phases. The memory search task showed no significant effects.
Figure 10.4. On-shift cheerfulness, calmness, and time pressure during different phases of the menstrual cycle.

Figure 10.5. Serial choice reaction time on different shifts during different phases of the menstrual cycle.

Nights per year and menstrual cycle variables

Given that there appeared to be some evidence that working night shifts altered experiences during the menstrual cycle, it was decided to test the relationship further by looking at the association between responses to items on the menstrual cycle questionnaire used in the survey of shiftworking nurses and the number of nights the nurses worked per year ($M = 80$ nights, $SD = 58$). A series of partial correlations
controlling for age were carried out. The results are shown in Table 10.3. A greater number of nights worked per year was significantly associated with longer and more severe premenstrual problems, a longer menstrual period and longer menstrual problems, but the effects were small.

Table 10.3
Partial correlations between menstrual cycle variables and the number of nights worked per year, controlling for age (N=290)

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Average length of menstrual cycle (days)</td>
<td>-.09</td>
</tr>
<tr>
<td>Average difference between consecutive cycles (days)</td>
<td>.03</td>
</tr>
<tr>
<td>Duration of premenstrual problems (days)</td>
<td>.15**</td>
</tr>
<tr>
<td>Severity of premenstrual problems (1-5)</td>
<td>.14*</td>
</tr>
<tr>
<td>Duration of menstrual period (days)</td>
<td>.10*</td>
</tr>
<tr>
<td>Duration of menstrual problems (days)</td>
<td>.13*</td>
</tr>
<tr>
<td>Severity of menstrual problems (1-5)</td>
<td>-.01</td>
</tr>
</tbody>
</table>

Note. ** p < .01, * p < .05

Discussion

The results suggest that working a night shift may change some measures of well-being during the premenstrual and menstrual phases of the menstrual cycle for rotating shift nurses. However, some measures showed differences between phases of the menstrual cycle irrespective of the type of shift worked and other measures were unaffected by the phase of the menstrual cycle with or without the influence of night shifts.
Affect

The alertness ratings of the nurses in this investigation showed a much greater drop over the course of a night shift during the premenstrual phase than during any other shift and menstrual phase combination. It is, therefore, possible that the premenstrual phase exacerbates fatigue on night shifts. One explanation of this result is that the menstrual cycle trough is coinciding with the circadian trough. An alternative explanation, however, is that the menstrual cycle phase is modulating circadian phase. For example, the premenstrual phase may be advancing the circadian trough in alertness to an earlier time of night.

A drop in alertness is some source for concern but it is unknown whether this size of deficit is sufficient to have cognitive and behavioural consequences. The results do, however, provide some evidence of cognitive consequences in that, although not significant, serial choice reaction time was slowest on the night shift during the premenstrual phase compared to other shift and menstrual phase combinations. It is also possible that low alertness may have a greater impact on more routine tasks where the motivation to maintain performance is lower, or on more creative tasks requiring divergent rather than convergent thinking (Horne, 1989).

Irritability was highest on the night shift during the premenstrual phase compared to the night shift during other phases, but this only meant that it was elevated to the level of irritability on other shifts because irritability was generally lower on night shifts. Abdominal pains were generally highest during the menstrual phase, but they were also as high on night shifts during the premenstrual phase. A number of studies have shown that reported pain increases over the course of a day, but it normally reaches a peak in the early evening (Folkard, Glyn, & Lloyd, 1976). If anything, therefore, reported pain should have been highest on the late shift, which it clearly wasn't.

The fact that there were differences between day and night shifts during different phases of the cycle and that these were found using concurrent ratings, in some cases made every 2-hr, probably means that these results represent something
other than stereotypical expectancies. It would still be possible, however, to construct such an explanation. For example, the nurses may have the expectation that the night shift is the worst shift and that the premenstrual phase is the worst phase and adjust their ratings accordingly. Some of the main effects and nonsignificant effects are, however, difficult to interpret with this argument. The results from the retrospective questionnaire measures of a larger sample also showed that a greater number of nights worked per year was associated with a longer premenstrual and menstrual phase and with more severe premenstrual problems. It is unlikely that this association was facilitated because the nurses provided information on the number of nights some six months before completing the menstrual cycle questionnaire.

**Performance**

There were no significant interactions between menstrual cycle phase and nightwork on the two performance tasks. A possibility that was not investigated is that diurnal and menstrual changes show a similar shift in cerebral hemisphere dominance (Corbera & Grau, 1990). The only significant performance effect was that reaction time was faster in the menstrual and postmenstrual phases. Other studies of reaction time have generally failed to find an effect of cycle phase (Sommer, 1973). There were no effects of phase on response time or detection sensitivity $d'$ on the more demanding memory search task. This supports the results of Nakatani, Sato, Matsui, Matsunami, and Kumashiro (1993) who found no phase effects on similar measures for a VDT-based task. They make the point that higher information processing may be less affected by the menstrual cycle. It is also possible, however, that subjective factors such as expectancy might have influenced performance (Sommer, 1973).

**Phase of cycle**

The results lend support to the view that differences between phases of the menstrual cycle may depend on the presence of external stressors. The night shift is one such stressor, but other work related factors also appear to have an effect. For
example, sleep quality was lower after the late shift during the premenstrual phase but higher after the late shift during the menstrual phase. The main effect of cycle phase on perceived time pressure is also interesting from this perspective. Ratings of time pressure were lowest during the menstrual phase and highest during the premenstrual phase.

These last results also highlight the fact that there may be psychological benefits as well as deficits associated with particular phases of the cycle. To be more precise, the menstrual cycle is a rhythmic phenomenon and therefore all comparisons between phases are relative and can therefore be construed as either positive or negative. For example, when it is reported that a measure is worse during the premenstrual phase it would be equally true to say that it is better during the menstrual and postmenstrual phases. Over-emphasis of the negative aspect has probably partly lead to the premenstrual and menstrual phases of the cycle being seen as disabling rather than as parts of normal variation. One study that found menstrual cyclicity in mood and symptom ratings also demonstrated that the cyclicity was usually within the range of variation reported by a male comparison group (Gallant et al., 1991).

This investigation provides limited evidence that the temporal stress of nightwork may alter some aspects of nurses' experience of the menstrual cycle. However, it is very difficult to assess the consequences of these changes, and they may simply reflect changes in the desire to deploy coping strategies. Messing et al. (1992) believe that "Cycle anomalies may be a useful indicator of occupational effects on reproduction, analogous to the use of sperm parameters to warn of effects on male workers". There is insufficient evidence to support their view at present, but this investigation has provided limited but additional evidence that nightwork does have the potential to alter some aspects of well-being during the menstrual cycle.

From the perspective of the theoretical framework of this thesis, the investigation has shown that temporal events in the social world (e.g., the timing of work) can interact with temporal events in the body (e.g., the menstrual cycle) to
influence well-being. The results also showed that the menstrual cycle can influence some aspects of well-being independently of shiftwork.
11

Temporal Association (I)

A temporal model of the latent effects of work shifts, sleep and workload on aspects of well-being

She liked her pieces to have something from every time of day in them - she didn't trust things written in the morning only - so she reread and rewrote painstakingly. No part of a day, its mood, its light was allowed to dominate. She hung on to a piece for over a year sometimes, revising at all hours, until the entirety of a day had registered there.

- Lorrie Moore

You’re Ugly, Too (1990)

For want of a better shift the sleep was lost; for want of sleep the mood was lost; and for want of a mood the evening was lost. The original proverb has been altered here to imply that what people do and feel depends on a chain of temporal associations. This chapter examines this concept by developing and testing a "day in the life" model of the temporal associations between events, behaviour and affect that occur during a shiftworker's day.

Previous chapters have considered temporal issues of well-being by examining the relationships between pairs of variables, for example the relationships between time of working (shift type) and mood, and between duration of time off (number of rest days) and satisfaction. Sometimes this has also involved looking at the joint effects of variables, such as the interactive effect of phase of menstrual cycle and phase of shift cycle on mood. However, these simple relationships are likely to be embedded in a more complex multivariate network of temporal associations. A temporal association means that a variable has a latent effect on another variable. In such cases, the variable
Temporal Association (I)

predicts the later behavior of the other variable. Simple relationships between variables may also in practice be mediated or even moderated by other constructs. For example, a relationship between shift type and mood may depend on the length of time spent sleeping before a shift rather than on how time is spent during a shift. This chapter therefore investigates the relationships between a range of variables hypothesised to have temporal associations during the course of a shiftworker's day.

One method for developing and testing causal theories of relations among a set of variables is structural equation modelling (SEM). Martin (1987) outlines the stages involved in SEM: The first stage is to specify the causal theory in terms of hypothetical constructs and relations between them; next the constructs (termed latent variables) are operationalised in the form of observed variables, and causal links between the constructs are hypothesised in the form of structural equations; and finally the structural equations are tested against empirical data.

It was hypothesised that daily mood and social satisfaction in shiftworkers is influenced by the type of shift worked, by the length and quality of prior sleep, and by mood and workload during a shift. The review of shiftwork effects in chapter 2 described research evidence showing that work shifts can interfere with sleep and social life and can have acute effects on moods and symptoms. The results of chapter 7 also demonstrated that rotating work shifts were associated with detrimental effects on nurse’s sleep, mood, symptoms, and social satisfaction. However, the pattern of influence between variables was not tested. In other words, it is possible that some of the effects were mediated by the other variables.

With respect to mood, work shifts could affect mood by disturbing circadian rhythms, by reducing sleep or by producing different work demands. The model tested here does not include circadian rhythm disturbance because of the difficulty of measuring it in field studies due to masking effects. The hypotheses of interest, therefore, are that:

H1. Work shifts influence daily mood via their influence on sleep.

H2. Work shifts influence daily mood via their influence on workload.
With respect to social satisfaction, work shifts force shiftworkers to have their free time at times that are out of step with other people’s free time. This should therefore directly affect their social satisfaction. However, work shifts may also have a more indirect affect on social satisfaction because social satisfaction is likely to be impaired if people do not feel good as a consequence of reduced sleep resulting from work shifts. It is therefore hypothesised that:

H3. Work shifts directly influence social satisfaction.

H4. Work shifts influence social satisfaction via their effects on sleep and mood.

Method

The investigation was based on data from the 61 nurses that took part in the intensive time-sampling study of shiftwork in nursing. See chapter 6 for a complete description of the sample, procedure, measures and analyses.

The investigation was confined to the 32 nurses that worked on a rotating shift system so that the effects of different types of shift could be examined in the model. Data from rest days were discarded because of the absence of on-shift measures on those days. The 2-hourly on-shift measures were averaged for each shift to provide a single datapoint per day for each on-shift measure.

The subset of measures used in this investigation were: Type of shift scheduled, timing, duration and quality of sleep before the shift, mood and workload ratings recorded during the shift, and mood, social satisfaction and symptom ratings (covering the whole day) recorded at the end of the day.

The measures were treated to remove between-subject, day of week, day of study and previous day effects by entering dummy variables for each participant and for each day of the week, and variables for the day of study and the first order lag of the dependent variable into a multiple regression model for each measure. The resulting standardized residual scores were used in all subsequent analyses.
Principal components factor analysis with varimax rotation was performed on the residuals of the on-shift measures and on the residuals of the end-of-day measures. The on-shift measures produced two factors. Alertness, cheerfulness, calmness, and effectiveness loaded > .6 on a factor which was identified as mood and which explained 23% of the variance. Mental demand, physical demand, time pressure, frustration and effort loaded > .7 on a factor which was identified as workload and which explained 42% of the variance. No item loaded > .5 on the other factor. The Cronbach's alpha coefficient of reliability was .66 for mood, and .87 for workload.

The end-of-day measures produced four factors. Alertness, cheerfulness, calmness and effectiveness loaded > .6 on a factor which was identified as mood and which explained 28% of the variance. Satisfaction with home life, satisfaction with social life and worries about non-work (reverse scored) loaded > .5 on a factor which was identified as social satisfaction and which explained 14% of the variance. Irritability and mood swings loaded > .8 on a factor which was identified as mood symptoms and which explained 12% of the variance. Abdominal pains and back pains loaded > .7 on a factor which was identified as physical symptoms and which explained 10% of the variance. No item loaded > .3 on any of the other factors. The Cronbach's alpha coefficient of reliability was .76 for mood, .58 for social satisfaction, .7 for mood symptoms, and .38 for physical symptoms. Physical symptoms was dropped from the model because of its low reliability.

**Modelling**

Structural equation models incorporate endogenous and exogenous variables. The variability of endogenous variables is explained by other variables within the model, whereas the variability of exogenous variables is explained by variables outside of the model (Anderson, 1987). The exogenous variables in the shiftwork model were the dummy variables for the early and night shifts. Together, these two variables explain the variance due to the late shift so the late shift is left out of the model. The endogenous variables in the model were: time of sleep onset, sleep length, sleep...
The design of the model was based on the temporal collection of data, namely that on any given day the sleep data was recorded first, then the on-shift data, and then the end-of-day data. A structural relation was therefore hypothesised between a pair of variables if one variable occurred later in time. No relation was hypothesised if the variables were measured at the same time. An exception was made for the sleep measures because although they were collected at the same time they refer to different points in time. Therefore, sleep onset was allowed to affect sleep duration and sleep quality, and sleep duration was allowed to affect sleep quality. The type of shift preceded all the other variables in the model because it could potentially affect all of them but could not be affected by any of them. The causal relations in the model therefore followed the arrow of time.

A structural equation model must be identified before it can be estimated. This means that there must be enough information in the model to estimate all the parameters. In this case, the model was identified because it was based on a recursive model and all recursive models are just identified or over identified. A non recursive model is one in which there are reciprocal relationships between variables (for example, variable X influences variable Y and variable Y influences variable X), or in which a variable feeds back on itself, or in which disturbances of the endogenous variables are correlated. The causal relations in the hypothesised shiftwork model were all one-way and so the model was recursive.

The model was analysed using LISREL (Jöreskog & Sörbom, 1984). Traditionally constructs are operationalized by using factor scores derived from a factor analysis of multiple items thought to relate to the construct. Unfortunately these factors are not a perfect measure of the construct and therefore include error variance. Latent variable structural equation models, such as LISREL, address this problem by including a measurement model which specifies both how the latent variables are measured by the items and the reliability of the measurement. An alternative to using
multiple items is to use a single indicator of the construct (derived from factor analysis for example) corrected for random measurement error by setting the measurement error to the product of the error variance ($I-\alpha$) and the strength of the relationship between the observed and latent variable ($\sqrt{\alpha}$) (e.g., Frone, Russell, & Cooper, 1992). This latter approach was used here using the reliability scores given above. Perfect reliability of measurement had to be assumed for the sleep measures because they were based on only single items.

A number of statistics are available to evaluate the goodness of fit of a structural equation model to the empirical data. One of these is the chi-square statistic which is based on a comparison of the predicted and observed covariance matrices. A non significant result indicates a good fit. However, this statistic depends on sample size and hence it may be difficult to obtain a nonsignificant result with large sample sizes. For this reason a goodness of fit statistic (GFI; Tanaka & Huba, 1985) that doesn't depend on sample size was also used. This statistic varies between zero and unity, where unity represents a perfect fit.

Modification indices indicate which parts of the model could be changed to improve the goodness of fit of the model. Estimates are given of the parameter changes that would result from the modifications. However, the modifications must be theoretically justified before they are made.

The strength of the design of the shiftwork model is that it is based on a pooled within-subjects analysis of time-ordered data. The pooled within-subjects analysis refers to the fact that the data was collected on many days from each nurse and then treated to remove between-subjects effects. This means that the model will represent the day to day relations between variables for a typical nurse. It therefore has the potential to show, for example, that shifts with high workload were associated with greater mood disturbance. A between-subjects design based on a single day's data from each nurse could only show that nurses who had higher workload also had greater mood disturbance compared to other nurses. The use of time-ordered data means that, although causal links between variables cannot be proven, the case for
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inferring causality is much stronger than if the data had been collected simultaneously. The model has the potential to show, for example, that on-shift mood affected end-of-day mood symptoms rather than the reverse. An alternative interpretation would be possible had all the data been collected at the end of a day, namely that mood symptoms affected the retrospective rating of on-shift mood.

Results

The analysis was based on the matrix of correlations between variables shown in Table 11.1.

Table 11.1. Correlations between variables in the model

<table>
<thead>
<tr>
<th>Variables</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>End-of-day Mood</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social Satisfaction</td>
<td>.22</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mood Symptoms</td>
<td>-.41</td>
<td>-.24</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>On-shift Mood</td>
<td>.50</td>
<td>.13</td>
<td>-.24</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Workload</td>
<td>-.14</td>
<td>.01</td>
<td>.23</td>
<td>-.02</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sleep Quality</td>
<td>.13</td>
<td>-.04</td>
<td>-.18</td>
<td>.05</td>
<td>-.10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sleep Length</td>
<td>.14</td>
<td>-.16</td>
<td>-.12</td>
<td>-.21</td>
<td>-.05</td>
<td>.20</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time of Sleep Onset</td>
<td>-.08</td>
<td>-.16</td>
<td>0</td>
<td>.18</td>
<td>-.02</td>
<td>-.1</td>
<td>-.13</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Early Shift</td>
<td>.02</td>
<td>.24</td>
<td>.07</td>
<td>.12</td>
<td>.03</td>
<td>.02</td>
<td>-.43</td>
<td>-.31</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Night Shift</td>
<td>-.04</td>
<td>-.20</td>
<td>-.02</td>
<td>-.19</td>
<td>-.10</td>
<td>-.05</td>
<td>.13</td>
<td>.55</td>
<td>-.52</td>
<td></td>
</tr>
</tbody>
</table>

The resulting structural equation model, showing the significant path coefficients, is illustrated in Figure 11.1. The parameters are based on maximum
likelihood estimates. The measurement model is not shown because it confuses the presentation.

Figure 11.1. Structural equation model showing significant within-day temporal associations between type of shift, sleep, and well-being of rotating shift nurses.
The chi-square statistic of the fit of the model was $\chi^2 (4, N=305) = 37.83, (p < .001)$, the goodness of fit statistic was .97 and the adjusted goodness of fit was .62. The chi-square suggests a poor fit, whereas the goodness of fit suggests a very good fit. However, the goodness of fit measure is more reliable than chi-square in this case because of the large sample size.

The two largest modification indices suggested that the error variances for on-shift mood and workload should be adjusted. This cannot be justified on theoretical grounds and hence no changes were made. The other modification indices suggested the introduction of reciprocal causal links between the end-of-day variables. The strongest changed parameter estimates were from end-of-day mood to mood symptoms (-.64), from end-of-day mood to social satisfaction (.45), and from mood symptoms to social satisfaction (.47). However, these changes were not made because they would compromise the temporal ordering condition underlying the model.

Discussion

The structural equation model shows that there were strong temporal associations between selected psychological variables over the course of a nurse’s workday. In particular, type of shift affected sleep, sleep affected on-shift mood, and on-shift mood and workload affected end-of-day mood and social satisfaction.

The model shows that the main influence of shifts on mood and social satisfaction were mediated by their effects on sleep. The hypothesis that the effect of shifts on mood would be mediated by sleep (H1) was therefore supported. The results also supported the hypothesis that work shifts influence social satisfaction via their influence on sleep and mood (H4). However, the hypothesis that shifts would have a direct effect on social satisfaction (H3) was not supported. A direct influence had been expected because the timing of late and night shifts makes it very difficult for shiftworkers to have leisure time in the evening, which is the time most valued for leisure (Hornberger & Knauth, 1993). However, it seems that the indirect influence via sleep and on-shift mood is more important.
The hypothesis that shifts would influence mood via their effect on workload (H2) was not supported because, surprisingly, different work shifts were not significantly associated with different workloads. However, higher workload during a shift was associated with more negative end-of-day mood, and greater mood disturbance, but was not associated with social satisfaction. This suggests that higher workload affects shiftworkers' leisure time by affecting how they feel "in themselves" rather than by affecting how they feel about their social activities.

Early shifts were strongly associated with shorter sleeps, but had no direct associations with other variables in the model. Early shifts were not therefore associated with an earlier sleep onset which supports the view that shiftworkers get less sleep before an early shift because they don't (or cannot) go to sleep earlier (e.g., Barton & Folkard, 1993). There are not only social pressures on shiftworkers to stay up late but it is also difficult for them to sleep earlier because their body clock is in a "forbidden zone" for sleep.

Night shifts were strongly associated with a later sleep onset but not directly with a shorter sleep. However a later sleep onset was associated with a shorter sleep. This is consistent with other research showing a circadian relationship between the time of day at which sleep begins and the subsequent duration of sleep (e.g. Zulley, Wever, & Aschoff, 1981), and partly explains why shiftworkers find it difficult to sleep for as long after a night shift. The reason why there was no direct association between night shifts and shorter sleeps was probably due to a confounding effect between sleep onset and duration. Sleep duration is made up of two parts: onset and offset, and so with onset already in the model that only leaves variance due to offset for other variables to explain in the duration variable.

The night shift had no direct associations with other variables in the model. The original correlation matrix suggested a relationship between the night shift and more negative on-shift mood but the model shows that this relationship was mediated by sleep, in other words mood is worse on the night shift because sleep between night shifts starts later, is therefore shorter and therefore of poorer quality.
The model shows that a shorter sleep was associated with lower perceived sleep quality, which in turn was associated with more negative mood during a shift. This may have unfortunate consequences because more positive on-shift mood was associated with more positive end-of-day retrospective ratings of mood, less mood disturbance, and greater social satisfaction. There were no direct associations between sleep and the end-of-day measures. This suggests that these relationships were mediated by mood during the shift, which probably simply reflects the fact that satisfaction ratings have an affective component.

However, the interpretation of the model should be treated with caution because the model does not preclude alternative causal explanations. For example, an alternative to the sleep influenced mood explanation is that when the nurses woke up in good mood they were not only more likely to subsequently experience better on-shift mood but they were also more likely to rate their sleep quality more highly and even to upwardly bias their sleep length estimates.

One of the limitations on the measurement model was that only single items were available for the sleep measures. It was, therefore, assumed that these items perfectly measured their corresponding constructs. This was clearly an overestimate and will have biased the parameter estimates. The model could, therefore, be improved by using multiple estimates of sleep parameters. However, subjective sleep length has been found to correlate very highly (> .8) with polysomnographic estimates (see Tepas & Mahan, 1989).

Another problem for the model was that the end-of-day measures were retrospective ratings of the whole day and therefore include the time interval covered by the on-shift measures. This somewhat compromises the temporal ordering condition because some of the variance in the end-of-day measures could be explained by concurrent association with the on-shift measures rather than a temporally lagged association.

Despite these limitations, the evidence does suggest that the nurses' shifts affected their mood and social satisfaction by affecting their sleep. In more general
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terms, this demonstrates that the timing of events can sometimes affect subsequent well-being via the influence of temporally intervening variables.

So far this thesis has only investigated what happens to well-being when the timing of events in the external world, in particular work shifts, requires that people displace their activities in time by a considerable amount. This type of extreme change in the timing of activities is a rare event for most people. The next study will therefore investigate whether there are reliable relations between temporal characteristics and well-being in everyday life in the absence of a temporal intervention.
12

Study Two

Design of Study of Activity and Mood (SAM)

My temperament, moods, and illness clearly, and deeply affected the relationships I had with others and the fabric of my work. But my moods were themselves powerfully shaped by the same relationships and work.

- An unquiet mind.

Kay Redfield Jamison (1995)

This chapter describes the second of the two main studies reported in this thesis. The study was an intensive time-sampling study of the daily experiences of a group of healthy employed participants. The context and method of the study are described in this chapter. Subsequent chapters will describe the specific investigations that were based on the dataset from this study.

The study is similar in design to the nursing shiftwork study but the important difference is that it uses non-nightworkers from a range of occupations. This makes it possible to examine some of the temporal aspects of well-being that occur without the temporal quasi-intervention of shiftwork.

The study was part of a research project conducted by a team of four researchers. The general aim of the project was to increase understanding of the everyday experiences of working men and women. In the past, psychologists have tended to study people’s reactions to relatively unusual or exceptional experiences, such as bereavement or unemployment. Although these events are of great significance when they occur, they only represent a small proportion of daily life. It was therefore intended that the project should examine the more mundane but more frequent daily experiences of working adults. The general objectives of the project were to investigate patterns of daily change in affect, symptoms, social interaction experience,
and cognitive performance in working adults, and to explore how these patterns relate to activity (including sleep) and to individual difference characteristics.

The specific aims of the project reflected the varied interests of the different researchers and each of them has undertaken his or her own research on the dataset, which was collected collaboratively. Some of the work conducted by the other researchers has been reported elsewhere (e.g., Briner, Reynolds, Totterdell, & Parkinson, 1994; Parkinson, Briner, Reynolds, & Totterdell, 1995). The research investigations based on this project that will be reported in this thesis were conceived, analysed, interpreted, and written solely by the author (with useful feedback from his co-researchers). The software programs for data collection and the resulting dataset were also prepared solely by the author.

The rest of this chapter explains the design, procedure and measures used in the study. The general analytic procedure used is described and descriptive statistics concerning the sample and compliance to the protocol are provided.

Method

Sample

Thirty volunteers, 16 females and 14 males, were recruited to the study via adverts at their workplaces. The study was described accurately as a diary-based investigation into the everyday factors affecting mood and symptoms. Participants were paid £50 for taking part. Informed consent was obtained after the procedures had been fully explained. One potential (additional) participant decided at this stage not to take part because of the amount of time required by the study. The participants all had full-time day jobs, which were either clerical, managerial, or professional. A pre-screening questionnaire was used to ensure that the participants were in good health and were not taking medication that might affect their responses.
Procedure

The study covered 14 consecutive days, started on a Saturday, and took place during January and February. The participants were trained in groups of five or less. Each participant recorded their responses on a Psion pocket computer (see chapter 5 for a fuller description of the instrument) which they carried around with them for the duration of the study. The participants used the pocket computer to complete a set of tasks at the start and end of each day, every 2-hr while awake during the day, and at the start of each week. A pilot study, using the four members of the research team as participants, was conducted prior to the main study to assess the practical aspects of using the pocket computer and completing the tasks.

The pocket computer was programmed to give an auditory reminder to the participant, every 2-hr on the even hour during waking hours, to complete a series of tasks which took up to 5-min to complete. The auditory reminder facility was automatically turned on when participants completed tasks at the start of the day and automatically turned off when they completed the end of day tasks but there was a manual override so that participants could turn the facility off if they did not wish to be disturbed. The tasks did not allow participants to backtrack to correct responses. All data were automatically given a time-stamp to record the time of entry.

The participants also filled out a questionnaire before and at the end of the study, at which time they were also interviewed and debriefed about the study. The measures described below are those used in the subsequent investigations of this thesis. They represent most but not the complete set of measures used in the research project. For example, the participants also recorded their activities during each hour of the day in a paper based diary but this information was not needed for the investigations reported in this thesis.

Within-day 2-hrly measures

Mood. Self-ratings of current mood were measured using a series of visual analogue scales labelled 0 at the extreme left and ++ at the extreme right, where 0
represented no experience and ++ maximum intensity of experience. There were 20 possible cursor positions along the scale. The mood adjective was centred above the scale. A positive and negative item was selected from the three dimensions of mood identified in the UWIST Mood Adjective Checklist (Matthew, Jones, & Chamberlain, 1990): energetic arousal (alert, tired), hedonic tone (cheerful, depressed), tense arousal (calm, tense). All of these items loaded greater than .5 on the relevant dimension and less than .3 on any of the other dimensions. A further dimension for engagement was added (involved, disinterested).

Anger. A scale for anger was also included. Matthews et al. (1990) found that anger and hedonic tone items could be separated, suggesting that there should be a separate mood scale for anger. However, anger is probably closer to an emotion than a mood. As such anger is more likely to be short acting, hence participants were asked what was the most angry they felt in the last 2-hr.

Time awareness. This was a single unipolar visual analog scale labelled "How quickly is time passing now?". The scale used the same format as the mood scales described above.

Symptoms. Using the same scale format described above, participants were asked to rate how much they had experienced a number of physical and cognitive symptoms over the previous 2-hr. Because the data were non-independent, they required treatment prior to factor analysis: A daily average was calculated from each day's 2-hr responses for each of the 10 symptoms. The data from all the subjects were then pooled. Using multiple regression a residual series was derived for each symptom series, having first removed the following: variance due to differences in level of response between subjects by entering a dummy variable for each subject; serial dependency by entering the first order lag of the symptom; and linear practice effects by entering a variable for the number of days into the study. A principal components factor analysis with varimax rotation on the residual series converged on two factors with single items loading above 0.5 on only one factor: cognitive symptoms (difficulty concentrating, difficulty making decisions, difficulty with memory, absent-mindedness,
clumsiness), and physical symptoms (back pain, bodily aches, eyestrain, sick or nauseous, cold symptoms). Cronbach's reliability coefficient, alpha, was 0.8 for cognitive symptoms and 0.75 for physical symptoms.

**Task workload.** Three self-rating scales were adopted from the NASA Task Load Index (Hart & Staveland, 1988). The scales were unipolar - labelled 0 at one end and ++ at the other. The items were: mental demand, physical demand, and time pressure. The participants were asked to rate each of these with respect to their current tasks.

**Social interaction experience.** Social interaction experience was measured by asking participants how much time they had spent alone in the last 2-hr, using scales labelled 0 and 2-hr at the two ends, and then using the same scale format asking what would have been their ideal amount. The difference score between these items can be used to quantify one type of coping by avoidance. An extensive factor-analytic investigation by Amirkhan (1990) found that avoidance was one of three fundamental coping strategies, the others were problem solving and seeking social support. Items loading on the avoidance factor included "avoided being with people", and "wished that people would just leave you alone". Although these items are similar to the present ones, the format used here was preferred because the relevance of this experience may depend on the actual time spent with people. A supplementary measure - wanting more or less time alone - was constructed by taking the absolute difference between the actual and ideal score. This difference or mismatch score, therefore, represents a general or non-directional dissatisfaction with the amount of time spent alone.

**Cognitive performance.** The participants also completed 20 trials of both a 1- and a 5-target version of a memory search task based on that of Sternberg (see chapter 5 for details of the implementation of the task). On each trial the participant had to decide whether or not a letter was one of the letters that he or she had memorised at the start of the task. Participants were instructed to work quickly but accurately and at the end of the task they were given feedback on their speed and accuracy. The mean correct response time (RT-1 and RT-5) and a standard measure of signal detection
sensitivity ($d'_{1}$ and $d'_{5}$) were calculated for each of the 1- and 5-target memory loads.

**Alcohol.** Participants were also asked to record the number of units of alcohol consumed in each 2-hr period. This measure was summed for each day. Alcohol is the most widely used psychoactive drug and is known to have effects on both mood and sleep (Buysse, 1991), and hence this measure was included as a control variable.

**Start-of-day measures**

**Sleep diary.** After each main sleep the participants were asked to recall: time they went to bed, time they tried to sleep, time taken to fall asleep, number of awakenings, amount of lost sleep, time they awoke, and time they got up. They also completed a bipolar visual analog scale (with 20 cursor positions) rating their quality of sleep. A number of summary measures were derived from the sleep diary: sleep latency, number of awakenings, sleep quality, sleep onset, sleep offset, and sleep duration.

**Affect.** At the start of each day the participants used the mood adjectives and scale format described above to rate their current mood (concurrent), their mood over the previous day (previous-day), and the mood they expected to be in for the rest of the day (predict-day). They were also asked to rate the speed of time for yesterday, now, and the rest of the day.

**End-of-day measures**

**Affect.** At the end of each day, the participants used the mood adjectives described above to rate their mood for that day (actual-day). They were also asked to rate how quickly the day had passed.

**Daily hassles.** The participants also rated how much they had experienced specific hassles during the day, using the same scale format as that used for mood. Twelve items were used from the revised hassles and uplifts scale (DeLongis et al., 1988): workload, task difficulty, colleagues, supervisors, clients or customers, partner
or spouse, family, friends, financial situation, health, physical appearance, domestic
tasks. Prior to these ratings the participants were asked if they had been working that
day and if so to provide the start and end time of their work day. The participants’
response to this question was used to ensure that the first five hassle items, which
relate to work, were only presented on workdays. A single hassle score was obtained
for each day by averaging the presented ratings.

Start-of-week measures

At the start of each week, the participants rated the mood they expected to be
in over the next week (predict-week) and their mood for the previous week (actual-
week) using the mood adjectives described above.

Questionnaire scales

The participants completed the Beck Depression Inventory (BDI) (Beck, Rush,
Shaw, & Emery, 1979) and the Optimism and Pessimism scale (O&P) (Dember,
Martin, Hummer, Howe, & Melton, 1989) at the start of the study, and the 12 item
version of the General Health Questionnaire (GHQ) (Goldberg, 1972) which assesses
general mental health, and the Negative Mood Regulation scale (NMR) (Catanzaro &
Mearns, 1990) which assesses expectancy for alleviating negative mood, at the end of
the study.

Data analysis procedures

A pooled time-series method was used for many but not all of the analyses (see
subsequent chapters for exceptions and variations), using a least squares dummy
variable regression model. See West and Hepworth (1991) for details of the use of
pooled time-series analysis with daily experience data. For each dependent variable,
the following variables were usually entered into the regression equation prior to entry
of the independent variable(s):
1) A set of N-1 dummy variables to represent each participant. This eliminates differences in level between different subjects' series, and transforms the analysis into a within-subjects analysis.

2) A variable for the lag of the dependent variable. This eliminates serial dependency in the series by assuming a first order autoregression in the series.

3) A variable for the number of days into the study. This eliminates any linear effects arising from repeated response to a measure.

4) A set of 6 dummy variables for (N-1) days of the week. This eliminates variance attributable to particular days of the week; for example, differences between weekends and weekdays.

5) A variable for the number of units of alcohol consumed. This controls for the possible effects of alcohol.

6) If the dependent or independent variable was for the ideal amount of time spent alone, then the variable for the actual amount of time alone was also entered. This controls for the level of social interaction, so that in the model the variable for the ideal amount actually represents wanting more (or less if negative) time alone.

Study Descriptives

Sample characteristics

The average age of participants was 31.6 years, with a range from 20 yrs to 59 yrs. The BDI scores ranged from 0 to 26, mean 6.1 ($SD = 6.2$), and the GHQ scores, where a higher score reflects worse mental health, ranged from 5 to 22, mean 10.2 ($SD = 4.2$). The BDI mean was between the norms reported (Nietzel, Russell, Hemmings, & Gretter, 1987) for a nondistressed category and a general population category. However, two of the participants scored above 16 on the BDI, which is above the threshold for clinical depression. The GHQ mean was between the norms reported (Banks, Clegg, Jackson, Kemp, Stafford, & Wall, 1980) for an employed sample and an unemployed sample.
Compliance to tasks

The 2-hrly measures were sorted by time of response into time bins of 2-hr (1-hr either side of the even hour), with only one entry allowed per bin per day. In total the participants completed each of the 2-hr ratings 2752 times, and each of the performance tasks 2577 times. Assuming that they could potentially complete the ratings 8 times a day for 14 days, this represents an average compliance of 82% for the ratings and 77% for the performance tasks.

Participants completed the sleep diary on 99% (N=417) of occasions, the start-of-day ratings on 97% (N = 409) of occasions, the end-of-day ratings on 93% (N = 390) of occasions, and the weekly ratings on 93% (N = 84) of occasions. The minimum compliance for any task for any participant was 50%. These compliance rates were considered to be sufficiently good to make it unnecessary to use special procedures for adjusting for missing data.

Overview of Investigations

The next five chapters describe investigations based on this dataset. These investigations will begin with a renewed and more detailed investigation (chapter 13) of the temporal associations between sleep and well-being that were examined in the previous chapter. However, this time the issue will be examined in the absence of the temporal interference of shiftwork. The investigations will then move on to look at two issues that involve the intentional conscious awareness of time. The first of these issues is the perceived speed of time and its relations to well-being (chapter 14), and the second is people’s ability to forecast their own future mood states (chapter 15). The final two investigations return to the issue of acute changes in well-being over time, but this time examined from the point of view of rhythms and nonlinearity. Specifically, one investigation will examine whether diurnal and ultradian rhythms in mood depend on individuals’ level of depressed mood (chapter 16), and the other will explore state-dependent changes in well-being by applying a novel graphical nonlinear technique to time-series in affect and performance (chapter 17).
Is there any truth in the proverbs "One hour's sleep before midnight is worth two after", and "Early to bed, early to rise, makes a man healthy, wealthy and wise"? Common wisdom suggests the importance of a good night's sleep for well-being the next day, and yet there is very little direct scientific evidence which either supports this assumption or characterises how it might work. This investigation, therefore, examines the associations between naturally occurring changes in sleep behaviour and both prior and subsequent self-reports of aspects of well-being.

Chapter 11 demonstrated a temporal association between sleep and subsequent well-being when sleep was displaced in time to accommodate shift work. This investigation examines everyday temporal associations between sleep and well-being without the temporal disruption of shift work.

Much of our current understanding of the psychological effects of sleep in humans is derived from studies of either total sleep deprivation, sleep reduction, sleep disturbances arising from external demands, or sleep disturbance in psychiatric disorders. With the exception of the last, these have often concentrated on physical and performance effects rather than changes in well-being.

Horne (1992) summarises the findings of total sleep deprivation (TSD) studies as indicating that most of the effects of TSD are on the brain - particularly the cerebrum - and behaviour, but that as yet there is no conclusive evidence that sleep is
Temporal Association (II)

restorative for the brain. Sleep following TSD recovers most of the lost slow wave (SWS) sleep and some of the lost rapid eye movement (REM) sleep. This led Horne (1990) to propose that only the first 5-6 hr of sleep, which contain nearly all the total SWS and about half of total REM sleep, are essential for the brain; this he refers to as core sleep. The remainder is referred to as optional sleep and is considered dispensable. However, although optional sleep is not essential to cerebral functioning, loss of optional sleep does appear to affect motivation adversely, so that increased effort - and usually incentive - is therefore required to maintain performance. Also, despite the fact that the health consequences of sleep deprivation appear minor, many studies have demonstrated consistent decrements in a range of variables associated with well-being (Naitoh, Kelly, & Englund, 1990). For example, in a study of four men undergoing 205-hr of continuous sleep deprivation, Pasnau, Naitoh, Stier and Kollar (1968) reported that the men exhibited increased irritability, anger, temporal and cognitive disorganisation, and regressive behavior, and decreased social co-operation, interest and competence.

Studies of sleep reduction over one or a few nights have consistently demonstrated impaired performance and alertness (Carskadon & Roth, 1991; Dinges, 1992). The long-term effects of gradual sleep reduction are less clear but one study (Johnson & Macleod, 1973), in which two adults reduced their sleep by 30-min every 2-weeks, demonstrated mood problems when sleep was restricted to below 5-hr.

There is also indirect evidence that sleep reduction or extension may have serious long-term consequences for health. Two independent studies (Kripke, Simons, Garfinkel, & Hammond, 1979; Wingard & Berkman, 1983) have shown that mortality rate is significantly higher amongst adults who habitually sleep for less than seven or more than eight hours a night, even after controlling for such factors as age, gender, smoking, alcohol consumption, and physical health.

Previous chapters have described research that suggests that the reduced well-being of shiftworkers is partly a consequence of sleep disturbance. Insomniacs also
Temporal Association (II)

appear to experience reduced well-being as a consequence of sleep disturbance. Insomniacs either cannot initiate or maintain sleep and are liable to suffer secondary mood problems (Culebras, 1992). Attempts to treat insomnia frequently focus on either reducing pre-bedtime anxiety or on regulating bedtime and waketime behaviour (Dorsey, 1991).

Mood disturbance may also be a cause, as well as a consequence, of sleep disturbance. For example, in a study of the relationship between sleep and mood disturbing events, Cartwright (1983) found that women who were more traditional in their gender-role were more depressed and had shorter REM latency following a divorce.

Sleep disturbance has also been associated with a range of psychiatric complaints. In a study of the sleep and mood of 375 psychiatric out-patients, Crisp and Stonehill (1976) found that sleep onset, but not bedtime, was later and sleep duration was shorter in most diagnostic groups including neurotic depression, but that the sleep period was earlier in endogenous depression. One of their conclusions was that there was a striking relation between sleep changes in the first half of the night and disturbances of mood.

Endogenous depressives, in particular, often show a shortened latency to the first onset of REM (e.g., Gann et al., 1992) and their sleep is usually shallower and more fragmented (e.g., Campbell & Gillin, 1987). These differences in sleep characteristics are thought to be part of the pathophysiology of depression, and not just secondary symptoms, because a number of interventions involving sleep such as sleep deprivation (Wu & Bunney, 1990) and advancing sleep onset (Wehr, Wirz-Justice, Goodwin, Duncan & Gillin, 1979) have been found to alleviate depression, at least temporarily. Manic-depressive patients have also been shown to spontaneously advance their time of awakening as they emerge from their depressive phase (Wehr et al., 1979).
Various theories have been proposed to account for these abnormalities in sleep regulation in affective disorders. The phase advance hypothesis, for example, asserts that during depression certain circadian rhythms, such as REM sleep, peak earlier relative to the sleep-wake cycle (Wehr et al., 1979). Internal coincidence theory (Wehr & Wirz-Justice, 1981) added to the phase advance hypothesis by proposing that there is an early morning depression switch that is activated if it is brought within the sleep period. This accounted for the therapeutic benefits of sleep deprivation during the second half of the night. However, studies of seasonal depression have shown that the circadian rhythms of sufferers may be phase delayed - not advanced - during winter compared to normals. This is supported by the fact that morning bright light, which produces a phase advance of circadian rhythms relative to sleep, is an effective treatment for seasonal depression. This led Lewy (1990) to propose a phase typing hypothesis in which mood and sleep disorders are classified according to abnormalities in the phase angle between sleep and the endogenous circadian pacemaker. A more complex explanation has also been proposed that requires consideration of the separate phase angles of a circadian pacemaker consisting of a morning and evening oscillator (Kripke, Drennan, & Elliot, 1992).

However, other explanations of affective disorders have focused on different circadian parameters. For example, circadian rhythms may be less stable during depression rather than changed in phase (Healy & Waterhouse, 1990), or there may be a deficiency in the buildup of sleep pressure (process S) during wakefulness (Borbély, 1987).

Taken together these studies strongly suggest that there are associations between sleep and well-being, and that these associations may be mediated by the circadian system. In particular, sleep length, sleep timing, sleep quality, awakenings, and REM latency have all been associated in one or more studies with changes in mood, social behaviour, physical symptoms, cognitive symptoms and performance. However, these associations have only been found in abnormal and extreme conditions.
such as sleep restriction, altered work schedules, and clinical disorders. There have been surprisingly few studies of the relations between sleep and mood in healthy subjects under normal conditions.

Kramer, Roehrs, and Roth (1976) found significant relationships between physiological sleep parameters and changes in mood from night to morning. Significant correlations with sleep parameters were found for the friendly, aggressive, clear-thinking, and sleepy sub-scales of mood, but not for the unhappy and dizzy subscales. The nonrapid eye movement parameters were more predictive of mood change than the REM parameters or total sleep time. A study by Berry and Webb (1985) examined the relations between mood states and the previous and following night's sleep in a sample of aging women. Only sleep efficiency (percent bedtime asleep) and REM latency were found to be reliably related to mood, and this was taken to indicate that sleep and mood are insulated from each other except in pathological conditions. The design of both these studies may have limited the results: The participants had limited choice over their sleep onset because they were all put to bed between 11 and 12 pm (in order to obtain EEG records); important variations in mood during the day may have been missed because mood was measured twice a day at most; analyses were based on between rather than within subject differences; and no account was taken of the contribution of yesterday's mood to today's mood or yesterday's sleep to today's sleep before looking at the covariation between sleep and mood.

Given these facts, the present investigation was designed to answer three questions: First, can associations between sleep and subsequent well-being be demonstrated in normal spontaneous daily behaviour? If associations can be demonstrated then, second, which are the key factors in these associations? For example, is the timing of sleep more important than the amount of sleep in determining subsequent well-being, as suggested by the proverbs described above. Third, does well-being affect subsequent sleep instead of, or as well as, sleep affecting subsequent well-being?
These three questions were examined by assessing the relative strength of relationship of several parameters of daily sleep, such as timing and quality, with both prior and subsequent self-reports of well-being, such as mood and symptoms, provided by an employed sample every 2-hr during a two week period.

Method

The investigation was based on data from the 30 volunteers that took part in the study of activity and mood. See chapter 12 for a complete description of the sample, procedure, measures and analyses.

Only a subset of the measures described in chapter 12 were used. In particular, a number of summary measures were derived from the sleep diary: sleep latency, number of awakenings, sleep quality, sleep onset, sleep offset, and sleep duration. Some secondary measures of interest were also constructed: absolute deviation from 8-hr sleep, delay in sleep onset from one day to the next (delay \(=\) onset - previous night's onset), length of prior wakefulness (prior wake length \(=\) onset - previous night's offset), and the hypothesised recovery of process S during sleep \((S' = 14.3-(14.3-7.96)e^{-0.381*duration})\). Process S is a homeostatic process that has been hypothesised to underlie the exponential buildup of sleep pressure during wakefulness (see chapter introduction). \(S'\) describes the exponential reversal of S during sleep. The parameters for \(S'\) were taken from Åkerstedt and Folkards' (1990) sleepiness model.

The 2-hrly mood ratings were used. A single score for each mood dimension was obtained by subtracting the score for the negative item from the score for the positive item. For ease of identification, the four dimensions are labelled by their positive items: alert, cheerful, calm and involved.

The items in the 2-hrly cognitive and physical symptom factors and the social interaction measures were also used and the number of units of alcohol consumed was used as a control variable.
The 2-hrly self-rating measures were averaged for each day of the study to provide one data point per day per participant for each measure. A pooled-time series method was used for the analysis, using a least squares dummy variable regression model. The variables entered into the regression equation prior to entry of the independent variable(s) were those specified in chapter 12.

**Results**

Table 13.1 shows the mean, standard deviation, and range of each of the sleep variables. Using the method of pooled regression analysis outlined above to examine selected associations amongst the primary sleep variables, it was found that a shorter latency ($\beta = -.38$, $R^2$ change = .112, $F (1, 337) = 62.84$, $p < .001$), an earlier onset ($\beta = -.15$, $R^2$ change = .01, $F (1, 337) = 5.01$, $p < .05$), and fewer awakenings ($\beta = -.54$, $R^2$ change = .145, $F (1, 337) = 20.82$, $p < .001$) predicted a higher rating of quality of sleep; however, sleep duration did not predict quality of sleep ($\beta = .05$, $R^2$ change = .001, $F (1, 337) = 0.52$, ns). It was also found that an earlier onset predicted a longer duration of sleep ($\beta = -.67$, $R^2$ change = .203, $F (1, 336) = 208.84$, $p < .001$), which fits with previous findings on the relationship between sleep timing and sleep duration.

<table>
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<th>Variable</th>
<th>Mean</th>
<th>SD</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
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<td>Quality</td>
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<td>20</td>
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<td>4.92</td>
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</tr>
<tr>
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<td>1.43</td>
<td>11</td>
<td>20.25</td>
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<tr>
<td>$S'$</td>
<td>13.96</td>
<td>0.17</td>
<td>13.24</td>
<td>14.25</td>
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</table>

*Note. N = 414 (pooled observations)*
Sleep variables as predictors of well-being

Each of the sleep variables was regressed on each of the mood, symptom, and social interaction variables. The sleep variables were analysed in separate regression models because of the non-independence of the sleep variables (partly demonstrated above). The results of the regression analyses are presented in Table 13.2. All of the well-being variables, except calmness and amount of time spent alone, were significantly associated with at least one of the sleep variables. Time of sleep onset, frequency of awakenings, and sleep quality showed the greatest number of (4 or 5 out of a possible 9) significant associations with well-being. In particular, a later onset predicted lower cheerfulness and alertness, and wanting more time alone the following day. Shorter latency, earlier onset, fewer awakenings, and higher quality of sleep all predicted higher cheerfulness the following day. However, the largest partial regression coefficient was only .33.

The significant associations between sleep onset and cheerfulness, alertness, and wanting more time alone, were examined in greater detail to see whether the effects were present during all or only parts of the following day. An analysis of covariance was carried out on each of these three well-being variables using the four quartiles of sleep onset time (20:15-23:00; 23:01-23:40; 23:41-00:20; 00:21-04:30) as levels of one factor, the three periods of the following day (07:00-12:59; 13:00-18:59; 19:00-00:59) as levels of a second factor, and all the sets of control variables that were used in the regression analysis except the lag as covariates. Cheerfulness showed a main effect of sleep onset ($F(3, 2497) = 3.71, p < .05$); wanting more time alone showed main effects for sleep onset ($F(3, 2502) = 3.0, p < .05$) and time of day ($F(2, 2502) = 14.61, p < .001$); and alertness showed a significant interaction between sleep onset and time of day ($F(6, 2497) = 4.28, p < .001$). These results are illustrated in Figure 13.1.
Table 13.2
Results of pooled regression analyses with sleep variables as predictors of well-being

<table>
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<tr>
<th>Independent variable</th>
<th>Cheerful</th>
<th>Alert</th>
<th>Calm</th>
<th>Involved</th>
<th>Cognitive symptoms</th>
<th>Physical symptoms</th>
<th>Time alone</th>
<th>Want more time alone</th>
<th>Want more or less alone</th>
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<td>-.08</td>
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<td>-.09</td>
<td>.05</td>
<td>.03 .08</td>
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</table>

Note. N = 367. * p < .05. ** p < .01. *** p < .001.
Figure 13.1. Mood and social interactions at different times of day following different times of sleep onset.

To determine whether the associations between the primary sleep variables and the symptom and social interaction variables were mediated by mood, the relevant analyses were repeated but this time entering the four mood variables before the sleep variable. The significance of the regressions of sleep quality on cognitive symptoms, and sleep onset on wanting more time alone dropped to \( p < .1 \); otherwise, there was no change. This suggests that the associations were largely independent of mood.

It is conceivable that sleep might affect the variability as well as the level of well-being. To examine this, the analyses for the primary sleep variables were repeated but this time using the within-day standard deviation of the well-being variables instead of the mean. Variability in cognitive symptoms was predicted by sleep latency (\( \beta = .08, R^2 \) change = .004, \( F(1, 329) = 4.09, p < .05 \)), onset (\( \beta = .11, R^2 \) change = .006, \( F(1, 329) = 5.32, p < .05 \)), and quality (\( \beta = -.08, R^2 \) change = .005, \( F(1, 329) = 4.24, p < .05 \)); physical symptoms by sleep quality (\( \beta = -.11, R^2 \) change = .008, \( F(1, 329) = 7.89, p < .01 \)); and alertness by sleep onset (\( \beta = .13, R^2 \) change = .008, \( F(1, 329) = 5.34, p < .05 \)).
Well-being variables as predictors of sleep

The lag (previous day's value) of each of the well-being variables was regressed on each of the primary sleep variables. The results are shown in Table 13.3. There were no significant predictors of sleep duration, quality, or time of offset, but there was at least one significant predictor of sleep latency, onset, and frequency of awakenings. In particular, a higher level of physical symptoms predicted longer latency, later onset, and more awakenings. However, the largest partial regression coefficient was only .19.

Discussion

This investigation provides evidence that a number of measures of sleep are related to both prior and subsequent states of well-being - including mood, symptoms, and social interaction experience - in a healthy, employed sample. This extends the findings of previous studies of the relationship between sleep and mood (e.g., Berry & Webb, 1985; Kramer et al., 1976). For example, associations were found between sleep and both social interaction experience and alertness, that may correspond to the associations Kramer et al. (1976) found between sleep and mood sub-scales for friendly and sleepy. Unlike Kramer et al. (1976), an association was found between sleep and cheerfulness but this seemed to depend on the timing of sleep, which was restricted in their study. Although Berry and Webb (1985) found only two sleep variables related to mood, there are similarities with their results because in both studies more significant relationships were found between sleep and the following day's well-being than between sleep and the previous day's well-being, and many of the relationships tested were non significant and those that were significant were small in size.
### Table 13.3
Results of pooled regression analyses with well-being variables as predictors of sleep

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Latency</th>
<th>Onset</th>
<th>Offset</th>
<th>Duration</th>
<th>Awakenings</th>
<th>Quality</th>
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<td>Partial</td>
<td>.19***</td>
<td>.18***</td>
<td>-.03</td>
<td>-.06</td>
<td>.12*</td>
<td>-.04</td>
</tr>
<tr>
<td><strong>Time alone</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beta</td>
<td>0</td>
<td>.03</td>
<td>.06</td>
<td>.06</td>
<td>.13</td>
<td>-.08</td>
</tr>
<tr>
<td>Partial</td>
<td>0</td>
<td>.04</td>
<td>.09</td>
<td>.08</td>
<td>.14**</td>
<td>-.07</td>
</tr>
<tr>
<td><strong>Want more time alone</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beta</td>
<td>.03</td>
<td>.16</td>
<td>.04</td>
<td>.08</td>
<td>.02</td>
<td>.13</td>
</tr>
<tr>
<td>Partial</td>
<td>.02</td>
<td>.15**</td>
<td>.04</td>
<td>.07</td>
<td>.02</td>
<td>-.09</td>
</tr>
<tr>
<td><strong>Want more or less time alone</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beta</td>
<td>.12</td>
<td>.16</td>
<td>0</td>
<td>-.02</td>
<td>.06</td>
<td>.07</td>
</tr>
<tr>
<td>Partial</td>
<td>.09</td>
<td>.15**</td>
<td>0</td>
<td>-.03</td>
<td>.06</td>
<td>.05</td>
</tr>
<tr>
<td>Prior R²</td>
<td>.221</td>
<td>.547</td>
<td>.720</td>
<td>.672</td>
<td>.519</td>
<td>.291</td>
</tr>
</tbody>
</table>

*Note. N = 374. * p < .05. ** p < .01. *** p < .001.*
Summary of well-being variables

Calmness was the only mood variable that was not predicted by any of the sleep variables; calmness did, however, predict reduced sleep latency. A higher level of cognitive symptoms was only predicted by reduced quality of sleep, but variability in cognitive symptoms was predicted by sleep onset and latency, as well as reduced sleep quality. Surprisingly, variability in most of the other well-being variables was not predicted by the sleep variables. The amount of time spent alone was not predicted by any of the sleep variables, whereas the variables that represented wanting a different amount of time alone were predicted by at least one sleep variable. This suggests that the reaction to, and not the amount, of social interaction was being influenced by sleep. The amount of time spent alone did, however, predict the number of subsequent awakening episodes. The experience of physical symptoms was the best predictor of subsequent sleep disturbance as shown by increased latency, later onset, and more frequent awakenings. This is presumably because physical symptoms keep people awake or wake them up. Importantly, the results demonstrated that the reports of symptoms and social interaction were not just a function of mood.

Summary of primary sleep variables

Higher self-rated quality of sleep was the best predictor of better mood and fewer symptoms the next day, but it did not predict social interaction experience. Perhaps the most interesting finding was that the timing of sleep onset was a better predictor of mood and interaction experience than either sleep duration or sleep offset. Specifically, a later onset was associated with reduced cheerfulness and alertness and increased dissatisfaction with the amount of time spent alone the following day. Figure 13.1 shows that the effects of sleep onset on cheerfulness and on wanting more time alone were maintained throughout the day, whereas the effect on alertness was only present in the morning.
These results, namely that a modestly later sleep onset was associated with mild but adverse mood changes, are consistent with studies that have shown that delaying bedtime in healthy subjects produces REM and mood changes that mimic those of depression (David, Maclean, Knowles, & Coulter, 1991). One interpretation of these results is that a change in sleep onset alters the phase angle between sleep and the endogenous circadian pacemaker, and this is the source of changes in mood. A change in phase angle could also explain Berry and Webb's (1985) finding that reduced REM latency was associated with lower mood in a normal sample, because even though they did not vary sleep onset it is possible that circadian phase changed.

However, the change in phase angle in the present study would only occur when the time of onset changed because the endogenous circadian rhythms would quickly entrain to a specific time. Therefore, a phase angle interpretation would predict the delay in onset from one day to the next to be a better predictor than absolute time of onset; however, this prediction was not supported by the results. Possibly this was because large delays or advances in sleep were normally for social purposes that mitigated other effects on well-being.

Another possibility is that the effects on well-being were a consequence of third variables that also correlated with sleep timing. Specifically, people may go to bed later or earlier for reasons that are associated with changes in well-being. For example, going to bed earlier and getting up earlier are probably viewed as more virtuous in our culture - as implied by the proverbs - which may consequently uplift subsequent well-being. However, if this were true then sleep offset might have been expected to show similar results to sleep onset.

There have, however, been other explanations for the role of sleep in the affective disorders which may also be relevant to the results. For example, it has been suggested that circadian rhythms during depression are not phase advanced but instead are distorted or unstable (Tsujimoto, Yamada, Shimoda, Hanada, & Takahashi, 1990).
due to disruption of external social zeitgebers (Szuba, Yager, Guze, Allen, & Baxter, 1992), hence explaining the similarities in symptoms to those experienced during enforced disrupted routines like shiftwork. In the present investigation, it is possible that going to sleep later was more disruptive (or perceived to be so) of social routines, such as work, and this reflected on well-being. It would have also been expected, however, that a change in duration of sleep, a change in sleep offset, or a deviation in either direction from an expected 8-hr sleep would be similarly disruptive: this was not found to be so except for physical symptoms.

A deficiency in the build-up of Process S during wakefulness has also been implicated in the changes in sleep seen during depression (e.g., Borbély, 1987). The results of two experiments that reduced wakefulness in normals showed sleep changes consistent with this hypothesis (Campbell & Gillin, 1987). However, in one of the experiments the changes could have resulted from later sleep onset times. In the present investigation, the length of prior wakefulness (which should be tied to Process S) was not a better predictor of well-being than sleep onset except for cognitive symptoms. However, it should be noted that the pattern of results for the two variables was very similar; this may reflect the fact that they are highly confounded.

Process S is thought to be reversed during sleep. However, neither total sleep duration nor the hypothesised recovery function for S was a better predictor of well-being than sleep offset. These results would also seem to argue against the view that sleep is depressogenic (e.g., Wu & Bunney, 1980).

If a change in phase angle is the likeliest explanation of the relationship between sleep timing and subsequent well-being, then it is still unclear whether the frequently observed changes in REM sleep are merely a symptom of this phase angle or the source of changes in well-being.

Although an earlier sleep onset may have some benefits for well-being the next day, it is unclear what the cumulative effect of a number of "early nights" or "late nights" would be. This is a question that needs to be addressed in future studies,
probably using an experimental intervention that requires the participant to engage in a series of "early" or "late" nights. Future studies might also address the possibility that the relationships found here show systematic inter-subject differences (see Kramer et al., 1976), for example on gender or age.

The evidence from this investigation shows that there can be significant but small associations between changes in sleep and both prior and subsequent well-being on a day-to-day basis in a healthy sample. These associations are similar in kind, but much weaker, than those found in many affective disorders. This suggests that the associations between sleep disturbance and reduced well-being found in psychological disorders may be epiphenomena rather than pathological. The evidence from this investigation also suggests that there may be a grain of truth to the proverbs referred to at the start of this chapter, namely that: going to sleep earlier, but not necessarily rising earlier, may show some subsequent benefits in well-being but the benefits are likely to be small and temporary.

Postscript

Subsequent to this investigation, two independent laboratories used forced desynchrony protocols to show that subjective happiness not only varies with circadian phase but is also influenced by an interaction between circadian phase and time since waking (Boivin et al., in press; see also chapter 16). This demonstrates that shifts in the timing of sleep can influence cheerful as well as alert mood and hence reinforces the findings of this investigation.
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Relations between the passage of time and mood

She would sigh a little for the passage of time, the endless corridor of it, how its walls washed by you on either side - darkly, fast, and ever, ever.

- Lorrie Moore

The Jewish Hunter (1990)

Time flies when you're having fun. This well-known expression implies that states of well-being can affect subjective experience of the passage of time. Likewise, the experience of time could also affect well-being. For example, a person that is trying to meet a deadline could feel tense because time is slipping away. This chapter tests these assumptions by examining relations between people's perceptions of the speed of time and their mood.

Previous chapters have examined the effects of objective features of internal and external time on states of well-being. These features were objective in that they were related to clocks based on equal time intervals. For example, the timing of shifts and of sleep are based on an external clock that functions according to socially agreed rules, whilst circadian rhythms and the menstrual cycle are generated by one or more internal body clocks. However, it is common knowledge that equal intervals of time are not always subjectively experienced as equal. Some days, weeks and even years seem to rush by whilst others seem to drag on endlessly.

The perceived speed of time has been related to many different variables including circadian changes in body temperature (e.g., Pfaff, 1968), the sleep-wake cycle (e.g., Aschoff, 1984), information storage (e.g., Ornstein, 1969), contextual change (e.g., Block & Reed, 1978), and age (e.g., Schroots & Birren, 1988). Most of these studies have been based on the relation between subjective estimates of the
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duration of a period of time and actual duration. McGrath and Kelly (1986) view these time estimation studies as inquiries into subjective time because the estimates are not based on external time. In contrast, Edlund (1987) classifies time estimation studies under objective time because the estimates are based on some form of internal clock. Edlund (1987) proposes two categories of subjective time: perspective and awareness. Subjective time perspective refers to people's integration of their past, present and future, whilst subjective time awareness refers to the feel of the speed of time. Edlund defends the distinction between time awareness and time estimation by pointing out that there are a number of organic brain disorders in which time is experienced as passing very slowly or very quickly but in which time estimation remains intact. The present inquiry represents an investigation into subjective time awareness rather than time estimation.

Most studies of subjective time awareness have been concerned with the distortion of time sense that results from various clinical disorders. For example, depression has been associated with a slowing of time, and mania with a speeding up of time (see Edlund, 1987). Melges (1966) found that unpleasant affect in a group of 50 psychiatric patients was positively correlated with distortions in time sense, and that time was faster in those patients that were suffering from reality disorders.

Unfortunately there have been relatively few studies of time awareness in healthy individuals. However, there is evidence that anxiety is associated with time passing more quickly, and boredom with time passing more slowly (see Edlund, 1987; McGrath & Kelly, 1986; Moiseeva, 1988). For example, Watt (1991) found that boredom-prone individuals perceived time as passing more slowly during a tedious task than low boredom-prone individuals, but that the two groups did not differ in their objective estimates of the time that had passed.

Another factor to consider is the time frame: The period of time over which the speed of time is judged. Time estimation studies, for example, have shown differences between estimations of time in passing and estimations of time in retrospect. The usual pattern of results is that time intervals filled with stimulation seem short in passing but
long in retrospect. McGrath and Kelly (1986) explain this phenomenon by proposing that time seems short in passing because there is more happening per unit time than usual, but long in retrospect because that number of events would usually take longer.

Changes in time sense have generally been treated as an outcome of changes in affect. However, it is also conceivable that changes in time sense could cause changes in affect. For example, Rapoport (1990) argues that many clinical disorders, including depression, are the result of a disturbed sense of time, and that treatment should therefore focus on addressing this temporal disturbance rather than on alleviating affective symptoms. However, much of his approach depends on time perspective - looking at the balance between an individual's sense of past, present and future - rather than on time awareness.

The present investigation uses a group of healthy participants to examine the relations between people's experience of the speed of time and dimensions of their mood over a variety of time frames. In particular, it examines whether the speed of time predicts changes in mood or whether changes in mood predict the speed of time or both.

**Method**

The investigation was based on data from the 30 volunteers that took part in the study of activity and mood. See chapter 12 for a complete description of the sample, procedure, measures and analyses.

Only a subset of the measures were used. These included the unipolar visual analog self-report scales for, "How quickly is time passing now?", "How quickly did today pass?", and "How quickly did last week pass", which were administered 2-hrly, at the end of each day, and at the end of each week respectively to form a current measure, a retrospective daily measure and a retrospective weekly measure of time awareness.

To measure mood, the unipolar visual analog self-report scales for cheerfulness, alertness, calmness and involvement were used. These scales were
administered every 2-hr, at the end of each day, and at the end of each week to form a current measure, a retrospective daily measure and a retrospective weekly measure. The 2-hrly workload ratings for mental demand, physical demand, and time pressure, and the 2-hrly social interaction ratings for amount of conversation were also used.

The pooled time-series method described in chapter 12 was used for analysing the 2-hrly and daily data. The variables entered into the regression equation prior to entry of the independent variable(s) were the dummy variables for the participants, the variable for the number of days into the study, and the lag of the dependent variable (see chapter 12).

Results

The effects of the speed of time on subsequent mood

To test whether the felt speed of time affected subsequent mood, regression analyses were carried out on the 2-hrly data using the four mood dimensions as the dependent variables. Dummy variables for the participants, a variable for the day of the study, and the lag of the mood variable were entered into the equation as described above. The lag of the speed of time was then entered into the equation. This tested whether the felt speed of time two hours ago predicted the change in mood from two hours ago to now. The results for each mood dimension are shown in Table 14.1. The speed of time did not significantly predict subsequent cheerfulness, alertness, calmness or involvement.

Mood might have been affected by the day of the week and by the time of day. Dummy variables for days of the week and a variable for the time of day were therefore entered into the regression equations before re-entering the speed of time. These results are also shown in Table 14.1. Calmness was significantly better on a Saturday and Sunday and cheerfulness was significantly worse on a Thursday than other days of the week. Participants were significantly less alert and less involved but calmer later in the day. However, the relations between speed of time and mood remained non-significant.
Table 14.1
Regression model showing speed of time as predictor of 2-hrly ratings of mood (N=2194)

<table>
<thead>
<tr>
<th>Dependent:</th>
<th>Cheerful</th>
<th>Alert</th>
<th>Calm</th>
<th>Involved</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Prior R^2 R^2 Change β F</td>
<td>Prior R^2 R^2 Change β F</td>
<td>Prior R^2 R^2 Change β F</td>
<td>Prior R^2 R^2 Change β F</td>
</tr>
<tr>
<td>Step 1 Dummy var</td>
<td>0</td>
<td>.44</td>
<td>57.47**</td>
<td>0</td>
</tr>
<tr>
<td>for subjects &amp; Day of study</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Step 2 Lag of mood</td>
<td>.44</td>
<td>.03</td>
<td>.25</td>
<td>141.47**</td>
</tr>
<tr>
<td>Step 3 Lag of Speed of time</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Step 3 Day of week</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>#Thursday</td>
<td>.48</td>
<td>.001</td>
<td>-.04</td>
<td>5.30*</td>
</tr>
<tr>
<td>#Saturday</td>
<td>.39</td>
<td>0</td>
<td>.05</td>
<td>7.24**</td>
</tr>
<tr>
<td>#Sunday</td>
<td>.39</td>
<td>0</td>
<td>.04</td>
<td>4.75*</td>
</tr>
<tr>
<td>#Time of day</td>
<td>.43</td>
<td>.03</td>
<td>-.19</td>
<td>134.33**</td>
</tr>
<tr>
<td>Step 4 Lag of Speed of time</td>
<td>.48</td>
<td>0</td>
<td>-.03</td>
<td>1.11</td>
</tr>
</tbody>
</table>

Note. * p < .05, ** p < .01
#Only days of week showing significant results are shown
The effects of mood on the subsequent felt speed of time

To test whether mood affected the subsequent felt speed of time, a regression analysis was carried out on the 2-hrly data using the felt speed of time as the dependent variable. Dummy variables for the participants, a variable for the day of the study, and the lag of the speed of time were entered into the equation as described above. The lag of each of the mood variables was then entered into the equation. This tested whether mood two hours ago predicted the change in felt speed of time from two hours ago to now. The results are shown in Table 14.2.

Table 14.2
Regression model showing 2-hrly mood variables as predictors of experienced speed of time (N=2194)

<table>
<thead>
<tr>
<th>Dependent: Speed of Time</th>
<th>Prior ( R^2 )</th>
<th>( R^2 \text{-Change} )</th>
<th>( \beta )</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1 Dummy vars for subjects &amp; Day of study</td>
<td>0</td>
<td>.56</td>
<td></td>
<td>91.25**</td>
</tr>
<tr>
<td>Step 2 Lag of Speed of time</td>
<td>.56</td>
<td>.03</td>
<td>.25</td>
<td>147.83**</td>
</tr>
<tr>
<td>Step 3 Lag of cheer</td>
<td>.59</td>
<td>0</td>
<td>.07</td>
<td>10.56**</td>
</tr>
<tr>
<td>Lag of alert</td>
<td>.59</td>
<td>0</td>
<td>.03</td>
<td>2.53</td>
</tr>
<tr>
<td>Lag of calm</td>
<td>.59</td>
<td>0</td>
<td>-.02</td>
<td>0.72</td>
</tr>
<tr>
<td>Lag of involved</td>
<td>.59</td>
<td>0</td>
<td>.06</td>
<td>8.68**</td>
</tr>
</tbody>
</table>

OR

Step 3 Day of week & Time of day
#Saturday | .59 | 0 | .04 | 9.00** |
#Time of day | .59 | 0 | -.03 | 4.47* |

Step 4 Lag of cheer | .59 | 0 | .07 | 11.16** |
Lag of alert | .59 | 0 | .03 | 2.57 |
Lag of calm | .59 | 0 | -.02 | 1.18 |
Lag of involved | .59 | 0 | .05 | 7.51** |

Note. * \( p < .05 \), ** \( p < .01 \)
#Only days of week showing significant results are shown

Greater cheerfulness and involvement significantly predicted a faster subsequent speed of time; however, they explained less than 1% of the variance.
Alertness and calmness did not significantly predict the subsequent speed of time.
As before, dummy variables for the days of the week and a variable for the time of day were then entered into the regression equation before re-entering the mood variables. The results are also shown in Table 14.2. Time was felt to pass more quickly on a Saturday, and to pass more quickly earlier in a day. However, there were no changes to the significance of the relations between mood and the speed of time.

Time in passing and time in retrospect

To test whether the speed of time in passing predicted the retrospective speed of time, a regression analysis was carried out using the retrospective daily felt speed of time as the dependent variable. Dummy variables for the participants, a variable for the day of the study, and the lag (previous day's value) of the daily speed of time were entered into the equation as described above. The daily average of the 2-hrly speed of time was then entered into the equation. Table 14.3 shows that time that was faster in passing was also faster in retrospect.

Concurrent associations between retrospective daily mood, workload and social interaction and the felt speed of a day

To test the associations between retrospective daily mood and the felt speed of a day, each of the daily mood variables was then entered into the equation instead of time in passing. The results are shown in Table 14.3. Greater daily cheerfulness and alertness significantly predicted a day that felt faster. Daily calmness and involvement did not significantly predict the daily speed of time.

To test the associations between workload and social interaction and the felt speed of a day, the workload and interaction variables were averaged for each day and then entered into the regression equation instead of the mood variables. The results are shown in Table 14.3. Days that contained greater physical demand, time pressure and amount of conversation felt significantly faster. Mental demand did not significantly predict the felt speed of a day.
Table 14.3
Regression model showing daily mood variables as predictors of experienced speed of time (N=337)

<table>
<thead>
<tr>
<th>Step</th>
<th>Variable</th>
<th>β</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Dummy vars for subjects &amp; Day of study</td>
<td>.62</td>
<td>16.73**</td>
</tr>
<tr>
<td>2</td>
<td>Lag of Speed of time</td>
<td>.62</td>
<td>.01</td>
</tr>
<tr>
<td>3</td>
<td>Mean 2-hrly Speed of time</td>
<td>.63</td>
<td>.09</td>
</tr>
<tr>
<td>OR</td>
<td>Cheer</td>
<td>.63</td>
<td>.03</td>
</tr>
<tr>
<td></td>
<td>Alert</td>
<td>.63</td>
<td>.01</td>
</tr>
<tr>
<td></td>
<td>Calm</td>
<td>.63</td>
<td>.00</td>
</tr>
<tr>
<td></td>
<td>Involved</td>
<td>.63</td>
<td>.00</td>
</tr>
<tr>
<td>OR</td>
<td>Mental demand</td>
<td>.63</td>
<td>.00</td>
</tr>
<tr>
<td></td>
<td>Physical demand</td>
<td>.63</td>
<td>.01</td>
</tr>
<tr>
<td></td>
<td>Time pressure</td>
<td>.63</td>
<td>.01</td>
</tr>
<tr>
<td></td>
<td>Amount of conversation</td>
<td>.63</td>
<td>.01</td>
</tr>
</tbody>
</table>

Note. * p < .05, ** p < .01
Entering days of week produced no significant results or changes to other variables

Concurrent associations between weekly mood and perceived speed of a week

To test whether retrospective weekly mood predicted how fast a week felt in retrospect, a regression analysis was undertaken using the weekly speed of time variable as the dependent variable and the weekly mood variables as the independent variables. The results for the first week of the study are shown in Table 14.4. Participants that felt more alert during the week also felt that the week passed faster. Cheerfulness, calmness and involvement were not significant predictors.
Table 14.4
Regression model showing weekly mood variables as predictors of experienced speed of time (N=28)

<table>
<thead>
<tr>
<th>Dependent: Speed of Time</th>
<th>Prior $R^2$</th>
<th>$R^2$ Change</th>
<th>$\beta$</th>
<th>$F$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1 Cheer</td>
<td>0</td>
<td>.01</td>
<td>.13</td>
<td>.32</td>
</tr>
<tr>
<td>Alert</td>
<td>0</td>
<td>.19</td>
<td>.53</td>
<td>5.48*</td>
</tr>
<tr>
<td>Calm</td>
<td>0</td>
<td>.08</td>
<td>.27</td>
<td>2.01</td>
</tr>
<tr>
<td>Involved</td>
<td>0</td>
<td>.01</td>
<td>-.13</td>
<td>.30</td>
</tr>
</tbody>
</table>

Note: * $p < .05$, ** $p < .01$

Discussion

The results support the proposition that the speed at which time seems to pass is affected by mood. However, there was no evidence that the perceived speed of time is a determinant of mood because perceived speed of time failed to predict cheerfulness, calmness, alertness or involvement.

Time passed more quickly for participants when they felt happier. This result is in keeping with studies that have shown that time passes more slowly during depression (see Edlund, 1987). In the present investigation, cheerfulness explained less than 1% of the variance in the subsequent perceived speed of time. However, this was partly due to the fact that the control variables had already accounted for much of the variance. In fact, for this same reason, perceived speed of time itself predicted only 3% of the variance in the subsequent perceived speed of time.

Previous studies have suggested that greater anxiety is associated with time passing more quickly (Moiseeva, 1988). However, there was no evidence in the present investigation that time was faster or slower when participants were less calm.

The results showed that days passed faster when physical demand, time pressure, and amount of conversation were greater. These results parallel those of the time estimation studies that have shown that time is estimated to be shorter when external stimulation is greater. The present investigation also showed that time passed faster on Saturdays. This may be explained by the fact that the participants could
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engage in tasks of their own choosing on Saturdays because they weren't working. However, time was not faster at other leisure times, for example Sundays, and it was actually slower in the evenings. This probably reflects the type of activities that the participants chose to engage in at these times because the results also showed that time passed faster when people felt more involved. Engagement with a task may therefore be an important factor in determining the felt speed of time. Csikszentmihalyi (1975) proposed that people experience an optimal affective experience known as "flow" when they engage in tasks that are matched by their skills. Clarke and Haworth (1994) found that optimal experience in flow was characterized by high cognitive involvement. It would therefore be interesting to find out whether time also passes faster during conditions of flow.

Days and weeks passed more quickly when alertness was higher. If alertness is a measure of internal tempo then, according to McGrath and Kelly's (1986) model of time judgements, the external world should seem slower because there is less stimulation per unit time when the internal tempo is faster. At first sight, the present results therefore seem to contradict their model. However, the results were based on retrospective judgements. The daily ratings in particular were made at the end of a day and hence alertness and internal tempo would have been low at this time of day and therefore the day might have seemed fast in retrospect. However, there was no evidence that the day was faster in passing when alertness was higher, as would be expected by the model.

There was also no other evidence that time experienced as fast in passing was experienced as slow in retrospect. In fact, the results suggested that the speed of time in passing was positively associated with the speed of time in retrospect. However, the participants made retrospective ratings at the end of days in which they had also made current ratings. To appear consistent, the participants might therefore have remembered their current ratings and applied something like an averaging process to produce their retrospective ratings. Previous studies that have involved time estimates
both in passing and in retrospect have usually involved fewer measurement points per day than the present investigation.

The design of the study made it possible to test for the lagged effects of mood on time awareness and the lagged effects of time awareness on mood. This enabled stronger inferences to be made about causal direction than would have been possible with cross-sectional analysis, but it does not rule out all possible spurious causes (Kenny, 1975). The relations that were found between the lagged independent variable and the dependent variable could have been due to the influence of a third unknown variable that affected both. For example, sunny weather could plausibly have an immediate effect on cheerfulness and a delayed effect on the perceived speed of time, such that the two appear to be causally related.

The investigation also had a number of limitations. Due to the large number of measures used in the study as a whole and not wishing to overburden the participants, only a single scale was used to measure speed of time. The scale was unipolar and hence only measured from normal speed to fast speed; therefore, there was no measure of time passing more slowly than normal. The weekly data had to be analysed using a between-subjects rather than a within-subjects design: The results may therefore reflect differences in the way participants respond to scales in general rather than the specific content of the scales; however, the different results for different mood items suggests otherwise.

The results of this investigation imply that the subjective awareness of time can be affected by mood and could even be considered as another dimension of mood, but that the subjective awareness of time is probably not a determinant of mood. This conclusion refers only to the awareness aspect of experiential time and not to temporal perspective. Temporal perspective will be investigated in the next chapter. The conclusion to this chapter, however, is that time can fly when you're having fun but that having fun isn't dependent on time flying.
15

Temporal Prediction

Determinants, accuracy and effects of self-predictions of mood

I have ever needed to be in advance of myself, to be able
to defend myself against the onslaughts of future time.

- Janet Frame

Daughter Buffalo (1990)

Coming events cast their shadows before. If people wake up with the
anticipation that they will be happy that day, does the day usually live up to their
anticipations? This investigation looks at whether people can predict their moods
accurately, at what influences their predictions and the accuracy of those predictions,
and at whether the self-prediction of mood affects mood itself.

This chapter continues the work of the last by also investigating the relation
between experiential time and well-being. However, this chapter examines temporal
perspective rather than temporal awareness. Chapter Two described temporal
perspective as that aspect of experiential time that enables people to make relations
between their past, present, and future. This chapter will investigate future perspective
in relation to the mood component of well-being.

Part of people's sense of future self includes perceptions about how they are
likely to feel in the future (Staats & Skowronski, 1992), which implies that people
make forecasts about their affect. What functions could such forecasts about affect
serve for a person? A prediction about affect may simply serve as a source of
information. For example, previous work has shown that people use their mood as
information for making judgements (Schwarz & Clore, 1983). If forecasts about mood
are also used as information, then the most important concern would be to make the
forecast as accurate as possible by using highly salient information.
Alternatively, people may use predictions about their affect to determine whether they should regulate it, either by acting directly on the affect itself or indirectly by changing subsequent events. In this case, mood prediction would be expected to influence mood itself. In support of this view, Persson and Sjöberg (1985) found that the negative aspects of anticipated events adversely affected current mood. However, people may also think about the future in order to produce self-improvements and they may therefore imagine behaviours and circumstances that lead to positive affect (Staats & Skowronski, 1992). In this case, a mood forecast would be expected to be usually more positive than current mood. Knowledge about accuracy of mood prediction, influences on mood prediction, and the effects of mood prediction is therefore needed in order to evaluate these alternative conceptions of mood prediction.

**Mood prediction**

Previous research on prediction has shown that people are generally unable to make accurate predictions about events that don't involve themselves and that they are not much more successful when predicting their own behaviour (Sherman, 1980). For example, people are generally poor at predicting how they would behave in social situations involving compliance. People commonly predict that they would act in a more socially desirable manner than they actually do. Although there have not been any previous studies of people's ability to predict their own mood, there have been a number of related studies that suggest that people may be as poor at mood prediction as they are at behavioural prediction.

Wilson, Laser, and Stone (1982) found that a group of participants that had recorded their own mood for five weeks were no more accurate than a group of "observers", who had no knowledge of the participants, in estimating the correlation between their recorded moods and potential predictors of mood, such as day of week, sleep and weather. As such, people seem to rely on general shared theories of mood rather than actual covariation between their affective experiences and external events.
However, the general theories of mood may be reasonably accurate because the average within-subjects correlation between mood and predictors was 0.42 in the Wilson et al. (1982) study.

Influences on mood prediction

The Wilson et al. (1982) study also found that participants showed some awareness of personal covariation between weekends and mood, perhaps because moods at the weekend were more salient. Despite this, the participants also held the erroneous belief that their moods were more positive on Fridays and Saturdays. However, this shared belief might have been explained by the fact that for most people mood is usually better at weekends (Stone, Hedges, Neale, & Satin, 1985), and that this sample therefore differed from the norm.

Wilson et al. (1982) also found that asking people to focus on the relationship between sleep and mood increased the accuracy of their estimates of the correlation between amount of sleep and mood. However, they became more accurate by changing the objective correlation between sleep and mood so that it became similar to their subjective estimate of the correlation, rather than the other way about. The participants were therefore making their theories come true. Predictions about behaviour have also been found to be self-erasing in nature in that people sometimes change their subsequent behaviour so that it becomes consistent with their prediction (Sherman, 1980).

However, there are a number of other variables that could potentially influence mood prediction, including: concurrent mood, past mood, mood disposition, mood regulation, and future perspective. Each of these will be discussed in turn, starting with the possible influence of concurrent mood.

Different moods have been associated with different styles of cognitive processing (Schwarz & Bless, 1991) and with different information, directive, and retrieval functions (Schwarz & Clore, 1983). Moreover, it is thought that material with
an affective tone that is congruent with current mood is most easily retrieved from memory (e.g., Singer & Salovey, 1988). Concurrent mood could therefore influence a judgement of future mood by facilitating retrieval of memories that have similar affective tone. Any similarity between these memories and anticipated events may mean that the affective tone of the memories will be used to help forecast mood. People may also use past mood more directly to indicate what is going to happen to their mood. For example, DeLongis, Folkman and Lazarus (1988) found that mood on a given day accounted for an average of 25% of the variance in mood on the following day. Past mood may therefore be a good predictor of future mood over short time spans. A general disposition for depressed mood may also enhance the accuracy of mood prediction. In support of this view, research has shown that recollection of negative affective states are more accurate, but over-estimated, in people who are depressed (Schrader et al., 1990).

Moving on to the possible influence of mood regulation, recent work on mental control suggests that people are able to exert control over their mental states (Wegner & Pennebaker, 1993). For example, people commonly use mental and behavioural strategies to regulate their mood in anticipation of social interaction (Wegner & Erber, 1993). Salovey, Hess, and Mayer (1993) also demonstrated that people exert control over their future feelings by arranging the order of events. It is therefore quite plausible that when people predict their mood, they take into account their ability to exert control over their mood in the context of anticipated events. Catanzaro and Mearns (1990) produced a scale which measures people's generalised expectancies for negative mood regulation (NMR). These expectancies encapsulate the belief that a cognition or behaviour can alleviate a negative mood. Scores on this scale have been found to be predictive of adaptive emotional outcomes. For example, high NMR scorers appear to recover more quickly from the breakup of a romantic relationship. People who score high on the NMR scale should therefore both predict and experience greater improvement in mood.
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Finally, people's general perspective on their future could affect mood prediction. For example, an optimistic or pessimistic outlook might be expected to affect both mood prediction and mood experience. In particular, positive thinking about outcomes has been shown to have short-term positive effects on well-being, whilst negative thinking seems to have more enduring negative effects (Goodhart, 1985). Optimists should therefore both predict and experience a greater improvement in mood than pessimists.

Effects of mood prediction

Only variables that could affect mood prediction have been considered so far. However, it is conceivable that the prediction of future mood may itself have important affective, as well as behavioural, consequences. Just as current mood can be affected by past mood (e.g., Strack et al., 1985), so it could also be affected by anticipated mood. When people wake up in a poor mood, it seems more likely that their poor mood is due to them anticipating feeling bad about forthcoming events than because they are feeling bad about their immediate situation (it could however reflect a low point in their diurnal rhythm - see next chapter). Mood at the start of the day should therefore be related both to anticipated mood and to the severity of hassles (undesirable events) that occur later in the day.

When people predict their mood, they are setting up an expectation about how they are likely to feel. This raises the possibility that people's mood may get better simply because of their expectation (a self-fulfilling prophecy). If this is true, then a person's expected improvement in mood should be associated with an actual improvement in mood even after controlling for the hassles that the person experienced during the day. Another possibility is that people will feel worse at the end of the day if they expected to feel good but then experienced undesirable events. This suggests that there should be an interaction between mood prediction and hassles experienced in predicting actual mood.
The present investigation examined these issues by looking at people's predictions about the mood they would experience during each day and each week of the study. These predictions were used to investigate the associations between mood prediction and concurrent mood, retrospective mood, daily hassles, days of the week, depression, mood regulation expectancy and optimism. In particular, the investigation examined whether there is an association between predicted mood ratings and subsequent mood, using both daily and weekly time frames. This included investigating the extent to which individuals differ in their ability to predict their own mood. The investigation also examined what influences predicted mood and what predicts the accuracy of mood predictions. Finally, the investigation examined whether mood prediction affects concurrent and subsequent mood.

Method

The investigation was based on data from the 30 volunteers that took part in the study of activity and mood. See chapter 12 for a complete description of the sample, procedure, measures and analyses.

Only a subset of the measures were used: the daily and weekly mood ratings, daily hassles, and selected questionnaire scales (BDI, NMR, O&P). At the start of each day the participants used the mood rating scales to rate their current mood (concurrent), their mood over the previous day (previous-day), and the mood they expected to be in for the rest of the day (predict-day). At the end of each day, they rated their mood for that day (actual-day). The timing of these daily ratings is shown in Figure 15.1. At the start of each week, the participants rated the mood they expected to be in over the next week (predict-week) and their mood for the previous week (actual-week). The composite mood scores for alertness, cheerfulness and calmness were used.

Although the participants were not explicitly asked about their mood prediction during the interviews at the end of the study, four of the participants (A-D)
spontaneously volunteered relevant information and so their comments are included in the results.

Figure 15.1. Schematic diagram showing relative timing of daily mood ratings.

The pooled time-series method described in chapter 12 was used for many of the analyses. The variables entered into the regression equation prior to entry of the independent variable(s) were the first four sets of variables specified in chapter 12, with the purpose of removing between-subject differences, serial dependency, day of study, and day of week effects. The other analyses were based on individual rather than pooled data, and used raw rather than residual scores.

Results

In order to examine the correlations between the daily mood variables, each daily mood variable was first residualised using a regression model that contained the four sets of variables described above. The correlations between the residual scores are shown in Table 15.1.
Table 15.1  
Correlations between residual daily mood variables (N = 332)  

<table>
<thead>
<tr>
<th>Variable</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Cheerful Predict-Day</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2) Cheerful Concurrent</td>
<td>.60</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3) Cheerful Actual-Day</td>
<td>.39</td>
<td>.28</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4) Cheerful Previous-Day</td>
<td>.33</td>
<td>.25</td>
<td>.08</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5) Alert Predict-Day</td>
<td>.33</td>
<td>.37</td>
<td>.16</td>
<td>.06</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6) Alert Concurrent</td>
<td>.19</td>
<td>.44</td>
<td>.09</td>
<td>.02</td>
<td>.43</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7) Alert Actual-Day</td>
<td>.34</td>
<td>.29</td>
<td>.49</td>
<td>.05</td>
<td>.31</td>
<td>.34</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8) Alert Previous-Day</td>
<td>.16</td>
<td>.14</td>
<td>.06</td>
<td>.33</td>
<td>.11</td>
<td>.14</td>
<td>.08</td>
<td>-</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>9) Calm Predict-Day</td>
<td>.47</td>
<td>.33</td>
<td>.19</td>
<td>.14</td>
<td>.19</td>
<td>.10</td>
<td>.17</td>
<td>.17</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10) Calm Concurrent</td>
<td>.30</td>
<td>.35</td>
<td>.10</td>
<td>.07</td>
<td>.07</td>
<td>.12</td>
<td>.17</td>
<td>.46</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11) Calm Actual-Day</td>
<td>.18</td>
<td>.18</td>
<td>.50</td>
<td>.12</td>
<td>.14</td>
<td>.05</td>
<td>.25</td>
<td>.07</td>
<td>.28</td>
<td>.13</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>12) Calm Previous-Day</td>
<td>.24</td>
<td>.13</td>
<td>.15</td>
<td>.46</td>
<td>.09</td>
<td>-.02</td>
<td>.09</td>
<td>.22</td>
<td>.25</td>
<td>.20</td>
<td>.12</td>
<td>-</td>
</tr>
</tbody>
</table>

Associations between predicted mood and actual mood  

Daily ratings. To test whether participants were able to predict their daily mood, separate regression models were constructed for the three mood dimensions using end of day retrospective ratings for cheerfulness, alertness, and calmness as the dependent variables. Dummy variables for the participants were entered into the models first. Then the start of day predicted mood ratings were entered. There were significant associations between predicted and actual mood for cheerfulness (β = 0.40, $R^2$ Change = .09, $F(1,306) = 58.4, p < .01$), alertness (β = 0.32, $R^2$ Change = .05, $F(1,305) = 30.2, p < .01$), and calmness (β = 0.31, $R^2$ Change = .06, $F(1,306) = 32.8, p < .01$). This suggests that the participants were able to predict their mood but that little of the variance in actual mood was accounted for by their predictions. The associations remained significant after entering variables for the lag of the dependent variable, day of study, day of week, and concurrent mood. In other words, the accuracy of the mood predictions did not depend on these factors alone.

Participant A said, "Oh I think I predicted fairly well really". In practice, her predictions were not very good: The correlation between her predicted and actual daily mood (using raw scores) over the 14 days of the study for cheerfulness was $r(12)$
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= .22, ns, for alertness was r(12) = -.09, ns, and for calmness was r(12) = .29, ns. In order to look at the range of variation between individuals, the correlations between predicted mood and actual mood were computed for all the participants. Twenty seven participants had positive correlations and three participants had negative correlations for cheerfulness (rs from -.33 to +.90). Nine of the positive correlations were significant (p < .05). Twenty four participants had positive correlations and six participants had negative correlations for alertness (rs from -.69 to +.86). Five of the positive correlations and one of the negative correlations were significant (p < .05). Twenty three participants had positive correlations and seven participants had negative correlations for calmness (rs from -.39 to +.86). Seven of the positive correlations were significant (p < .05). The coefficient of concordance (W) between the three mood dimensions for the participants' correlations was 0.40, which represents an average rank correlation of 0.1. This suggests that participants who showed a high association between predicted and actual mood on one dimension were not more likely to show high associations on the other dimensions.

Participant B said, "I always sort of put that I was going to be very cheerful because in the morning I'm not alert at all, I'm sort of leave me alone ... so when I did that I had to sort of assume that when I'd sort of woken up properly that I would sort of be more cheerful as the day progressed... Before I've had a cup of coffee, then to think about being cheerful is the last thing I want to do, but then again I'm not a grumpy person". A paired t-test comparing predicted mood and actual mood showed that, in practice, this participant still significantly underestimated her cheerfulness (t(12) = 3.3, p < .01). To determine whether the other participants' predictions were pessimistic or optimistic compared to their actual mood, paired t-tests were computed for each participant. Seventeen participants underestimated their cheerfulness, but only four of these underestimates were significant. Fifteen participants underestimated their alertness, but only one of these underestimates was significant; one overestimate was significant. Eighteen participants underestimated their calmness, five of these
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underestimates were significant. So the participants generally tended to predict that their mood would be worse than it actually turned out to be. However, the participants were generally inconsistent across the three mood dimensions: Only 7 participants underestimated on all 3 dimensions, and only 3 overestimated on all three dimensions.

**Weekly ratings.** Participant C said, "This idea of forecasting what the next week's going to be like, I felt that was a bit of a waste of time. Cos no matter what you said, I mean you could suddenly go down with flu or whatever and it makes a mess of it, and I think to a degree you tend to, well from my point of view, I would be forecasting how I feel generally. And probably how it's been the week before, and unless you can see some problems coming up which are gonna give you hassle, you would be on a fairly even keel I would have thought". There was not enough weekly data from this participant alone to examine this belief. However, to test whether the participants in general could predict their mood over a week, the predict-week ratings were correlated with the actual-week ratings. The correlations for the first and second weeks of the study for cheerfulness were $r(24) = .35, ns$ and $r(21) = .18, ns$, for alertness were $r(24) = .21, ns$ and $r(21) = .40, ns$, and for calmness were $r(24) = -.07, ns$ and $r(21) = .38, ns$. This suggests that the participants could not predict their mood for the next week; however, the sizes of effects were similar to those for daily predictions.

To determine whether participants' weekly predictions underestimated or overestimated their actual mood, paired t-tests comparing predict-week and actual-week mood ratings, averaged over the two weeks, were computed. Cheerfulness and calmness were overestimated, and alertness underestimated, but none were significant.

**Predictors of mood prediction**

**Daily ratings.** To determine which variables might have influenced the participants' mood predictions, separate regression models were constructed for the three mood dimensions using the predicted ratings for cheerfulness, alertness, and
calmness as the dependent variables. Dummy variables for the participants were entered into the models first. Then the predicted ratings from the previous day (lag) were entered, followed by a variable representing day of study and dummy variables for days of the week. At the next step, either variables for concurrent mood, previous day’s mood, and actual (subsequent) mood were entered, or variables for (subsequent) hassles and hassles from the previous day were entered. The results are shown in Table 15.2.

The results show that concurrent mood was the strongest predictor for all three dimensions of mood prediction. Subsequent mood and hassles were better predictors of mood prediction than mood and hassles from the previous day. Participants predicted lower cheerfulness on a Sunday and Monday; but there were no other significant associations with days of the week.

**Weekly ratings.** Correlations were computed to test whether concurrent mood or mood from the previous week predicted the participants’ prediction of mood for the following week. The correlations for the first and second weeks of the study between concurrent mood and predict-week for cheerfulness were \( r(30) = .10, ns \), and \( r(19) = .19, ns \), for alertness were \( r(30) = -.26, ns \) and \( r(19) = .30, ns \), and for calmness were \( r(30) = .28, ns \), and \( r(19) = .18, ns \). The correlations for the first and second weeks of the study between previous-week and predict-week for cheerfulness were \( r(30) = .31, ns \), and \( r(23) = .46, p < .05 \), for alertness were \( r(30) = .36, p < .05 \) and \( r(23) = .40, ns \), and for calmness were \( r(30) = .10, ns \), and \( r(23) = .39, ns \). Mood prediction for a week therefore seemed to depend more on mood over the previous week than on concurrent mood.
Table 15.2
Regression model showing predictors of daily predicted ratings of mood (N=334)

<table>
<thead>
<tr>
<th>Dependent:</th>
<th>Cheerful</th>
<th>Alert</th>
<th>Calm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$R^2$</td>
<td>Change</td>
<td>$R^2$</td>
</tr>
<tr>
<td>Prior</td>
<td>$\beta$</td>
<td>$F$</td>
<td>Prior</td>
</tr>
<tr>
<td>Step 1 Dummy vars</td>
<td>0</td>
<td>.42</td>
<td>7.46**</td>
</tr>
<tr>
<td>Step 2 Lag of prediction</td>
<td>.42</td>
<td>0</td>
<td>-.01</td>
</tr>
<tr>
<td>Step 3 Day of study</td>
<td>.42</td>
<td>0</td>
<td>-.03</td>
</tr>
<tr>
<td>Day of week: Sunday</td>
<td>.42</td>
<td>.01</td>
<td>-.11</td>
</tr>
<tr>
<td>Day of week: Monday</td>
<td>.42</td>
<td>.02</td>
<td>-.18</td>
</tr>
<tr>
<td>Step 4 Concurrent mood Previous day's mood Actual mood</td>
<td>.46</td>
<td>.16</td>
<td>.49</td>
</tr>
<tr>
<td>OR</td>
<td>.46</td>
<td>.04</td>
<td>.21</td>
</tr>
<tr>
<td>OR</td>
<td>.46</td>
<td>.05</td>
<td>.24</td>
</tr>
<tr>
<td>Step 4 Hassles Previous day's hassles</td>
<td>.46</td>
<td>.01</td>
<td>-.27</td>
</tr>
<tr>
<td>OR</td>
<td>.46</td>
<td>.01</td>
<td>-.16</td>
</tr>
</tbody>
</table>

Note: * $p < .05$, ** $p < .01$

#Only days of week showing significant results are shown
Predictors of accurate mood prediction

Within-participants analysis. To determine which factors predicted the participants' accuracy of mood prediction, separate regression models were constructed for the three mood dimensions using scores for the absolute difference between predicted and actual mood ratings as the dependent variables. The results are shown in Table 15.3.

Dummy variables for the participants explained 20%, 21%, and 23% of the variance in the absolute difference scores for cheerfulness, alertness and calmness respectively. The difference scores from the previous day (lag) were entered, followed by a variable representing day of study and dummy variables for days of the week. The only significant effect was that participants were more accurate (smaller difference scores) in predicting their cheerfulness on Sundays. Variables for concurrent mood, previous day's mood, predicted mood, the absolute difference between concurrent and predicted mood, and the absolute difference between previous day's mood and predicted mood were then independently entered into the models. Better concurrent mood predicted greater accuracy for cheerfulness, alertness, and calmness. Predicting better mood predicted greater accuracy for cheerfulness, alertness, and calmness. A smaller difference between yesterday's mood and predicted mood predicted greater accuracy for alertness and calmness. A smaller difference between concurrent mood and predicted mood predicted greater accuracy for alertness. These results suggest that participants were more accurate in their predictions when they were in a better mood, when they predicted better mood, and when their predictions diverged less from their concurrent and previous day's mood.
Table 15.3
Regression model showing predictors of accurate mood prediction (N=332)

<table>
<thead>
<tr>
<th>Dependent:</th>
<th>Cheerful</th>
<th>Alert</th>
<th>Calm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Prior $R^2$ Change</td>
<td>$\beta$</td>
<td>$F$</td>
</tr>
<tr>
<td>Step 1 Dummy vars for subjects</td>
<td>0</td>
<td>.20</td>
<td>2.64**</td>
</tr>
<tr>
<td>Step 2 Lag of prediction</td>
<td>.20</td>
<td>0</td>
<td>-.02</td>
</tr>
<tr>
<td>Step 3 Day of study</td>
<td>.20</td>
<td>0.01</td>
<td>-.08</td>
</tr>
<tr>
<td>Day of week: Sunday</td>
<td>.20</td>
<td>0.01</td>
<td>-.12</td>
</tr>
<tr>
<td>Step 4 Concurrent mood (C)</td>
<td>.23</td>
<td>.02</td>
<td>-.21</td>
</tr>
<tr>
<td>OR Previous day mood (Y)</td>
<td>.23</td>
<td>0</td>
<td>-.03</td>
</tr>
<tr>
<td>OR Predicted mood (P)</td>
<td>.23</td>
<td>.01</td>
<td>-.15</td>
</tr>
<tr>
<td>OR Abs(P - C)</td>
<td>.23</td>
<td>0</td>
<td>.09</td>
</tr>
<tr>
<td>OR Abs(P - Y)</td>
<td>.23</td>
<td>0</td>
<td>.05</td>
</tr>
</tbody>
</table>

Note. * $p < .05$, ** $p < .01$
#Only days of week showing significant results are shown
Abs = Absolute difference
Between-participants analysis. Correlations between daily predicted mood and actual mood were computed for each participant for each mood dimension to form an alternative measure of accuracy of mood prediction. These correlations were then correlated with 14 other measures to find significant predictors of accuracy. These other measures were: BDI scores, NMR scores, Optimism and Pessimism scores, the correlation between previous day's mood and predicted mood, the correlation between concurrent and predicted mood, mean and standard deviation scores per participant for previous day, concurrent, predicted and actual mood. The mean and standard deviation reflect the influence of level of mood and variability of mood respectively. There were only four significant correlations between: BDI scores and prediction accuracy for calmness \( r(30) = .45, p < .05 \), the correlation with yesterday’s mood and prediction accuracy for calmness \( r(30) = .38, p < .05 \), the correlation with yesterday's mood and prediction accuracy for cheerfulness \( r(30) = .37, p < .05 \), the correlation with concurrent mood and prediction accuracy for cheerfulness \( r(30) = .38, p < .05 \). These results suggest that participants were more accurate in their prediction of mood when their predictions correlated with their previous and concurrent mood. The trait factors seemed to have little influence on accuracy.

Effects of mood prediction

Relations with concurrent mood. To test whether mood prediction had a greater association with concurrent mood than mood on the previous day, separate regression models were constructed for the three mood dimensions using the concurrent ratings for cheerfulness, alertness, and calmness as the dependent variables. Dummy variables for the participants, concurrent ratings from the previous day (lag), a variable representing day of study and dummy variables for days of the week were entered into the models. At the next step, variables for predicted mood and previous day’s mood were entered. Predicted mood, but not the previous day's mood, significantly predicted concurrent cheerfulness \( \beta = .61, R^2 \text{ Change} = .19, F(1,302) = \)
Temporal Prediction

154.08, p < .01), alertness (β = .41, \( R^2 \) Change = .08, \( F(1,302) = 69.96, \ p < .01 \)), and calmness (β = .43, \( R^2 \) Change = .10, \( F(1,302) = 68.97, \ p < .01 \)). Variables for (subsequent) hassles and hassles from the previous day were then entered instead of predicted and previous day's mood. Hassles, but not the previous day's hassles, significantly predicted concurrent mood for cheerfulness (β = -.29, \( R^2 \) Change = .02, \( F(1,302) = 14.25, \ p < .01 \), and alertness (β = -.17, \( R^2 \) Change = .01, \( F(1,302) = 6.3, \ p < .05 \)). There were no significant effects of hassles for calmness. These results suggest that the anticipation of hassles had a greater influence on concurrent mood than the hassles of the previous day.

**Relations with subsequent mood.** Participant D said, "You start the day and you sort of think 'what's today going to be like?' It'll tell if you're an optimist or pessimist or a realist. I always wake up hoping that the day's going to be good. I mean obviously as you go along the day, people throw buckets of horrible things in your direction, but I think if you believe your day's going to be good then it's bound to be better than believing your day's going to be terrible, you may as well stay in bed". However, this participant's partial correlations between expected and actual improvement in mood, controlling for hassles, for cheerfulness was \( r(8) = .40, \ ns \), for alertness was \( r(8) = .21, \ ns \), and for calmness was \( r(8) = .25, \ ns \), which suggests that this participant's mood did not improve as a consequence of his purportedly high expectations.

To test whether generally participants' mood improved if they expected it to improve, independently of the hassles they experienced, separate regression models were constructed for the three mood dimensions using the differences between concurrent and actual mood ratings (improvement scores) as the dependent variables. Dummy variables for the participants, improvement scores from the previous day (lag), a variable representing day of study and dummy variables for days of the week were entered into the models, as well as the variable for hassles. The differences between concurrent and predicted mood ratings (expected improvement scores) were then
Temporal Prediction

entered into the models. Expected improvement predicted actual improvement for
cheerfulness (β = .48, R² Change = .12, F(1,292) = 83.43, p < .01), alertness (β = .53,
R² Change = .13, F(1,292) = 114.23, p < .01), and calmness (β = .56, R² Change =
.17, F(1,292) = 117.0, p < .01). These results confirmed that mood did improve when
participants expected it to improve, independently of the hassles they experienced.

Interestingly, an improvement in mood the previous day generally predicted a
decrement in mood today for cheerfulness (β = -.18, R² Change = .02, F(1,292) =
13.69, p < .01), and calmness (β = -.13, R² Change = .01, F(1,292) = 7.11, p < .01),
suggesting a contrast effect or more simply a regression to the mean. Hassles did not
significantly predict an actual improvement (or decrement) in mood. However, in
separate regression models (with the same control variables) fewer hassles did
significantly predict higher actual cheerfulness (β = -.36, R² Change = .04, F(1,298) =
20.97, p < .01), alertness (β = -.27, R² Change = .02, F(1,297) = 11.52, p < .01), and
calmness (β = -.22, R² Change = .01, F(1,299) = 7.88, p < .01).

The association between the trait variables and mean levels of both expected
and actual improvement were then tested in a series of partial correlations, controlling
for mean level of hassles. Surprisingly, there were no significant correlations with the
BDI, or with the optimism and pessimism scales. The NMR scores correlated
significantly with expected improvement in cheerfulness (r(27) = .33, p < .05) but not
with actual improvement (r(27) = .29, n.s.), although there was little difference in the
size of correlation. Therefore, those participants that had a higher expectancy for
alleviating negative mood expected a greater improvement in mood but they actually
experienced only a marginally greater improvement in mood.

Interaction with hassles. To test the influence of predicted mood on the
association between hassles and actual mood, terms for the composite hassles score
and the interaction between predicted ratings and hassles were entered into the
regression models reported at the start of the results section (with actual mood as the
dependent variable and predicted ratings as one of the independent variables). Only the
interaction term for cheerfulness was significant ($\beta = -.06, R^2 \text{ Change} = .01, F(1,295) = 5.4, p < .05$). Figure 15.2 shows that mood was worse if participants predicted good mood but then experienced severe hassles, but was still better than if they had predicted bad mood and experienced severe hassles. However, the effect was very small.

![Figure 15.2. Cheerfulness as a function of predicted cheerfulness and hassles experienced.](image)

**Discussion**

The purposes of this investigation were to find out whether people can successfully predict their own mood and to examine potential influences and effects of mood prediction. The results showed that although the participants were able to reliably predict their mood, their predictions explained between only 5% and 9% of the variance in actual mood after the variance due to differences between participants had been removed. The results also showed that participants could predict their mood over a week about as well as they could over a day. There were large individual differences in the accuracy of mood prediction. Some of the participants were extremely poor at predicting, in some instances even showing a small negative correlation between their
predictions and actual mood. Differences between participants explained over 20% of the variation in accuracy of predictions.

The results showed that the ability of the participants to predict their mood was not based on the day of the week or concurrent mood. More participants underestimated than overestimated their actual mood, which suggests that they tended towards a pessimistic outlook. Pessimistic forecasting might represent one means by which people cope with negative events, in that their actual mood will turn out to be better than they expected. However, mood was more likely to actually improve when participants expected it to improve.

The relative importance of variables that might affect people's mood prediction was also assessed. Concurrent mood explained between 7% and 16% of the variance in daily predicted mood, although as will be seen later this could be due to the effect of prediction on concurrent mood rather than the other way about. The predicted ratings were more strongly associated with hassles that happened later in the day than hassles from the previous day, suggesting that the participants were to some extent aware of impending events. The participants predicted lower cheerfulness on Sundays (and in fact were more accurate on Sundays) and Mondays. The latter result is probably explained by the fact that people incorrectly believe that Monday is the worst day of the week: the "Blue Monday" phenomenon (Stone et al., 1985). Mood prediction for a week was based more on mood over the previous week than on concurrent mood, which suggests that people may adjust their frame of reference so that it corresponds to the time period covered by the prediction. Alternatively, the fact that participants made ratings about the past week just before making ratings about the forthcoming week may have made the past week a more obvious basis for prediction than concurrent mood.

The results also provide information about the conditions under which mood prediction is more accurate. For example, participants were more accurate when they were in a better mood at the time of making the prediction and when they predicted a
better mood. This latter result may partly be explained by the fact that the majority of
the participants underestimated their mood. Alternatively, the participants might have
been more accurate because they were less likely to regulate their moods when they
were in a good mood or when they predicted good moods. In support of this, Mayer
and Gaschke (1988) found that the feeling that a mood will change soon and the
instigation of repair processes to bring it about were more likely to occur in unpleasant
than pleasant moods. People’s greater propensity to regulate negative mood may
make it more variable than positive mood (see the results of chapter 17 for evidence of
this) and hence more difficult to predict.

The results also showed that participants were more accurate when there was a
greater association (smaller difference scores and higher correlations) between their
predicted mood and their concurrent and previous day’s mood. This implies that
people will be more accurate if they can make their predictions covary with other
aspects of their affective experience. For example, people’s mood predictions will be
more accurate if they base them on either their concurrent mood or on their mood the
previous day. However, previous research has shown that people find it very difficult
to use deliberate covariation (Wilson et al., 1982). The lack of association between the
verbal comments from three of the participants about their mood prediction and their
actual data also suggests that people may not have sufficient insight into their affective
processes to use covariation.

Participants with stable mood could have been expected to be more accurate in
their predictions because their mood rarely changes, or less accurate because they are
unable to differentiate between their mood states. In practice, neither the participants’
general level of mood or variability of mood during the study affected the accuracy of
their predictions. Participants with higher levels of depression, as measured by the
BDI, were more accurate in predicting their calmness but not their cheerfulness or
alertness. Optimism, pessimism, and expectancy for negative mood regulation were
unrelated to accuracy.
Surprisingly, the BDI, optimism and pessimism scales were also unrelated to the participants' expectation that their mood would improve during the day compared to their current mood. However, participants who had a higher expectancy for negative mood regulation had higher expectations that their cheerfulness would improve, and showed a trend for greater actual improvement. Wegner and Erber (1993) pointed out that peoples' attempts at mental control often fail and so it is not surprising that the association between negative mood regulation and actual improvements in cheerfulness was not as strong. It seems, therefore, that people who believe they can alleviate negative mood are able to actively bring about some improvement in their mood. However, given that the NMR scale was administered at the end of the study it is also possible that participants completed the scale on the basis of how their negative moods changed during the study.

Another explanation is that people's mood improves when they look on the "bright side", and in support of this the results on the effects of mood prediction showed that mood was more likely to improve when participants expected it to improve. This cannot be explained by the fact that the participants were aware of forthcoming hassles because the effect remained even after controlling for hassles. However, this result can be explained from a regulatory perspective because the participants' high expectations might have indicated their intention to deploy regulatory strategies. An explanation based solely on an optimistic outlook seems unlikely given that the results for the negative mood regulation scale were not paralleled by those for the optimism scale and given that the results were specific to cheerful mood.

The results also showed that cheerfulness was lower if participants had high expectations but then experienced a high level of hassles, but that it was still better than if they predicted depressed mood and then experienced either low or high levels of hassles. Affective outcome therefore seems to depend on an interaction between the
prediction of mood and actual experience, which again suggests the influence of mental control.

Perhaps the most interesting result, however, was that predicted mood seemed to have a greater influence on mood at the time of prediction than yesterday's mood. This could have been explained by the fact that concurrent mood was influencing predicted mood, rather than the other way about, however it was also found that hassles that hadn't yet happened were more strongly associated with current mood than hassles from the previous day. The implication, therefore, is that people's affective near future influences their affective present more than their affective near past.

On balance, the results seem to favour the view that mood prediction functions as a mood regulator. The participants' general level of inaccuracy in their predictions and the considerable differences between participants' accuracy argues against a purely informational function for mood forecasts. Likewise, the fact that the forecasts didn't generally overestimate actual mood, and the lack of associations with the optimism and pessimism scales argue against a purely self-improvement function. In contrast, the fact that predictions turned out to be less accurate when participants were in a bad mood or predicted a bad mood, the associations between expected and actual improvements in mood and negative mood regulation expectancy, and the influence of mood prediction on current mood, all suggest a mood regulation function.

However, the results of this investigation might have been affected by two types of methodological limitation. The first type relates to the assessment of mood. The investigation required the participants to provide many ratings of mood and other variables over a relatively short span of time. This not only placed an intensive demand on the participants but limited the number of mood adjectives to two for each of the mood dimensions of cheerfulness, alertness and calmness. The participants' responses might therefore have been affected because they were required to focus on their mood much more than usual. It is unknown, for example, how often people naturally predict their mood. It is also conceivable that the participants recalled their predictions at the
end of the day and rated their actual mood to fit with those predictions. However, both
the participants' level of inaccuracy in their predictions and their relative lack of
comment during the interviews about the predictions, suggest that this did not happen.
The frequency of ratings and the size of the ratings battery also make this unlikely.

It was also assumed that mood recalled at the end of the day and end of the
week is the same as actual mood experienced during the day and during the week. This
assumption seemed reasonable given that it had previously been shown, for the same
study, that there were strong associations between the end of day retrospective ratings
and the average of the momentary ratings made during the day, and end of week
retrospective ratings and average daily mood (Parkinson, Briner, Reynolds, &
Totterdell, 1995).

The second type of limitation relates to the assessment of hassles. A number of
analyses used hassles as a control variable. This assumes that the list of hassles covers
the most important undesirable events for each participant on each day. Another
problem with using ratings of hassles is that they may be contaminated by mood.
However, previous work (Lu, 1991) has shown that the contamination hypothesis may
be over-pessimistic. The results show that hassles predicted worse mood, however, the
variance explained was only between 1% and 4%. This suggests that confounding
wasn't a problem but it could also suggest that the hassles measure did not sufficiently
capture the problems that affected the participants' mood. However, none of the
participants mentioned this potential problem in their interviews.

There has been a recent increase in research effort devoted to understanding
the processes by which people monitor and manage their moods (e.g., Wegner &
Pennebaker, 1993). This includes determining the frequency of use and effectiveness
of the different strategies that people use to self-regulate their mood (e.g., Thayer,
Newman, & McClain, 1994). The results of the present investigation suggest that
asking people to forecast their own mood may initiate self-regulatory processes,
particularly when they anticipate negative affect. Future studies might therefore test
whether people use more or different mood regulation strategies on days on which they anticipate worse mood. Another question for investigation is whether asking people to explicitly focus on anticipated mood acts as a mood-regulatory intervention. For example, it is thought that keeping a personal diary reduces anxiety because it helps organise personal material and because its planning function helps to reduce future hassles (Burt, 1994). Asking people to predict their mood may help in a similar way.

This investigation has shown that people are not very good at predicting their future mood but that the prediction of mood can affect both their present and their subsequent mood. Therefore, the role of mood prediction may have less to do with providing an accurate guide to future prospects than to do with getting the person into the right frame of affect for transforming the future. The results of this exploratory investigation of mood self-prediction therefore offer promise for a wider understanding of affect regulatory processes. In terms of the temporal aspects of well-being, this investigation has demonstrated that future affective perspective influences concurrent well-being.
Temporal Rhythm

Effects of well-being on diurnal and ultradian variations in mood

We are frail in time and thus in relationship to our personalities.

Regulating bodies -

_Bryan Turner_ (1992)

Previous investigations in this thesis have emphasised different parts of the social time, body time, and experiential time triad from the theoretical framework outlined in chapter four. However, the framework also proposes that well-being depends on previous states of well-being. This chapter and the next will therefore also investigate hypotheses that relate to that proposition. This chapter investigates the relation between two types of history: The implicit history of states that is reflected in an individual’s level of well-being, and the history of mood states within each day. In particular, this chapter will investigate how individual differences in level of well-being relates to diurnal and ultradian rhythms in mood.

Diurnal variation in mood, usually with worse mood in the morning, is recognised as a symptom of endogenous depression. However, chapter three described research showing that healthy individuals also sometimes show a diurnal variation in mood. Haug and Wirz-Justice (1993) hypothesised that diurnal variation in mood reflects a circadian rhythm that is normally masked by daily events but that is unmasked during depression because of reduced responsiveness to external events. In support of this hypothesis, a circadian rhythm in global affect (which included ratings of happiness and sadness) has been found in a nondepressed group after an unmasking routine involving 36 hrs of wakeful bedrest (Monk, Buysse, Reynolds III, Jarrett, & Kupfer, 1992). More recently, two independent laboratories used _forced desynchrony_
protocols, which involved participants living on a sleep-wake cycle of sufficient length to induce desynchrony between the body clock and the sleep-wake cycle, in order to determine the relative contribution of these processes to subjective happiness. The results showed that subjective happiness not only varies with circadian phase but is also influenced by a complex interaction between circadian phase and time since waking (Boivin et al., in press).

In addition to circadian rhythms, people are known to exhibit higher frequency ultradian rhythms during a day. A 12-hr rhythm in alertness has commonly been reported and is probably a component of the circadian rhythm (Hildebrandt, Rohmert, & Rutenfranz, 1974). Recent evidence suggests that people also exhibit ultradian rhythms in mood that are of higher frequency than 12-hr. One study reported rhythms of 4-6 hr in both positive and negative moods for a group of healthy males (Tsuji et al., 1981).

There may also be an association between ultradian rhythms and depression. For example, a recent study (Daimon, Yamada, Tsujimoto, & Takahashi, 1992) found that there were significantly more ultradian rhythm components in the temperature spectrum of depressed patients. With respect to mood, Hall and co-workers (Hall, Sing, & Romanoski, 1991) found 3-9 hr cycles in mood in both a nondepressed and a depressed group. The depressed group, however, showed ultradian rhythms of greater amplitude and had greater variability in their scores. The increase in amplitude was speculated to represent an increase in the activity of an oscillating network other than the circadian oscillator. However, no such secondary oscillatory network is known and the output of such a network would probably be masked under normal conditions. It is also possible that the ultradian rhythms are in fact artefacts of a masked circadian rhythm. Cowdry (1992) also criticised Hall and co-workers study on its methodology and choice of sample. The methodological weaknesses were that: Self-ratings of mood were made over only one day per subject, the crossover method used is likely to find a cycle in almost any data, and the complex demodulation method used allows rhythm
amplitude to vary across time. Clearly there is therefore a need to confirm or repudiate the existence of such rhythms under natural conditions using an improved design before addressing their theoretical status.

The present investigation therefore tests the following hypotheses: 1) There is a diurnal variation in cheerful and depressed mood in a healthy sample. 2) Diurnal variation in mood is greater in participants scoring higher on scales of depression and psychological distress. 3) There are ultradian rhythms in cheerful and depressed mood in a healthy sample. 4) The amplitude of ultradian rhythms in mood is greater in participants scoring higher on scales of depression and psychological distress.

Method

The investigation was based on data from the 30 volunteers that took part in the study of activity and mood. See chapter 12 for a complete description of the sample, procedure, measures and analyses.

The subset of measures used in this investigation were the Beck Depression Inventory and General Health Questionnaire scales and the 2-hrly mood ratings for depressed and cheerful mood. The participants completed a mean of 95 ($SD = 16.4$) ratings for each mood item; the minimum was 59 ratings. The mean score for the depressed mood ratings was 3.04 ($SD = 3.1$) and for cheerful mood was 11.28 ($SD = 4.43$).

To assess diurnal variation in mood, an average of the mood ratings at each time of day per participant was first calculated from each 14 day time-series. A two factor repeated measures analysis of variance, with time of day as the repeated measures factor and either BDI or GHQ as the second factor, was then used to assess the effect of time of day and the interaction between depressed affect and time of day on cheerful and depressed mood. Time of day was made up of the nine 2-hr measurements between and including 08:00 and 24:00. Median splits divided the participants into groups scoring high and low on the BDI and GHQ. The high groups
scored 5 or more on the BDI, and 10 or more on the GHQ. T-tests were also used to test whether the high and low BDI and GHQ groups differed in average sleep onset time or in average change in sleep onset time from the previous day.

To assess ultradian rhythms in mood, the 14 day time-series for depressed and cheerful mood ratings from each participant were first analysed by cosinor analysis, which uses a least-squares method to fit sine curves to a time-series (Fort & Mills, 1970). Periods between 3 and 9 hr in 0.1 hr increments were tested because this was the range reported by Hall and co-workers (1991). Unfortunately this means that 3 significant (p<.05) fits per participant could arise by chance alone. Cosinor analysis also assumes that the rhythm is sinusoidal which may not be the case. A "binfit" analysis was, therefore, also used: Using the same periods, the data were cast into six equal time-bins for the period under test, and then subject to one-way analysis of variance with the six time-bins as the levels of the independent variable. However, noncosinor period analysis of a time-series containing both a long term trend in the data (for example due to practice) and gaps in the data (for example due to sleep) can produce rhythms that are artefacts (Folkard & Monk, 1987). A conservative approach was therefore adopted, in that a rhythm was only accepted if it was significant by both methods. In practice, no more than three subjects were excluded on any of the analyses because he or she had a significant fit using cosinor analysis but not using binfit analysis.

To counter potential problems of nonstationarity in the time-series (West & Hepworth, 1991), the time-series for mood were regressed on independent variables for days into the study, day of week, and the first order lag (autocorrelation) of the mood rating. The lag was significant for both depressed mood, $R^2$ change = .33, $F(1,2185) = 1108, p < .01$, and cheerful mood, $R^2$ change = .33, $F(1,2185) = 1070, p < .01$. The cosinor analysis was therefore repeated on the residual time-series.
The cosinor analysis was also extended to include the range of periods 13-19 hr, so that a comparison could be made against a range which was equivalent in size but in which no rhythms were expected.

Results

The correlations between scores on the BDI and GHQ and the mean, standard deviation and autocorrelation in the depressed and cheerful mood ratings are shown in Table 16.1. The results show that higher scores on the BDI and GHQ were associated with greater mean depressed mood, greater variability in depressed mood, and greater serial dependency between consecutive 2-hrly ratings of depressed mood. There were no significant associations with cheerful mood.

Table 16.1
Correlations between mean, standard deviation and autocorrelation of depressed and cheerful mood self-ratings and scores on the BDI and GHQ.

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
<th>AR(1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depressed Mood</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BDI (n=30)</td>
<td>.45*</td>
<td>.50**</td>
<td>.40*</td>
</tr>
<tr>
<td>GHQ (n=29)</td>
<td>.38*</td>
<td>.51**</td>
<td>.38*</td>
</tr>
<tr>
<td>Cheerful Mood</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BDI (n=30)</td>
<td>-.09</td>
<td>.32</td>
<td>.05</td>
</tr>
<tr>
<td>GHQ (n=29)</td>
<td>-.21</td>
<td>.30</td>
<td>.05</td>
</tr>
</tbody>
</table>

Note. * p<.05, ** p<.01;
AR(1) = autocorrelation lag (1)

Diurnal variation in mood. The results of the repeated measures analyses of variance showing the effects on depressed and cheerful mood of time of day and the interaction between time of day and BDI/GHQ are shown in Table 16.2. The effects of time of day and level of BDI on depressed mood and cheerful mood are shown in Figures 16.1 and 16.2. Figure 16.2 suggests that the two groups may have a diurnal rhythm in cheerful mood but that the rhythms are shifted in time relative to each other.
and therefore cancel each other out at certain times of day. Repeated measures analyses of variance were therefore performed separately on the two groups. The low BDI group showed a significant time of day effect ($F(8, 111)=4.25, p<.01$), but the high BDI group did not ($F(8, 108)=0.75$, n.s.).

Table 16.2
Repeated measures analyses of variance showing the effects of time of day and the interaction between time of day and BDI/GHQ scores on depressed and cheerful mood.

<table>
<thead>
<tr>
<th></th>
<th>Depressed Mood</th>
<th></th>
<th>Cheerful Mood</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>df</td>
<td>F</td>
<td>df</td>
<td>F</td>
</tr>
<tr>
<td>Time of Day</td>
<td>8, 219</td>
<td>3.73**</td>
<td>8, 219</td>
<td>0.27</td>
</tr>
<tr>
<td>Time of Day by BDI</td>
<td>8, 219</td>
<td>3.76**</td>
<td>8, 219</td>
<td>0.18</td>
</tr>
<tr>
<td>Time of Day</td>
<td>8, 211</td>
<td>4.21**</td>
<td>8, 211</td>
<td>0.47</td>
</tr>
<tr>
<td>Time of Day by GHQ</td>
<td>8, 211</td>
<td>3.95**</td>
<td>8, 211</td>
<td>0.31</td>
</tr>
</tbody>
</table>

Note. ** $p<.01$
Time of Day was split into nine 2 hr intervals between 08:00 and 24:00
BDI and GHQ were split into above and below median groups

Figure 16.1. Ratings of depressed mood at different times of day for participants scoring above and below the median on the Beck Depression Inventory (BDI).
Temporal Rhythm

Figure 16.2. Ratings of cheerful mood at different times of day for participants scoring above and below the median on the Beck Depression Inventory (BDI).

The differences between the groups could be due to differences in their sleep behaviour (as suggested by the results of chapter 13 in which the daily course of mood was shown to be affected by sleep onset time). However, T-tests showed no significant differences between the sleep onset times of the high and low BDI groups or the high and low GHQ groups. Similarly, there were no significant differences between the change in sleep onset times of the high and low BDI groups or the high and low GHQ groups.

Ultradian rhythms in mood. Table 16.3 shows the periods and variance explained of the significant ultradian fits in the range 3-9 hr found using cosinor and binfit analysis on the raw and residual time-series for depressed and cheerful mood. Fifteen participants had significant fits by both types of analysis for the raw depressed mood ratings, and 21 participants for the raw cheerful mood ratings. The percentage variance explained by the best significant fits ranged from 7.2% to 12.1% (mean 9%) for depressed mood, and 5.9% to 16.7% (mean 9.7%) for cheerful mood. After residualising the data, 27 participants had significant fits for the depressed mood ratings, and all 30 for the cheerful mood ratings. By comparison, only four participants
produced significant cosinor fits in the range 13-19 hr for the residualised depressed mood ratings.

Table 16.3

*Ultradian rhythms (in range 3-9 hr) in depressed and cheerful mood self-ratings in a healthy sample*

<table>
<thead>
<tr>
<th>Subj</th>
<th>Depressed Mood</th>
<th>Cheerful Mood</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Period (best sig fit)</td>
<td>Variance</td>
</tr>
<tr>
<td></td>
<td>Raw</td>
<td>Resid</td>
</tr>
<tr>
<td>1</td>
<td>8.4</td>
<td>6.2</td>
</tr>
<tr>
<td>2</td>
<td>4.1</td>
<td>17.0</td>
</tr>
<tr>
<td>3</td>
<td>3.5</td>
<td>3.5</td>
</tr>
<tr>
<td>4</td>
<td>5.4</td>
<td>10.0</td>
</tr>
<tr>
<td>5</td>
<td>5.4</td>
<td>8.4</td>
</tr>
<tr>
<td>6</td>
<td>3.6</td>
<td>8.7</td>
</tr>
<tr>
<td>7</td>
<td>6.4</td>
<td>7.8</td>
</tr>
<tr>
<td>8</td>
<td>6.6</td>
<td>20.6</td>
</tr>
<tr>
<td>9</td>
<td>4.0</td>
<td>4.0</td>
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<td>28</td>
<td>8.1</td>
<td>8.2</td>
</tr>
</tbody>
</table>

Total Sig. 32 92 60 136

*Note.* Sig fits prep .05

Raw = raw time-series; Resid = residual time series
T-tests showed no significant difference on BDI or GHQ scores between those participants showing and those not showing significant fits for raw depressed and cheerful moods. The correlations between scores on the BDI and GHQ and the amplitude, period, and variance in ultradian rhythms in the range 3-9 hr for raw and residual depressed and cheerful mood are shown in Table 16.4. Participants scoring higher on the BDI were more likely to have higher amplitude and slower rhythms in raw depressed mood but not in residual depressed mood. Figure 16.3 shows the ultradian rhythms in depressed mood of a participant scoring high on the BDI and a participant scoring low on the BDI. Figure 16.4 shows the ultradian rhythms in depressed mood from the raw and residual time-series of a participant scoring low on the BDI.

Table 16.4

<table>
<thead>
<tr>
<th></th>
<th>Amplitude</th>
<th>Period</th>
<th>Variance</th>
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<tbody>
<tr>
<td><strong>Depressed Mood</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BDI (n=15)</td>
<td>.54*</td>
<td>.62*</td>
<td>.20</td>
</tr>
<tr>
<td>GHQ (n=14)</td>
<td>.40</td>
<td>.75**</td>
<td>.38</td>
</tr>
<tr>
<td><strong>Cheerful Mood</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BDI (n=21)</td>
<td>-.11</td>
<td>.34</td>
<td>.22</td>
</tr>
<tr>
<td>GHQ (n=21)</td>
<td>.26</td>
<td>.29</td>
<td>.37</td>
</tr>
<tr>
<td><strong>Depressed Mood</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BDI (n=28)</td>
<td>.17</td>
<td>.13</td>
<td>-.11</td>
</tr>
<tr>
<td>GHQ (n=27)</td>
<td>.12</td>
<td>.16</td>
<td>.03</td>
</tr>
<tr>
<td><strong>Cheerful Mood</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BDI (n=30)</td>
<td>.14</td>
<td>.05</td>
<td>.24</td>
</tr>
<tr>
<td>GHQ (n=29)</td>
<td>.26</td>
<td>.15</td>
<td>.21</td>
</tr>
</tbody>
</table>

Note: ## Only participants with significant ultradian fits were used
   * p<.05, ** p<.01.
Figure 16.3. Ultradian rhythms in depressed mood ratings for a participant scoring low and a participant scoring high on the BDI. The periods of the rhythms are divided into six time bins and double-plotted. Each time bin therefore represents 1.35 hr for the low BDI participant and 1.45 hr for the high BDI participant.

Figure 16.4. Ultradian rhythm in depressed mood ratings before and after the removal of serial dependency, linear trend, and day of week effects from the time-series for a participant scoring low on the BDI. The period is divided into five time bins and double plotted. Each time bin therefore represents 0.74 hr.
Discussion

The results support the hypothesis that there is diurnal variation in depressed mood in a healthy sample, and support the hypothesis that diurnal variation in depressed mood is greater in subjects scoring higher on scales of depression and psychological distress. The results did not disprove the hypothesis that there are ultradian rhythms in mood in a healthy sample. However, the hypothesis that the amplitude of the ultradian rhythm is greater in participants with greater depressed affect was supported only by the raw time-series for self-rated depressed mood.

Previous studies (Robbins & Tanck, 1987; Wood & Magnello, 1992) have found that mood is more likely to get worse over the course of a day in healthy individuals. However, the current results suggest that this pattern of diurnal variation depends on an interaction between time of day and level of depressed affect. The depressed mood of individuals scoring high on scales of depression and psychological distress got worse over the day, whereas the depressed mood of individuals scoring low on the depression scale was relatively stable over the day.

Recent work (Boivin et al., in press) has suggested that there is a circadian rhythm in mood which is affected by the timing of sleep. However, this finding does not seem to explain the interaction found in the present investigation because there were no significant differences in the sleep onset times or change in sleep onset of those scoring high and low on the depression scale. The interaction is, however, consistent with the view that there is a relationship between depression and a circadian rhythm in mood. However, the relationships that hold over the normal range may be different to those in the clinical range. For example, endogenous depression is usually associated with worse mood in the morning, and not worse mood in the evening as found in the present investigation for the group with higher levels of depressed affect.

A significant diurnal variation in cheerful mood was not found for the whole sample. A possible explanation is that cheerful mood is more responsive to external events and hence more susceptible to masking effects. Previous studies have shown
that positive affect is more likely to be influenced by the environment and social activity than negative affect (Baker, Cesa, Gatz, & Mellins, 1992; Clark & Watson, 1988). However, it seems more likely that the time of day effects for the low and high BDI groups cancelled each other out. A diurnal variation in cheerful mood was found for the low BDI group, with cheerful mood reaching a peak in the early evening but then getting worse. This pattern is consistent with the unmasked circadian rhythm in cheerfulness (Boivin et al., in press). Although the high BDI group did not show a significant diurnal variation, the difference between the groups could still plausibly reflect a phase shift or distortion of an underlying circadian rhythm.

With respect to ultradian rhythms, over half of the 30 participants showed at least one significant ultradian rhythm in depressed and cheerful mood in the period range 3-9 hr during a 2-week period, and all but three of the participants showed significant ultradian rhythms in depressed and cheerful moods when serial dependency, trend, and day of week effects had been removed from the time-series. The best fitting periods from the raw time-series were slower than those from the residual time series. This could be due to the masking effect of changes in arousal in the raw time-series, which can introduce slower ultradian components (Lavie, 1989).

Except for the few rhythms that ran at periods that were integer divisors of 24 hr (i.e. 4, 6 and 8 hr), most of them ran out of phase with the 24 hr day. This would seem to preclude most social explanations because it is difficult to imagine an external event that occurs at systematically different times each day, which is what would be required in order to entrain a rhythm that is out of phase with the 24 hr day. Meals, for example, tend to occur at approximately the same time each day.

One possible explanation derives from studies that have shown that different moods may be associated with different types of cognitive function (Parrott, 1993; Schwarz & Clore, 1983). From this perspective, an ultradian rhythm in mood might once have conferred an adaptive advantage on an organism by ensuring that it passed through various mood like states and hence through different modes of mental
functioning. However, an artefactual explanation cannot be ruled out: Only, the number of significant fits for residual cheerful mood was substantially above the 90 significant fits that would be expected by chance alone and the number of fits for raw depressed mood was substantially below chance. Also, although there were far fewer significant fits in the comparison range 13-19 hr, this could be due to a reduced likelihood of finding significant fits in the lower frequencies.

Significant positive correlations were found in the present investigation between both the amplitude and period of the ultradian rhythms and scales of depression and psychological distress but only for raw depressed mood ratings and not for cheerful mood. However, there was significant serial dependency (first order autocorrelation) in the raw time series and the significant relationships all but disappeared when the residual time-series were used.

This implies that the relationship between ultradian rhythm amplitude and severity of depression may actually reflect an association between serial dependency and severity of depressed affect. This proposition is supported by the significant positive associations between the autocorrelation in the participants' time-series of depressed mood and their scores on the BDI and GHQ. In other words, the 2-hr depressed mood ratings of people that were more depressed were more dependent on their previous rating, which suggests that they were less responsive to external events. The variability of depressed mood was also higher with increased depressed affect. In contrast, the autocorrelation and variability of cheerful mood was not significantly related to depressed affect. The greater serial dependency in depressed but not cheerful mood with increased levels of depressed affect may also help explain the differences between diurnal variations in depressed and cheerful mood in relation to the level of depressed affect.

A number of conclusions can be made from the investigation. First, the investigation has found that diurnal variation in mood is related to level of depressed
affect. However, the relations found in this investigation may only apply to healthy individuals and not to individuals experiencing clinical depression.

Second, the investigation found some evidence for ultradian rhythms in mood and for a relation with depressed affect. However, the weak theoretical status and the practical difficulties of overcoming masking effects and ruling out artefactual explanations of ultradian rhythms argue for a concentration on diurnal and circadian rhythms in mood.

Finally, the investigation has highlighted that research on serial dependency between mood states may prove helpful to an understanding of variations in mood in relation to depression. The next chapter contributes to that research by using a nonlinear approach to investigate serial dependency in the time-series of affect and performance variables in a nondepressed group.
17
Temporal History
Dynamic nonlinear patterns in time-series of aspects of well-being

When you assess something, you are forced to assume that a linear scale of values can be applied to it .... Never at any time in the history of the world has anyone - for anything ever so slightly more complicated than the straightforward play of a ball or a 400m race - been able to come up with a code of practice that could be learned and followed by several different people, in such a way that they would all arrive at the same mark. In all the history of the world, no code of practice has ever existed for the assessment of complex phenomena. And certainly not for what crops up in the laboratory.

- Peter Høeg

*Borderliners* (1995)

Previous chapters have shown that there are both linear and cyclic components to our well-being, but does our well-being also change in ways that depend on history and are therefore deterministic but not necessarily linear or rhythmic? The last chapter showed that ratings of depressed mood were more dependent on previous ratings in people that had poorer well-being. The size of a fluctuation in mood could therefore depend on the intensity of recent mood rather than being uniform across all mood states. This investigation examines state-dependent changes of this type by adopting a graphical nonlinear approach to time-series in affect and performance variables.

Over the last decade, an increasing number of studies have investigated the processes by which the thoughts, feelings, and behaviours of individuals unfold over
A fundamental question behind much of this work concerns the extent to which it is possible to explain variations in state measures in terms of: an individual’s response to external and internal events, an individual’s personality as defined by an individual difference measure, or an individual’s previous history of states. Different studies have emphasised different sources of state variability.

For example, in a study that examined the influence of external events on daily mood in 166 married couples studied over a period of 6 weeks, Bolger et al. (1989) found that a checklist of 21 of the most common daily stressors explained 20% of the variance in mood. In a study that examined the influence of personality, Campbell, Chew, and Scratchley (1991) asked 67 subjects to rate their mood at regular intervals for two weeks, and found that individuals with low self-esteem exhibit more mood variability (r = -.37). In studies that examined the influence of previous history, Eckenrode (1984) found that mood on a given day accounted for 28% of the variance in mood on the following day, and similarly DeLongis et al. (1988) found that aggregated mood scores for a month accounted for 25% of the variance in the following month’s scores.

The relationships that have been established in these and similar studies represent an important step forward in the understanding of the dynamics of well-being. Yet it is also apparent that the predictive power of these results is rather low. It is generally assumed that adding more factors into the models and reducing the variance due to measurement error and noise will improve the situation. Work in other disciplines in recent years, however, suggests another possibility.

The statistical models on which the majority of studies in psychology are based assume that systems behave in a linear fashion and can therefore be described by linear equations. Linear equations are useful because they are additive and can therefore be combined to produce unique solutions. However, there is increasing evidence that many natural systems change in a nonlinear rather than a linear fashion. In a nonlinear
system, a continuous change in one parameter can produce a mixture of continuous and discontinuous changes in the behaviour of another parameter. This means that jumps in behaviour can occur for no apparent reason.

Nonlinear systems can be described by nonlinear equations, which are not additive and do not necessarily produce unique solutions. These equations are also iterative, which means that their solutions are fed back into the same equation. The implication of this is that the system's history of states is important in determining its behaviour. In other words, the system may react differently to the same event depending on its current state. For example, if we assume that mood is nonlinear, a song that induces a sad mood on one occasion may have no affective impact at all on another occasion. Likewise, a remark that once seemed funny may seem hurtful on another occasion.

Work on a range of nonlinear dynamical systems has shown that deterministic models can generate aperiodic or chaotic behaviour (see Gleick, 1987, for an introduction to chaos theory). The behaviour of a chaotic system is highly irregular and therefore difficult to predict. However, chaotic behaviour arises from a deterministic or rule-based system and therefore although the behaviour is complex, it is not random. The behaviour of chaotic systems can diverge wildly from very similar starting points. For example, two stones released together into a river will usually end up at very different places because the turbulent water flow is chaotic. This is known as sensitivity to initial conditions and makes long-term point prediction virtually impossible.

More recently, complexity theory (see Mitchell Waldrop, 1993, or Lewin, 1993) has shown that nonlinear systems that lie at the boundary between order and chaos can have important emergent properties, such as an increase in information processing capacity and self-organisation. In many respects, complexity theory may have more relevance for psychology because it emphasises the wider set of nonlinear
processes that are complex and often adaptive in behaviour rather than focusing on the subset of nonlinear processes that are actually chaotic and often exotic in behaviour.

The behaviour of nonlinear systems can be understood by determining their attractors in phase space. This means that each state of the system is represented by a point in phase space (an area or volume that encompasses all the possible states of the system), and unless the process is random the points will converge on a fixed subset of the space known as the attractor. The shape of the attractor depends on the system; for example, the phase-space representation of a sine function is a closed curve known as a limit cycle. The phase-space representation of a chaotic system is known as a strange attractor. The shape of the strange attractor is curved and irregular but contains self-similarity. The attractor is measured in terms of its dimensionality (Froehling, Crutchfield, Farmer, Packard, & Shaw, 1981). A first step in determining dimensionality is to embed the outputs of the system in a multi-dimensional phase space that uses time delays or lags as its dimensions (Wolf, Swift, Swinney, & Vastano, 1985). This requires sampling the system at fixed intervals.

Dimensionality may be a useful measure of certain types of functional capacity in biological systems. For example, the dimensionality of the brain EEG may be a basic measure of the complexity of information processing being undertaken. This is supported by results showing that the dimensionality of the human EEG during sleep is smaller than during wakefulness (Röschke & Aldenhoff, 1992). As well as studying the chaotic dynamics of the brain's electrical activity, attempts have also been made to model human circadian rhythms as the product of coupled cellular oscillators that are individually chaotic (Klevecz, Pilliod, & Bolen, 1991), and to model the effects of extrinsic influences on the human circadian system using dynamic systems analysis (Ortega et al., 1992).

Many psychologists are beginning to believe that these concepts represent a new paradigm for understanding system dynamics in their own areas of research (see Barton, 1994; DeAngelis 1993; Lonie, 1991; Mc Carthy, 1993). Gregersen and Sailer
(1993) have identified the types of social system that may show chaotic behaviour over parts of their domain as those that are highly iterative, recursive or dynamic over time, and those that show highly discontinuous behaviour. These systems can be characterised as transformation systems in which the state of the system at time \( t + 1 \) is a function of the system state and the environment state at time \( t \). Clearly many social and psychological processes can potentially be characterised in this way.

However, these concepts have two important implications for psychological research. First, although it will be possible to model relationships between psychological variables and make forecasts at an aggregate level, and even predict outcomes in the short-term, long-term forecasts of specific outcomes for an individual will not be possible. This is very similar to the situation faced by meteorologists, whereby their models of climatic systems enable reasonably accurate long-term aggregate forecasts and short-term local forecasts but do not permit long-term local forecasts. This must necessarily shift our scientific goals from those of prediction to understanding (Gregersen & Sailer, 1993).

Second, analytic methods that can differentiate between processes, rather than attempting individual point prediction, will be required. Standard statistical methods are blind to the presence of nonlinear, chaotic, or complex behaviour. According to Gregersen and Sailer (1993), "Such is the nature of discontinuous chaotic systems that statistical means, linear and nonlinear regressions, or structural equations are useless in one's attempt to understand chaos. However, graphical representations can help us understand chaos where these traditional analytic tools fall short".

Most time-series techniques, such as those described in chapter four, test for linear relationships within and between variables and are therefore also insensitive to nonlinear relationships. All of the commonly used time-series techniques also assume that the time-series is stationary (same mean and variance throughout). For example, both spectral analysis and cosinor analysis fit sine curves to the complete time-series and will give inaccurate results if the rhythms being modelled drift from a dynamic
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equilibrium. In some cases the researcher will test for and if necessary remove non-stationarity, for example by using difference scores between consecutive time points. However, alterations to the dynamic equilibrium may be state dependent and therefore of considerable interest. For example, changes in affect might be found to be dependent on the level of affect, or on prior sleep. Simply removing non-stationarity from the time-series is therefore not the solution if the researcher is interested in detecting and understanding asymmetric changes.

A method of time-series analysis is therefore required that does not assume the process being modelled is linear and that can detect state dependent changes. Such a method was used by Raetz, Richard, Garfinkel, and Harper (1991) in the physiological domain to show that beat-to-beat variation in heart rate depends on sleep stage. These procedures use a two-dimensional phase space with a time lag as one of the dimensions. In other words, they plot the value of a variable against its previous value. This means that they are specific instances of the more general procedures used to identify nonlinear systems (Wolf et al., 1985). This investigation applies the same graphical procedures used by Raetz et al. (1991) to analyse difference equations in heart rate, but here they are applied to the mood, symptom, social interaction experience, and cognitive performance data. The aims are to demonstrate the utility of the procedures, to improve understanding of the dynamic control of the variables studied, and to highlight a new direction for future research in this area.

Method

The investigation was based on data from the 30 volunteers that took part in the study of activity and mood. See chapter 12 for a complete description of the sample, procedure, measures and analyses.

This investigation used a subset of the measures. In particular, the measures were chosen so that comparisons could be made both within and between constructs of mood, symptoms and performance. The measures used were the 2-hrly ratings of
mood and anger, the *want more company* variable derived from the social interaction experience measures; the mean correct response times (RT-1 and RT-5) and signal detection sensitivities ($d'$-1 and $d'$-5) from the 1- and 5-target memory search task; and the symptom ratings of bodily aches, cold symptoms and difficulty concentrating. The symptom ratings correspond to items from three of the four symptom factors used by Larsen and Kasimatis (1991), respectively: aches, upper respiratory infection, and depression.

**Poincaré plots**

Two types of plot were prepared for each variable. The first was a Poincaré frequency plot in which the value of the measure is plotted on the y-axis and a previous value (lag) of the measure is plotted on the x-axis. The lag chosen in this case was the first order lag of 2-hr. The plot can therefore be viewed as the scattergram of the first order autocorrelation. If the behaviour of the variable is steady the points will tend to cluster around a single spot. Overall variation is shown in the width of dispersion of points along an axis. The range of subsequent values for any particular score is shown in the scatter of values on the y-axis for a given value of $x$. The further the points lie from the $x = y$ axis, the greater the variability in state-to-state changes. Random behaviour would be reflected by points being dispersed throughout the plot.

The second procedure (Raetz et al., 1991) plots consecutive changes in state against each other. First, difference values are obtained by subtracting the lag value from each value of the variable, and then to construct the frequency plot each difference value is plotted against the previous difference value. The resulting plot consists of four quadrants, which show the direction (+ve or -ve) and extent of change in successive intervals. The change can be either a decrease followed by either another decrease or an increase, or an increase followed by either another increase or a decrease. If successive changes are independent then the quadrants should be occupied equally; this can be tested by a chi-square test. The chi-square test requires single
category membership, and hence those values that lie along an axis (when scores stay steady) are randomly assigned to one of the two adjoining quadrants.

**Preparation of data**

Three options were available for pooling the data: use the raw scores, subtract the participant's mean score from each score, or use standard Z scores. The second option was chosen. This was because plots of raw scores were more found to be more diffuse and less clear than those reported. Further, although plots of Z scores were similar to those reported, Z scores may unduly accentuate trivial changes in self-ratings for those participants with a small range of values for a variable. The chosen option uses scores that are relative to each participant's mean score rather than using absolute scores. This has the effect of eliminating any differences that may have arisen from different participants using different parts of the scale. It is a technique that has been previously used for pooling data in intensive time-sampling studies (e.g., Bolger et al., 1989).

A score was not used if the lag of the score in the time-series was missing. The first value provided each day was not, therefore, used except as the lag of the second value or as part of a difference value, and hence the number of observations was slightly reduced. Apart from this, and unlike most time series analysis, the techniques do not require a complete data set. However, the resulting plots could be distorted by missing data if the data are missing for reasons that pertain to the process. For example, if for some reason people tended not to provide data when their mood was labile then the plots would misrepresent the phenomenon.

Identical or near-identical scores were common and it was therefore necessary to represent frequency of scores on the plots because of the number of points being plotted. The five frequency ranges were chosen so that each range included a relatively equal share of the scores.
Results

Descriptive statistics based on raw scores for all relevant variables are shown in Table 17.1.

Table 17.1

<table>
<thead>
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<th>Mean</th>
<th>SD</th>
<th>Skew</th>
<th>N</th>
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<td></td>
</tr>
<tr>
<td>Cheerful</td>
<td>11.28</td>
<td>4.43</td>
<td>-0.09</td>
<td>2752</td>
</tr>
<tr>
<td>Depressed</td>
<td>3.04</td>
<td>3.10</td>
<td>+2.20</td>
<td>&quot;</td>
</tr>
<tr>
<td>Alert</td>
<td>10.58</td>
<td>4.39</td>
<td>+0.03</td>
<td>&quot;</td>
</tr>
<tr>
<td>Tired</td>
<td>7.51</td>
<td>5.09</td>
<td>+0.5</td>
<td>&quot;</td>
</tr>
<tr>
<td>Calm</td>
<td>11.01</td>
<td>4.89</td>
<td>-0.26</td>
<td>&quot;</td>
</tr>
<tr>
<td>Tense</td>
<td>5.04</td>
<td>4.29</td>
<td>+1.18</td>
<td>&quot;</td>
</tr>
<tr>
<td>Angry (peak)</td>
<td>2.59</td>
<td>3.07</td>
<td>+3.0</td>
<td>2660</td>
</tr>
<tr>
<td>Symptoms (1-20)</td>
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<td></td>
</tr>
<tr>
<td>Difficulty concentrating</td>
<td>4.95</td>
<td>4.44</td>
<td>+1.14</td>
<td>2752</td>
</tr>
<tr>
<td>Bodily aches</td>
<td>4.54</td>
<td>4.43</td>
<td>+1.43</td>
<td>&quot;</td>
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<tr>
<td>Cold symptoms</td>
<td>3.21</td>
<td>3.87</td>
<td>+2.18</td>
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<tr>
<td>Social interaction experience</td>
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<td>2.63</td>
<td>+4.4</td>
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</tr>
<tr>
<td>Want more company</td>
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<td>Memory task</td>
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<tr>
<td>RT-1 (100ths sec)</td>
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<td>d'-1</td>
<td>4.31</td>
<td>0.83</td>
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<tr>
<td>d'-5</td>
<td>3.83</td>
<td>1.05</td>
<td>-0.69</td>
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</tbody>
</table>

Poincaré plots

The Poincaré frequency plots for affect, symptoms, social interaction experience and cognitive performance are shown in Figures 17.1 and 17.2. All of the plots except d'-1 showed a significant positive linear correlation. The smallest significant correlation was for d'-5, r(1933) = .05, p <.05, and the largest was for cold symptoms, r(2186) = .72, p <.001. This indicates that all of these variables, except possibly d'-1, were autocorrelative, meaning that the value of each variable was to some extent related to the previous value.
Figure 17.1. Poincaré frequency plots of affect self-ratings made every 2-hr for 14 days by 30 participants. All scores are expressed as the difference from the participant's mean score. Each score is then plotted against its previous value (lag).
Figure 17.2. Poincaré frequency plots of self-ratings of symptom and social interaction experience (top half), and response times (RT) and response sensitivity ($d'$) for 1- and 5-target versions of a memory task (bottom half).
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With the exception of the items tired, bodily aches and cold symptoms, all the plots show a pattern in which points scatter further from the $x = y$ axis at one end of the distribution. This is more pronounced for some variables, such as depressed, than others. Closer inspection shows that this always occurs when the score for the variable is below average in psychological, not absolute, terms: for example, when cheerfulness is low, or depression is high, or response times are high, or response sensitivity is low. This indicates greater variability from time point to time point when these variables are worse than usual.

The three exceptions show what can best be described as an elliptical shape. This implies least variability from one 2-hr interval to the next at the extremes of these variables. Cold symptoms shows the least dispersion of points from the $x = y$ axis, representing the least overall variability from one interval to the next. Cold symptoms and physical symptoms also show high frequency spots at the two ends of the distribution. This probably reflects the fact that these variables are more likely either to be absent or at a maximum than in transition between states.

In some of the plots there is an increase in the relative number of points near the $x = 0$ and $y = 0$ axes. The variables most angry, want more company, and RT-1 are the best examples. This indicates that these variables commonly changed from the zero (or mean) state to any other state.

The most diffuse plot is $d'$-sensitivity which suggests that variations in response sensitivity from one interval to the next, on a task with high memory load, were more random than variations on the other items (however see comments on $d'$ changes below).

Poincaré change plots

The plots for changes in affect, symptoms, social interaction experience and cognitive performance are shown in Figures 17.3 and 17.4.
Figure 17.3. Poincaré frequency plots of changes in self-rated affect. Each score is expressed as the difference from the participant's mean score, and is then subtracted from the subsequent mean difference score. The resulting difference score is then plotted against the previous difference score for that variable.
Figure 17.4. Poincaré frequency plots of changes in symptoms and social interaction experience (top half), and changes in response time (RT) and response sensitivity ($d'$) for 1- and 5- target versions of a memory task (bottom half).
All change plots showed a non-random distribution, chi-square(1, \(N > 1449\)) > 14.4, \(p<.001\). In all but two cases there were more points than expected in the top left and bottom right quadrants and fewer than expected in the other two quadrants. This indicates that it was more likely that positive changes were followed by a negative change in the next interval, or vice versa. For the tired item, there were fewer points than expected in the bottom left quadrant; this indicates that the least likely change was a decrease in tiredness followed by another decrease. For the cold symptoms item, there were fewer points than expected in the top right quadrant; this indicates that the least likely change was an increase in cold symptoms followed by another increase.

A number of the items showed the same distinctive distribution over the quadrants, namely a large number of points along the \(x = 0\) and \(y = 0\) axes of the top left quadrant (decrease followed by increase) and a large number of points along the negative diagonal of the bottom right quadrant (increase followed by a decrease). The best examples are the same items that frequently changed from the zero (or mean) state to any other state: most angry, want more company, and RT-1. This distribution is also shown by items depressed, tense, bodily aches, difficulty concentrating, and RT-5.

The successive changes in response sensitivity for the two versions of the memory task \((d'1\) and \(d'5\)) both show the same distinctive distribution, which is very different from the other distributions. This distribution can be described in words as a herring-bone with a "spine" running along the negative diagonal. This pattern has probably been accentuated by the fact that number of different scores is very limited, thus producing gaps or jumps in the distribution.

Discussion
The Poincaré plots have proven to be a simple and effective means of displaying the dynamic behaviour of affect and cognitive performance. Their advantage over conventional techniques is that they show how variability from interval-to-interval
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relates to the state of the variable. Unlike many time series techniques they do not
assume that the data is stationary or periodic. The discussion will focus firstly on how
the techniques have offered insights into the processes being examined, secondly on
some of the limitations of the techniques, and finally on possible further developments
and applications of the techniques.

Interpreting the plots

Many of the variables show a distribution of points representing greater
variability from one two-hour interval to the next when the value of the variable is
worse than usual. One interpretation is that this result is a consequence of floor or
ceiling effects piling up observations at one end of the distribution. However, the
distributions for the positive mood items appear normal. Furthermore, bodily aches
and cold symptoms have skewed distributions and yet show a different plot pattern to
other variables with skewed distributions, such as difficulty concentrating.

In a recent study, Combs, Winkler, and Daley (1994) also found that mood
was more likely to oscillate when people were less happy. An alternative explanation
of this result, therefore, is that the increased variability in negative circumstances is the
outcome of automatic or deliberate processes within the person that are instigated in
response to adverse situations and act to return the person to a dynamic equilibrium.
People are known to have behavioural and cognitive expectancies for alleviating
negative mood (e.g., Catanzaro & Mears, 1990). In particular, Mayer and Gaschke
(1988) found that the feeling that a mood will change soon, including repair processes
to bring it about, was more likely to occur in unpleasant than in pleasant moods. This
argument is also given indirect support by a study that used a between- rather than a
within-subjects analysis to show that depressed persons have lower levels of positive
affect but higher mood variability over the course of a day than non-depressed persons
(Hall, Sing & Romanoski, 1991); this result may, however, depend on depression type
Another possible explanation is provided by a study conducted by Schrader, Davis, Stefanovic and Christie (1990) which found that patients who were more depressed had more accurate recall, particularly for negative symptoms. However, in the present investigation, recall is less likely to be a significant factor because the ratings only refer to the previous two hours. Finally, it might be that people are better able to differentiate between negative states and hence use more of the negative ends of the scales. However, it is difficult to reconcile this explanation with performance on the memory task which shows the same pattern as affect and symptoms yet is not based on self-report.

Whatever the final explanation proves to be, the plots have revealed behaviour that might otherwise have been missed using a standard approach. For example, a within-subjects standard deviation, which is the most commonly used measure of variability, would have disguised this result of increased variability at one end of the distribution.

From the plots it appears that the dynamic behaviour of the variables falls into groups, however these groups do not always correspond to the constructs from which the variables are meant to originate. For example, responses to the anger item are more likely to make a transition to and from the zero state and less likely to make transitions between other possible states than the other affect items. This suggests that anger is more reactive than the other affect variables and perhaps should not be used as measure of mood. However, it could also be a consequence of the fact that anger was measured as a peak value unlike the other mood items.

The dynamics of tiredness appear to be more similar to physical symptom items than to the other affect items. In this respect it is interesting to note that Larsen and Kasimatis (1991) used tired as a symptom, but that it loaded on their depression factor rather than on one of their physical symptom factors. The distribution for tiredness may simply be the consequence of an imperfect autocorrelation, but it could also be explained by the fact that the variable is under circadian control. The phase space
representation of a sine function, which is the function closest to a circadian rhythm, is a closed curve or ellipse. Measurement error between participants and between time points could account for the filling of this ellipse in the plot.

Difficulty concentrating, which Larsen and Kasimatis use as a depression symptom, appears to behave similarly to the depression item but it also appears similar to response speed on the memory task, which may reinforce its cognitive aspect. Cold symptoms show the least variability and the highest correlation, which fits with the Larsen and Kasimatis finding that the upper respiratory infection factor had the longest series of significant lagged autocorrelations.

An inspection of the plots shows a general symmetry about the \( x = y \) axis. This implies that transitions up and down the scales are similar. If the transitions up and down a scale were different then there would have been an asymmetrical distribution. Had, for example, cheerfulness increased by small amounts but dropped by large amounts then the plot for cheerfulness would have shown more points above the \( x = y \) axis and these points would have been closer to this axis than the points below. It seems, however, that the increments are similar in both directions.

The plots of successive changes are a means of removing the correlation of successive intervals to reveal the dependencies of changes on previous changes (Raetz et al., 1991). In this investigation the change plots revealed an order of control not apparent in the previous plots. For example, the \( d' \) measures of response sensitivity on the memory task appear relatively random in the first plot, and yet show a high level of structure in the change plots. A parsimonious but not necessarily correct interpretation of the \( d' \) change plots is that for each change in one direction there is likely to be a subsequent change in opposite direction, but this change can take a range of values centred on one of equal magnitude.

It is well established that there are circadian rhythms in alertness (e.g., Folkard, Hume, Minors, Waterhouse, & Watson, 1985) and performance (e.g., Folkard, Wever, & Wildgruber, 1986). It was, therefore, somewhat surprising to find that successive
increases or decreases in alertness, response time, response sensitivity, and all other variables except tiredness and cold symptoms were less frequent than a change in direction every two hours. This may imply that these variables are subject to the action of short-term homeostatic mechanisms. These results are also commensurate with the presence of a high frequency ultradian rhythm (see chapter 16). Alternatively the results may be evidence of regression towards the mean, which would imply that error variation between sampling points outweighs any systematic changes in these variables.

A number of the variables such as anger, want more company and RT-1 show the same characteristic distribution in the change plots. It is interesting to note that each of the three variables mentioned was measured differently and yet gave the same distribution, perhaps indicating the robustness of the technique to different measuring techniques. One likely explanation of the distribution for these variables is that a positive change of any magnitude can follow a zero change (hence points along $x = 0$), but it will then be followed by an equal and opposite negative change (hence points along $x = -y$), that is then followed by a zero change (hence points along $y = 0$).

**Limitations**

There are, however, some disadvantages to using the plots as an analysis technique. Firstly, the plots require an ability to detect and interpret patterns, and although graphical representation is accepted practice in many disciplines, statistical parameterisation of data is the accepted practice in psychology. With sufficient data and experience it may be possible to develop a coding manual for identifying plot types, though at present this is premature. It may also be possible to compute descriptive statistics for the plots, in much the same way that Lyapunov exponents are now used to characterise the dynamical behavior of chaotic systems (e.g., Wolf et al., 1985).
Secondly, it was necessary because of the overlap in scores to use frequency symbols in the plots. It is not clear to what extent this distorts the perception of the distribution by putting undue focus on low frequency scores which are usually at the extremes of the distribution. This might be rectified to an extent by using frequency as a third dimension, but part of the distribution will then inevitably be obscured when it is reproduced in two dimensions (Chambers, Cleveland, Kleiner, & Tukey, 1983).

Thirdly, it is not known how sensitive the technique is to the way in which a measure is constructed. However, as noted above, the plots illustrated dissimilar distributions for different variables measured in the same way and similar distributions for different variables measured in completely different ways, which indirectly suggests that it is the behaviour of the variable and not just the method of measuring that is being reflected. However, difference measures are known to amplify measurement error (Webb, 1992) and this may have unequal effects on different measures and their associated plots.

Fourth, respondent reactivity may create validity threats (Gregersen & Sailer, 1993). The data from the participants were pooled in order to maximise the number of data points. This assumes, however, that the same transition matrix characterises all participants and all time periods. It was also assumed that interval level measurement characterises the participants' use of the scales, and that data are missing at random.

**Potential developments and applications**

The plots were constructed using two dimensions and a time delay of two hours. However, it is possible to construct multi-dimensional plots by using additional time lags as extra dimensions (provided they are a whole number function of the time delay), and if required the plots could have different time delays. Indeed, in order to reconstruct an attractor it will be necessary to choose the number of embedding dimensions and the time delay carefully (Wolf et al., 1985). If the number of dimensions is too low, points that are on different lobes of the attractor may be
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coincident and indistinguishable on the plot. If the time delay is too small then the
attractor will stretch along the line $x = y$, but if the time delay is too great then it may
be larger than the orbital period.

A variation on these methods would be to use a second variable as the third
dimension in the plot. For example, using an individual difference measure as the third
dimension would have the effect of showing how state-to-state changes vary at
different levels of the individual dimension. Alternatively, a daily measure such as sleep
duration or a concurrent measure such as workload could be used as the third
dimension. This would be very similar to the time crystal technique that Winfree
(1987) used to identify the resetting behaviour and phase singularities of biochemical
clocks. Based on the predictions of this work, Jewett, Kronauer, and Czeisler (1991)
have shown that given the right magnitude and timing of bright light, it is possible to
terminate or severely attenuate circadian rhythmicity in humans. It is possible that
given the right resetting stimulus, similar singularities might exist in psychological
behaviour.

The nonlinear techniques have demonstrated that some psychological state
variables exhibit dynamic behaviour that leaves a recognisable fingerprint on a
Poincaré plot. By identifying the characteristic distributions of particular variables in
different situations or for clinical sub-groups, the techniques may lend themselves to
the diagnosis or assessment of disorders of state control. Using computer technology it
would be possible to show a Poincaré plot develop one point at a time at a chosen
speed, making it a possible future tool for interactive clinical assessment of individuals.
The individual might, for example, be guided onto a different plot trajectory. However,
the sheer amount of data required from an individual to capture such processes may
make this unviable.

In conclusion, the exploratory graphical procedures for analysing difference
equations described here have proved to be a useful and simple means for
characterising dynamic behaviour in state variables. Instead of restricting investigations
to processes that are constant across time, these simple techniques enable the researcher to characterise changes that are a consequence of the adaptive interplay between people and their environment. As such they offer a promising start towards an alternative understanding of acute changes in a range of psychological variables, and of how those changes may relate to one another and to more stable trait or situation variables. This investigation has used these techniques to demonstrate that states of well-being depend on previous states in ways that are characteristic of the variable being considered.

Postscript: Chaos and mood disorders

It has recently been suggested that mood processes switch to a chaotic pattern during certain types of affective disorder, such as clinical depression (see Heiby, 1995). Indeed, there is already evidence that mood has chaotic characteristics during bipolar affective disorder. In a recent study, Gottschalk, Bauer, and Whybrow (1995) found that mood in bipolar patients can be characterized as a low-dimensional chaotic process. Their study showed that mood in this disorder is not cyclic over long periods, as had been previously assumed, but that it shows a higher degree of temporal organization than mood in individuals without a mood disorder.

It is possible that mood processes normally operate at the boundary between order and chaos as described by complexity theory (see chapter introduction) but deviate from it during abnormal conditions such as those characterizing affective disorders. This deviation could either be towards highly ordered non-flexible dynamics or towards uncontrollable chaotic dynamics. However, these ideas are entirely hypothetical at present and would probably prove difficult to test in practice.

It would also be wrong to assume that mood is only chaotic during mood disorders. For example, Combs and colleagues (1994) found that the mood of the five healthy participants in their study had a chaotic-like structure. Furthermore, Gottschalk and colleagues (1995) pointed out that the mood of their normal
comparison group may have had a high chaotic dimension that was beyond their measurement range. It also seems likely that mood dynamics vary depending on the nature of the particular disorder in question. For example, Möller and Leitner (1987) have developed a nonlinear model for analyzing mood curves which they have used to identify differences in the mood changes of patients suffering from different types of affective disorder.

The connections that are currently being made between chaos and mood, however, suggest that the nonlinear-dynamic approach to mood described in this chapter may complement the rhythm-based approach described in the last chapter. For example, Gottschalk and colleagues (1995) suggest that "an abnormally coupled or configured internal circadian oscillator involved in mood regulation could be driven to chaotic behavior by exogenous oscillations" (p. 957). In other words, chaos in mood may emerge from underlying cyclical processes. With respect to bipolar disorder, Gottschalk and colleagues speculate that psychosocial stressors may set up sustained pathologic dynamics that are responsible for subsequent bipolar episodes but that appear unlinked to the original stressors. In support of this view, Ehlers (1995) contends that patients with bipolar disorder may be particularly sensitive to social factors that disrupt their biological rhythms, and proposes the therapeutic use of behavioural and cognitive techniques to restabilize these rhythms.

These recent views and studies from the clinical domain therefore complement the findings of this and the last chapter and reinforce the need for continued research using both the rhythm-based and nonlinear-based temporal approach. In the long-term, the two approaches might be integrated and the differences between healthy and clinical populations reconciled.
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General Discussion

It is only by the way our body adapts to the varied conditions of the day, and our emotions to what unfolds in our human environment that we come to understand causality with our deepest feelings; in our viscera, as it were... As conditions differ, so does our sense of well-being - first the well-being of our body, and then the sense of well-being we get from being with others. All this makes up our primary experience of highly personalized causality.

- The Empty Fortress

*Bruno Bettelheim* (1967)

This thesis has investigated the proposition that aspects of time influence well-being. In particular, it was theorised that a person's well-being is dynamically influenced by the temporal characteristics of his or her social world, body, and experience. Two intensive time-sampling studies were used to investigate this theory. The first was a field study of sixty one shiftworking nurses, who used a pocket computer to provide measures of sleep, affect, and cognitive performance two-hourly and daily for four weeks. The second was a field study of thirty employed healthy volunteers who used the same instrument to provide similar measures for two weeks. Ten investigations, five from each study, were reported. Each investigation examined different hypotheses derived from the theory and illustrated a different temporal characteristic.
Empirical Findings

The results showed that time and well-being are deeply intertwined. In general, the first study showed that changing the timing of people's activities affects their well-being, probably by affecting aspects of body time and experiential time. The first three investigations showed that the effects of the timing, order, and duration of events depends on the temporal characteristics of surrounding events. The fourth investigation showed that the effects of external events can depend on the internal state of body rhythms. The fifth investigation showed that events can affect well-being via the influence of temporally intervening variables.

In general, the second study showed that, even without a major change in social time, aspects of body time and experiential time influence, and are influenced by, well-being. The first investigation demonstrated temporal associations between sleep and well-being. The second and third investigations demonstrated associations between mood and aspects of experiential time. The fourth and fifth investigations showed that rhythmic and nonlinear changes in well-being depend on previous states of well-being.

The results and implications of the individual investigations were discussed in detail in previous chapters but here is a summary of the main empirical findings:

Summary of empirical findings from investigations

Schedule (chapter 7). This investigation demonstrated that the timing of work affected well-being. The well-being of nurses on permanent night shifts was no worse and for some measures was better than that of nurses on rotating shifts. The early shift and the night shift caused problems for the rotating shift nurses. Mood got worse and reaction time got slower over the course of a night shift but extra slow responses and rated workload were lower on the night shift. The results are relevant to the design of shift systems, in particular to the types of shift system used by organisations.

Sequence (chapter 8). This investigation demonstrated that the order of work shifts affected aspects of well-being. Of all possible combinations of early and late shifts and rest days, an early shift that was preceded by another early shift (EE) was
associated with the greatest disturbance to well-being, whereas an early shift preceded by a rest day (RE) was associated with the least disturbance. Yet the EE combination was the second most frequently worked combination, and RE was the second least frequently worked combination. The results are relevant to the design of shift systems, in particular to the development of guidelines for sequencing shifts.

Duration (chapter 9). This investigation demonstrated that the amount of rest between blocks of work shifts affected aspects of well-being. Well-being was worse on rest days that followed a night shift and tended to be worse on first rest days compared with subsequent rest days. Some aspects of well-being, such as social satisfaction, were better on workdays that were preceded by two rather than one rest day. The results are relevant to the design of shift systems, in particular to development of guidelines for scheduling rest periods.

Interaction (chapter 10). This investigation demonstrated that the timing of shifts interacted with the menstrual cycle to affect aspects of well-being. For example, alertness was lowest at the end of the night shift during the premenstrual phase. There was also an association between the number of nights worked per year and severity of premenstrual problems. The results are relevant to research on occupational health risks for female shiftworkers.

Association I (chapter 11). This investigation demonstrated that there were latent within-day associations between type of shift worked, sleep behaviour, workload, and well-being. The association between work shifts and subsequent mood was mediated by sleep. The association between sleep and subsequent social satisfaction was mediated by mood. Workload was associated with subsequent mood but not with subsequent social satisfaction. The results show that shiftworkers' daily well-being depends on complex temporal relations with other daily variables.

Association II (chapter 13). This investigation demonstrated that there were associations between sleep behaviour and next-day well-being, and between well-being and subsequent sleep behaviour in non-shiftworkers. An earlier sleep onset was associated with better mood and social interaction experience the next day and was a
better predictor than sleep duration. These results have been supported by recent research showing that there is a circadian rhythm in cheerfulness that is affected by the timing of sleep. The results have relevance to the regulation of mood and to models of chronobiologic mood disorder.

**Awareness (chapter 14).** This investigation demonstrated that changes in mood predicted participants' perceptions of the speed of time, but that speed of time did not predict changes in mood. Time passed faster when participants were happier. There was no evidence that time that was perceived as fast in passing was perceived as slow in retrospect. The results suggest that the passage of time can be affected by mood.

**Prediction (chapter 15).** This investigation demonstrated that participants were not very accurate in predicting their subsequent mood but were more accurate when they made their predictions in a better mood or predicted a better mood. Mood was more influenced by predicted mood and subsequent hassles than it was by retrospective mood and previous hassles. Mood was also more likely to improve when participants expected it to improve, even after controlling for hassles. The results suggest that mood prediction may have a mood regulatory function.

**Rhythm (chapter 16).** This investigation demonstrated that participants with lower well-being were more likely to show diurnal variation in depressed mood, with mood getting worse over the day. Participants with reduced well-being were also more likely to show higher amplitude ultradian rhythms, although this probably reflected an increase in serial dependency between mood states. The results have relevance to the chronobiology of depression.

**History (chapter 17).** This investigation demonstrated that different aspects of well-being show different state-dependent changes over time. These dynamic patterns can be uncovered using simple nonlinear graphical techniques. Many of the variables showed a pattern in which there were greater changes from one time interval to the next when well-being was worse than usual. The results suggest that well-being may involve complex, even chaotic, nonlinear processes. This has been supported by recent research showing that mood has a chaotic-like structure.
The thesis also described the development and validation of a research instrument for collecting affect and performance measures in intensive time-sampling studies. This instrument was a software environment for a pocket computer, which can be used to signal respondents and record their responses. The instrument has proven its reliability and usability in both field and laboratory settings, and has been used successfully by a number of research groups worldwide for a variety of research purposes, including studies of the effects of jet-lag, sleep loss, phototherapy, melatonin, food, skin cream, caffeine, benzodiazepines, workload, and work schedules.

Methodological limitations

The intensive time-sampling methodology used in this thesis has a number of limitations as a research method. Some of these limitations have already been discussed. For example, repeated frequent measurement can cause problems such as response decay, response habituation, and reactivity. However, other limitations of the time-sampling method arise from problems concerning measurement error and analysis.

There are two types of measurement error: random and systematic. Random error occurs because responses to scale items are not a perfect measure of the construct being measured. One of the usual ways of reducing random error is to have a large number of items for each construct. Increasing the number of items usually leads to higher reliability estimates. However, although this is a viable approach in survey methods, it is not a practical approach in time-sampling studies because of the high demand put on participants by repeated measures of each item. The use of multiple items also introduces possible systematic errors in measurement.

Systematic error arises when there is some form of response bias that causes errors to be correlated. Response style is a common source of systematic error. Response style is the tendency for participants to respond in a uniform fashion to items that have the same format. For example, a particular participant may always avoid the ends of scales. The visual analogue scales that were used in this thesis are less prone to systematic errors than adjective checklists (Green, Goldman, & Salovey, 1993) but are
still susceptible to errors from response style. The studies in this thesis frequently measured different constructs using the same method or format. Consequently participants might have responded similarly to the common format, hence inflating the amount of response variance that appeared to be shared between constructs. This is known as the problem of common method variance and in some cases can even reverse the sign of a true correlation between variables.

One way of reducing such measurement errors is to use a multimethod approach, in which different formats are used to measure the same construct but with fewer items on each format (Green, Goldman, & Salovey, 1993). The multimethod approach doesn’t eliminate systematic error within each format but the redundancy in method improves the robustness of the results. However, the practicality of using a multimethod approach in intensive time-sampling studies is questionable because of the high demand it would put on participants.

Another measurement concern in time-sampling studies is the use of factor analysis. Factor analysis is usually applied to data measured at a single timepoint or to data that have been aggregated over time. The alternative approach taken in this thesis was to use factor analyses based on a pooled time-series method. However, this approach still assumes that constructs are stable over time. In practice, items could load on different factors or have different loadings for different time frames. For example, a preliminary analysis of the mood data from the study of activity and mood has revealed that alertness and tiredness load on one factor for the two hourly ratings, possibly due to circadian influences, but load on different factors for the daily ratings. Some researchers have begun to develop a dynamic approach to factor analysis that enables the investigator to examine lagged factor structures in time-series (e.g., Molenaar, 1985), but these methods are still immature and the results are difficult to interpret.

Another measurement problem that can affect the analysis of data, but is not restricted to time-sampling studies, occurs when variables are very similar and therefore likely to share response variance. High inter-correlations between variables
can lead to problems of multicollinearity during analysis. Relations between variables can be suppressed or distorted by the influence of highly correlated variables, particularly when independent variables are entered into a regression equation at the same time. However, good statistical packages usually detect and report major problems of multicollinearity. Care was also taken, during the analysis of the studies in this thesis, to examine the influence of variables with and without the entry of other variables.

Other threats to the veracity of the findings in this thesis arise from the methods of analysis that were used and their underlying assumptions. For example, the methods used generally assume that all time intervals are equivalent, changes are linear over time, and constructs are measured with complete reliability. These assumptions are clearly unlikely to have been fully met in reality. For example, chapter 17 demonstrated the presence of nonlinear effects. In practice, however, these threats are unlikely to have undermined the general thrust of the findings because of the high level of plausibility and consistency of results both within and between investigations.

The pooled time-series analyses that were used make a number of additional assumptions. These analyses used dummy variables to remove between-subject differences. However, this technique assumes that participants differ only in the level of their time-series, but the slopes of the time-series could also differ. Participants could also differ in their response variability. Differences in variability could reflect differences in participants’ response style, differences in participants’ sensitivity to the construct, or differences in the situations that the participants experienced. These differences could be eliminated by converting the time-series into standard scores prior to analysis. However, standardisation could distort some participants’ time-series, especially if the time-series contain a few extreme scores.

Some of the control variables used in the pooled time-series analyses also made additional assumptions about the nature of the effect being controlled. For example, serial dependencies in the time-series were removed by using terms for the first order autoregressions, but first order autoregression is only an approximate model of serial
dependency. Likewise, the influence of practice and habituation in the time-series were removed by using control variables that assumed these effects were linear over time. In practice, these effects are sometimes better estimated by exponential or higher polynomial functions.

The methodology therefore has a number of limitations. However, it is interesting to note that many of these limitations are temporal in nature, which further reinforces the importance of temporal issues in psychology. In fact, the major threat to external validity in this thesis is that the findings are based on time-frames that may not generalise to other time-frames. The bihourly, daily, and weekly time-frames were chosen so that they would be sensitive to a range of within-day and daily effects arising from everyday life. It is plausible, however, that a different choice of time-sampling frequencies and time-sampling duration might have lead to different conclusions. However, with these limitations in mind, some conclusions can be made from the results of the two studies.

Theoretical Implications

Time

Chapter 2 described how McGrath and Kelly's (1986) framework categorises time into structure, reality, flow, and validity. The framework splits each of these categories into two dimensions and the resulting eight dimensions can be used to distinguish between classical, Einsteinian, transactional, and Eastern mystical views of time. The eight dimensions are: divisible vs holistic, differentiated vs homogenous, concrete vs abstract, relational vs absolute, phasic vs linear, directional vs reversible, low convergence vs high convergence, and high discrimination vs low discrimination. Using McGrath and Kelly's categories and dimensions, the results of the two studies in this thesis reinforce the transactional view of time. This is probably not surprising given that the results emerged from a transactional paradigm. However, for the record, this is how the transactional view was reflected in the results.
General Discussion

The structure of time was divisible and differentiated because not all time intervals were equivalent and their effects depended on events. For example, in the first study, work shifts of equal duration had different effects at different times of day. The reality of time was concrete and relational because time had effects on well-being that depended on relations between events or depended on the observer. For example, in the first study, the amount of time off for recovery between shifts had concrete effects on well-being that depended on the type of shift worked previously. Other examples are that, in the second study, mood prediction had concrete effects on concurrent mood, and the experience of the speed of time depended on people’s mood.

The flow of time was phasic and directional because time showed cyclic and historical effects. For example, in the second study, there were consistent rhythmic variations in mood each day but successive mood states were shown to be dependent on previous mood states. The validity of time was low on convergence because different constructs of time were necessary. For example, distinctions were made both within and between body time and experiential time. The results provide no information on the discriminant validity of time because it is impossible to know whether or not the constructs were independent of other constructs such as space and motion.

The transactional view is that constructs of time are independent of space and motion but it would be interesting to know whether the results of this thesis would have been different if, for example, participants’ movements and speed of motion had been altered in some way. There is some evidence to suggest that motion can affect the experience of time and vice versa. For example, elite athletes have a changed experience of the passage of time during races (see Moiseeva, 1988), and some people have been found to walk more slowly during unemployment (see Jahoda, 1988). However, other factors such as level of personal involvement may explain such results.

Well-Being

The standard view of subjective well-being is that it is a relatively stable construct and that changes in well-being over time can therefore be largely ignored or
averaged out. There is some support for this view. For example, standard measures of well-being generally have relatively high long term reliability coefficients and relatively high cross-situational consistency. The factor structure of mood ratings has also been found to be consistent over different time frames (however, see the comments earlier in this chapter on the limitations of factor analysis).

Other research, however, has suggested that there are instabilities in well-being over time that need to be addressed. For example, some studies have shown that subjective well-being is affected by current mood. It has therefore been proposed that these transient effects should either be partialled out or that well-being should be measured by the mean of regular assessments (Yardley & Rice, 1991). Other studies have shown that a significant number of people change classification on depression inventories only days after initial testing. It has therefore been recommended that depression should only be diagnosed following assessment at multiple timepoints (Tennen, Hall, & Affleck, 1995).

Additional analyses of the two datasets used in this thesis lend support to both the stable and the unstable views of well-being. For example, a comparison of the two-hourly alertness ratings from the nurses in the shiftwork study with a survey measure of their general alertness at different times of day showed highly reliable cross-correlations. This suggests that the pattern of alertness over the day is relatively stable and therefore generalises to other days. However, the average of the cross-correlations from each participant accounted for less than 40% of the common variance. (Folkard, Spelten, Totterdell, Barton, & Smith, 1995). Similarly, an analysis of the mood ratings from the second study showed that an average of the two-hourly ratings provided a good estimate of the retrospective daily ratings. However, the peak mood during the day and the most recent mood explained additional variance in the retrospective daily ratings, and there were large individual differences in the accuracy of retrospective reports (Parkinson, Briner, Reynolds, & Totterdell, 1995). This suggests that both averaged momentary assessments and retrospective assessments may miss salient information.
Both the stable and unstable views of well-being therefore have merits. However, this thesis draws a different conclusion. The findings of this thesis suggest that well-being partly depends on temporal dynamics and can therefore only be fully understood by considering its multiple temporal characteristics. Generalised measures and averaged multiple assessments of well-being may be suitable for examining coarse relations between aspects of well-being and certain other variables, or for crude diagnostic classification. However, such measures misrepresent important temporal characteristics of well-being and may therefore prove misleading to understanding the processes involved. Previous research has put too much emphasis on the measurement of well-being and not enough on the processes. The next section will show that the processes of well-being and time are perhaps even closer related than previously thought.

**Time and well-being**

The results of this thesis have supported the theory of temporal aspects of well-being. However, the theory made minimal assumptions about the relationships between time and well-being. The results when considered in the light of other available evidence suggest that a much stronger position is possible. This position will be described here. The following is a statement of the reformulated theory of the temporal aspects of well-being:

**A person's well-being is the emotional aspect of consciousness that arises from dynamic temporal relationships between the body and constructive memory as a consequence of dynamic everyday interactions with the social world.**

In this statement, well-being is no longer viewed as merely influenced by time. Instead, well-being is bound to time such that without time, that is without relations...
between past, present, and future states of well-being, well-being becomes something that is abstract rather than felt.

The reformulated theory introduces the notion of well-being as an aspect of consciousness. Well-being is now deemed to be people's ongoing consciousness of their embodiment in the world in relation to their self-image. Embodiment refers to the stream of information that is generated by a body as it acts within its physical and social environment. Self-image refers to the dynamic interpretation of previous and anticipated experience in relation to current experience. The term self-image is preferred to body image (which is frequently used by others -see next few pages) because it is intended to capture people's representations of their social self as well as their body.

The dynamic interpretation of self-image is what is meant by constructive memory and refers to the fact that that the development and recall of memories (including plans and expectations) depend on current embodiment. In other words, memories are not absolute and independent of time but instead relational and changing over time. The dynamic nature of the relationships is intended to incorporate the notion of nonlinear processes, which in practice means that well-being may show discontinuities and irreversible transitions over time.

Time in this new view only has concrete meaning to the person in the sense that it is constructed by interpreted relations between past, present, and future states of the person. This means, for example, that the concept of “last Tuesday” is given emotional meaning through its relations to the person’s embodiment. Without embodiment, the concept of “last Tuesday” would merely be an abstract signifier that could be used for reasoning but that would not have special self-significance (see Rosenfield, 1995).

Although well-being is now asserted to be an aspect of consciousness, this is not meant to imply that a person has continual awareness of well-being. Nor does it mean that the processes involved are all conscious, in the sense of being deliberate and intentional. Well-being is, however, considered to be a subjective experience.
Nevertheless, consistencies in external and internal processes across people mean that peoples' well-being is broadly comparable in comparable circumstances.

The theory predicts that well-being will be disturbed whenever the temporal dynamics of the body, constructive memory, or social world are compromised in some way. It also predicts that this disturbance will be accompanied by a distorted sense of time because of the interrelatedness between the experience of well-being and the experience of time.

These ideas and predictions are speculative and partial but they will be given support in the sections that follow by showing that the reformulated theory has its roots in phenomenology, is consistent with a recent reinterpretation of classical neurology, may have a neurophysiological basis, and is consistent with cases of extremely disturbed well-being. This will lead to some new directions for research.

**Philosophical antecedents.** Some of the ideas contained in the reformulated theory are reminiscent of views expressed by certain phenomenologists. For example, the view that a person's being (but not specifically well-being) is bound up with time was expounded by Heidegger in his treatise “Being and Time” (see Heidegger, 1927/1962, 1968). The treatise’s principal concern was the everydayness of existence. Heidegger proposed that there were three modes of being, or existentialia, corresponding to state of mind, understanding, and discourse. In the first mode, being placed in life (known as dasein) is said to manifest itself in moods (known as stimmung or gestimmstein). With respect to temporality, Heidegger believed that a person’s being is directed towards the potentiality of the future. On the relation between mood and temporality, Heidegger remarked that “Except on the basis of temporality, moods are not possible in what they signify in an existential way or in how they signify it”. This implies that moods are made concrete by relations between past, present, and future. Kierkegaard (1843/1992) also believed that happiness depends on how a person focuses on the past, present and future. For example, the following point, which he attributed to Hegel, “The unhappy man is always absent to himself, never present to himself. But one can be absent, either in the past or in the future”. This means that
individuals are unhappy when they are either hoping or remembering in such a way that they do not see themselves as being part of those hopes or memories.

Embodiment has also been an important theme in phenomenology. For example, Schilder described a phenomenological view of the body as a lived experience in his book "The Image and Appearance of the Human Body" (Schilder, 1935/1964). Schilder was concerned with the constructive nature of body consciousness. In particular, he discussed the physiological, libidinous, and sociological structure of a person's body image. According to Schilder, the body image is "the picture of our own body which we form in our mind" and is a fundamental aspect of personality. The libidinous structure of the body image refers to its emotional tone, which he thought affected both cortical activities and vegetative functions such as temperature and metabolism. However, Schilder also believed that the body image is constructed through social relations. He proposed that these relations depend on a continual interchange between a person's own body image and the body image of others. The connections that Schilder made foreran some of the ideas expressed in the reformulated theory. For example, Schilder's connection between the emotional tone of the body image and homeostatic processes is very similar to the proposed relations between well-being, self-image and aspects of body time (including the body clock). Likewise his proposal that the body image is continually being constructed through social relations is very similar to the idea that well-being depends on the ongoing relationship between the body and constructive memory in the context of everyday social interactions.

The phenomenological view of embodiment as a lived experience has become an important theme in medical sociology (see Shilling, 1993; Turner, 1992). Some medical sociologists have argued that the body is often experienced as an alien environment during illness, leading to a loss of identity or transformation of personhood. However, other sociologists have developed an alternative framework in which the body is seen as a discourse about the nature of social relations. In this framework, the body is socially constructed through the power of institutions. Turner
General Discussion

(1992) reconciles the two views by arguing that although changes in embodiment can affect a person's self-identity, the exact nature of the change in self-identity depends on the cultural framework. This reconciled view is supported in the reformulated theory of well-being by the recognition that dynamic relations within the person depend on everyday interactions with the social world.

Consciousness, well-being, and time. Using the concept of body image introduced by Schilder and others, Rosenfield (1995) has recently challenged the classical neurological view that individual memories are stored in specific locations in the brain. Rosenfield has re-examined many case histories of neurological damage and found that there is usually evidence of profound changes in consciousness. These changes are indicative of broader functional damage rather than impairment or loss of localised memory functions. His explanation of these profound changes is that memory is an integral part of consciousness. Rosenfield believes that memory emerges from the relations between the body and the brain's image of the body in relation to its surroundings. These relations, which are part of a dynamic self-referencing system, create a sense of self that has continuity but that evolves over time. In his view, understanding requires a frame of reference and that reference is the body image.

However, according to Rosenfield, it is not just understanding that requires the body image as a frame of reference. Sensations from the body, emotions, and a sense of time also require it too. According to Rosenfield, all these things are given meaning by the self-referencing set of relations between past and present body image. On time and feelings, Rosenfield writes, “Time is relational, and without a body image, one's temporal relation to the world is inevitably destroyed. And hence the self to which remembered events refer is abstract; one knows that self felt pain or joy, for example, but can no longer really feel that pain or joy except in an abstract way” (p. 133).

Rosenfield supports these claims using cases in which damage to memory or changes in body image have resulted in a loss of the sense of time, loss of sense of self, and loss of feeling. For example, Korsakov patients, who have little retention of events in the immediate past, have no sense of time and no sense of self. Changes to the
senses and hence the body image can also lead to a different sense of time. For example, the blind often have the feeling that time hardly passes because they can only measure time in relation to the movement of their own body, becoming aware of events only after they happen. Rosenfield has also proposed that cases of multiple personality can be explained in terms of a breakdown of a single integrated interpretation of the body image into multiple dissociated interpretations. In such cases, each personality often has its own characteristic emotional state and its own sense of time, which further reinforces the connections that the reformulated theory makes between consciousness, well-being and time.

Other researchers are reaching similar conclusions about the relation between body image and self-consciousness (see Bermudez, Marcel, & Eilan, 1995) and recent neurological evidence suggests that these ideas may have a physical basis. For example, Kinsbourne (1995) has identified the location of neurological mechanisms of selective attention that focus awareness on body parts. According to Kinsbourne, these mechanisms are guided by the person’s knowledge about his or her body and may be a precursor of the development of a sense of self. Like Rosenfield, Kinsbourne believes that memory processes use the background awareness of the body to anchor remembered events to the self. The next section will show that there is also broader neurophysiological evidence for the reformulated theory and its allies.

Neurophysiological mechanisms. Much of the emotional activity of the brain is thought to originate in the limbic system. It was previously thought that the limbic system was relatively unimportant to the higher conscious functions of the brain. However, it is now known that information in the brain is transmitted not only via the pathways of the neurons but also via extracellular fluid in a process known as volume transmission. Volume transmission means that the limbic system can influence all of the nervous system. Consequently, the cortex has more inputs from the limbic system than the reverse. Therefore, although the cortex and limbic system regulate each other, the traditional view that the cortex dominates the limbic system or that reason dominates emotion is wrong (see Cytowic, 1994).
Damage to the limbic system can cause changes in memory as well as changes in emotional reactions. There is a known feedback circuit from the hippocampus of the limbic system to the cortex (see Bowsher, 1979), and it is probable that this circuit mediates memory-related processes. The hippocampus may therefore act as a gateway for new information. In support of this view, the hippocampus is known to emit a theta rhythm whenever new stimuli are attended (and during REM sleep), and damage to the hippocampus leads to an inability to retain new information (see Cytowic, 1994).

There is also evidence that the limbic system is involved in processes concerning the emotional consciousness of time. Parts of the limbic system within the temporal lobe have a low threshold for seizure. This can lead to temporal lobe epilepsy. Temporal lobe epilepsy causes changes in consciousness including automated actions performed without awareness, hallucinations, an inability to distinguish between dreaming and reality, and distorted time sense. Electrical stimulation of the temporal lobe can also make patients emotionally experience and relive events from the past in real time (see Cytowic, 1994).

The limbic system is also involved in the regulation of body time. The hypothalamus of the brain, a structure that lies close to the limbic system, is responsible for the maintenance of internal milieu in the body, including temperature, wakefulness, and hunger. In chapter 2, the hypothalamus was also described as the site of the primary body clock. This means that it is responsible for the generation of endogenous circadian rhythms and other timekeeping functions. It is also known that the hypothalamus communicates with the cortex via the circuits of the limbic system, although the exact function of these circuits is unknown.

Taken together, this anatomical evidence suggests that “the limbic system is essential for establishing the correlations between body image and external stimuli that are the basis of consciousness” (Rosenfield, 1995). Not only does the limbic system look like it has the necessary connections for establishing dynamic relations between the body and body-image (assuming that it is the cortex that holds the model of the body), but its associations with the temporal lobe and with the hypothalamus may fulfill
the combined emotional and temporal functions required by the reformulated theory of
the temporal aspects of well-being.

However, it must be stressed that these neurophysiological systems could only
provide the biological means for instantiating the reformulated theory. The theory also
opines that people’s well-being depends on the meaning of dynamic relations between
people and their social world. Understanding a person’s well-being therefore also
requires knowledge of the person’s belief systems, history, and cultural framework.
This includes understanding the social norms for ordering time.

Social interaction (the case of autism). An example of the importance of social
relations to the experience of well-being and time is provided by the case of autism.
Autism, which was originally identified as a disturbance of affective contact, is
characterised by an extreme inability to communicate socially. A range of biological,
behavioural, psychodynamic and cognitive theories have been proposed to explain
autism. Some of the more recent theories are based on the idea that autism represents
an inability to construct and manipulate mental representations (or beliefs) about the
external world (see Frith, 1991).

One of the characteristics of autism is an intense desire to preserve sameness.
Autistic children will often direct their efforts towards stopping events, even insisting
that time stands still. All forms of relation, including those implied by causality, are
viewed as destructive by the autistic child. By suppressing time, the autistic child
attempts to avoid the possibility of disappointment but at the same time loses the
possibility of hope.

Autistic children are usually unable to make predictions, or they only predict
what will not happen and try to order events to make this prediction come true.
Bettelheim (1967), who did much of the pioneering work on understanding autism,
points out that it is “better not to tremble ahead of time, if we cannot prepare for, or
change it”. He observes that the ordering of events precedes prediction, and prediction
precedes goal-directed action. This means that the less people can act the more they
predict, and the less they can act and predict the more they order. As a result, autistic
children often spend a lot of time ordering objects and events in obsessive rituals that have no purpose.

Time and space are not conceptualised as separate by the autistic child. For example, to an autistic child, school can mean the place, the teacher, or the time of day the child goes to school. The concept of time as a separate category begins to emerge during recovery from autism. This is illustrated in the following extract from a case history (taken from Bettelheim, 1967) in which an autistic child (Marcia) begins to develop a relationship with her counsellor (Karen): “Time had entered her life as an experience and a concept, and there was a future in her life: when Karen would return. Time was now broken into an orderly sequence of events; the presence or absence of Karen gave emotional rhythm to Marcia’s day ... This rhythm she wanted to learn to understand, because then she would be able to predict when Karen would be with her ... So Marcia developed a concept of time, learned to name the days of the week ... As people in her present world became real and she looked forward to seeing them in the future she also acquired a more definite sense of what had happened in the past”.

Bettelheim speculated that the development of the concept of time is related to an increase in concern about bodily functions. Autistic children often seem alienated from the signals of their own body, showing loss of pain reaction, loss of feelings, and loss of self. Bettelheim likened these reactions to the changes of personality exhibited by many prisoners in the extreme situation of German concentration camps. The destruction of personality that he witnessed in the camps included loss of all hope and plans, replaced by certainty of imminent death, loss of physical coordination, emotional depletion, delusional fantasy, and eventually abandonment of self. Unfortunately, methods for dissolving well-being through the systematic disruption of aspects of time, for example by solitary confinement and sleep deprivation, are widely-known and widely-practiced.

New research (body listening). The evidence that has been presented for the reformulated theory of the temporal aspects of well-being is clearly partial. However, the range of topics that have been covered suggest that the theory could potentially
unify and embellish a number of diverse strands of research. In the same way that the weaker version of the theory was used to establish a program of research for this thesis, the reformulated theory could also be used to generate a research program. This thesis therefore ends by starting that process.

One of the common elements of the topics described in the last few pages, such as embodiment, consciousness, and autism, seems to be people's conscious experience of their body over time. The understanding and interpretation of one's own body experience has recently been termed body listening. This term was first coined in a study of diabetics but the concept has subsequently been explicitly studied in healthy and chronically ill adults (Price, 1993). For example, Price used a phenomenological approach involving interviews and diaries to identify features of what she called people's body paradigm.

One of the key features of this paradigm turns out to be people's awareness of their personal daily rhythms, especially in relation to their energy levels. Other features include past body experiences, physical experiences of others while growing up, in the moment awareness (of symptoms for example), and personal gnosis (knowing what is usual or characteristic of one's own body). According to Price, the body paradigm forms the background against which people evaluate new physical experiences.

Many of the features of the body paradigm have much in common with the theory of temporal aspects of well-being presented in this thesis. The importance of personal body rhythms, the relation between present and past body experiences, and the temporality of the social and experiential aspects of the phenomenon, all suggest common ground. Research on body listening, and in particular its temporal aspects, has clearly only just begun. Potentially, however, it offers rich pickings for an understanding of self-concept and changes in self-concept during illness, and for the treatment of illness. For example, Price (1993) believes that people's "expert" knowledge of their own body responses over time could be used beneficially in treatment protocols during illness. A research program that develops and investigates
concepts of body listening and other aspects of body consciousness over time in both healthy and ill populations therefore seems warranted.

Conclusion

This thesis has demonstrated that a person's well-being is dynamically influenced by the temporal characteristics of his or her social world, body and experience. A temporal approach to the study of well-being is therefore justified. New ideas concerning consciousness, emotion, and neurophysiology suggest that the relation between time and well-being may be much stronger than first thought. Concepts such as embodiment, body image, and body listening appear to be reconcilable within a temporal framework. Our understanding of health and well-being may therefore be facilitated by advances in our understanding of temporality.
Epilogue

Each chapter in this thesis began with a quote. Sometimes authors use quotes to show that the concepts that they are exploring stem from an ancient and learned tradition. This was not the intention here. Most of the quotes used in this thesis were modern and most were written by non-scientists. Some of the quotes were plucked from texts that probably contained little else of relevance. However, many of the texts contained considerable insights into the issues of time and well-being. Observations in three of the texts in particular seem to both reinforce and expand the theory of temporal aspects of well-being, and will therefore be described here.

In his book *Einstein’s Dreams*, Alan Lightman (1994) uses a series of very short stories to describe how people’s lives would be different if time were different. In each story, time has a different nature, for example: it repeats, it fragments, it is sticky, it runs backward, its speed depends on events, it offers glimpses of the future, it lasts for one day. In one of these stories, time has a shifting past in which time is “a pattern of images that shift with each disturbance of a sudden breeze, a laugh, a thought”. The main character in the story wakes up and can only remember a past event that caused him great shame. As a consequence his mood and personality takes on the burden of that shame. However, the past then shifts and he can only remember a triumphant time and hence his demeanour changes accordingly. In this simple story, Lightman illustrates how the past affects present well-being. Of course in our time, the time of our world, we have many past moments on which to reflect our present selves.

In her autobiography, *Prozac Nation*, Elizabeth Wurtzel (1994) describes her experience of time in relation to her depression. For example, “Time became palpable and viscous. Every minute, every second, every nanosecond, wrapped around my spine so that my nerves tightened and ached. I faded into abstraction”, and “I see that he has no idea how long and hard and palpable time is for me, that even four minutes of feeling the way I do right now is too long”. She also describes how she deals with her
diurnal mood changes, "I figured out that I could manage my mood fairly well if I stuck to a rigorous chemical routine of beer and wine in the evenings, followed by mornings of major uppers", and how she uses time to make herself feel better, "Instead of thinking that there was no future, all I did was plan for the future, treating the present tense and all its tension like a lengthy, labored preamble to a real life that awaited me somewhere, anywhere but here".

Some of Wurtzel's comments fit well with the concept of the developing and relational nature of well-being and personality. For example, "Every day you might come to some new conclusion about yourself and about the reasoning behind your behaviour, and you can tell yourself that this knowledge will make all the difference. But in all likelihood you're going to keep on doing the same old things. You'll still be the same person. You'll still cling to your destructive debilitating habits because your emotional tie to them is so strong - so much stronger than any dime-store insight you might come up with - that the stupid things you do are really the only things you've got that keep you centred and connected. They are the only things about you that make you you", and, "What I'd stopped realising was that if you feel everything intensely, ultimately you feel nothing at all. Everything registers at the same decibel so that the death of a roach crawling across a Formica counter can seem as tragic as the death of your own father."

Peter Høeg (1995) provides an important and compelling account of how time affects well-being in his novel Borderliners. Borderliners is the story of three emotionally damaged children who were brought up in a Danish school during the 1960s as part of an experiment on integrating delinquent and learning retarded children in state schools. The book eventually reveals that one of the children, the narrator of the story, was Høeg himself. The narrative describes how the children came to understand and undermine the secret of the school, which was its oppressive use of linear time. "We were held down as tightly as anyone can be held down by a clock. So hard, in fact, that if your shell was not very thick, then you fell completely or partially to pieces". The school with its rigid timetable, its system of class years, its regular
assessments, and its unchanging background reveals itself as a device for removing doubt, a system in which time seems to raise you up, “There are lots of places out there where time drags you downwards towards destruction. That is what they must keep out. You must be left in no doubt that the world raises you up, otherwise it would be impossible to cope with the expectations. Coping is something you do best when you believe in time. If you believe that the whole world is an instrument through which you become elevated, just so long as you do your best - that is the metaphor the school presents.”

The story broadens to include a discussion of the nature of time, theories of time, the motives of the theorists, and the consequences for the social regulation of time. Høeg’s own view is that, “Time comes into being when the mind encounters the world in a normal life.” He proposes that the perception of time involves the consciousness of change and constancy. This consciousness depends on the sensory apparatus and on language. Høeg provides many examples of how time is used in language to cope with feelings. For example, “When children cry, you talk to them about tomorrow .... You move their awareness on a day, away from their lives. You introduce time into their lives.” This is also an example of his view that time is bound up with human fellowship, that people are involved in its creation and maintenance.

Høeg refers to the fact that historically time has been perceived as both linear and cyclic, but that the linear view is now predominant and permeates everything. In his view there are multiple times and each is valid, “Time refuses to be simplified and reduced. You cannot say that it is found only in the mind or only in the universe, that it runs in only one direction or in every one imaginable. That it exists only in biological substructure, or is only a social convention. That it is only individual or only collective, only cyclic, only linear, relative, absolute, determined, universal or only local, only indeterminate, illusory, totally true, immeasurable, measurable, explicable or unapproachable. It is all of these things”. Høeg clearly believes that the dominance of the linear view of time has had adverse consequences, “If you grow up in world that
only permits and rewards one form of memory, then force is being used against your nature. Then you are imperceptibly nudged out towards the edge of the abyss”.

However, according to Høeg, “It is important that people enter the laboratory every now and then, and ask questions of a different kind to those that are otherwise asked. If we are all maintaining time, then you have a place of your own, then it matters that you do something slowly, then even an experiment as transitory as this one can serve to touch time, in such a way that it will change”. Høeg is referring to his own kind of laboratory, presumably the writing laboratory in which he produced his book, but it is also the perfect justification for this thesis.

Finally

This thesis began with a quote from a fictional night security worker named Brian. By coincidence, the first validation of the methodological instrument used in this thesis, the pocket computer, was a study of site-security shiftworkers. These shiftworkers rotated between a week of night shifts, a week of afternoon shifts, and a week of early shifts in a 28 day shift cycle. One of these shiftworkers, Ken, provided an almost complete dataset of two-hourly self-ratings over a shift cycle. Figure 19.1 shows some of Ken’s self-ratings at different times of day and night averaged over the shift cycle.

The figure shows that time passed faster for Ken when he wasn’t at work. Ken had the least regrets about being at work during the night, even though time passed most slowly for him at night. Like Brian, Ken wasn’t particularly bored at work even during the night. Perhaps Ken also contemplates his future at night. Perhaps Ken also feels that his future is an interesting place to be.
Figure 19.1. Self-ratings of a security worker at different times of day averaged over a 28 day shift cycle.
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