INTRODUCTION

Mental fatigue at work is not only an interesting scientific topic; it is also a pressing social problem. For instance, in The Netherlands about one in every three work disability benefit recipients are assessed as work disabled on mental grounds. The vast majority (approximately 90%) suffer from chronic job stress and burnout, mental states that closely relate to mental fatigue.

Mental fatigue is defined as the change in the psychophysiological control mechanism that regulates the task behaviour, resulting from previous mental and/or physical effort which have become burdensome to such an extent that the individual is no longer able to adequately meet the demands that the job requires on his or her mental functioning; or that the individual is able to meet these demands only at the cost of increasing mental effort and the surmounting of mental resistance. In other words, mental fatigue reflects both lacking capability and lacking motivation. This agrees with Edward Thorndike who concluded over eighty years ago that the basic tenet of mental fatigue is ‘the intolerance of any effort’.

Acute mental fatigue is to be distinguished from chronic mental fatigue. The former is characterised by reversibility, task-specificity, and the functional use of compensation mechanisms. Acute fatigue disappears after a period of rest, when tasks are switched, or when particular strategies are used (e.g. working at a slower pace, using less demanding information processing strategies, or spending additional effort). In contrast, chronic mental fatigue is irreversible, not task-specific, and the compensation mechanisms that were useful in reducing acute fatigue are no longer effective.
Subjective fatigue and subjective mental effort were measured using 15 cm. visual analogue scales. CFFF was measured using the Portable Fatigue Meter (Jimbo Pocket CFFF), a small, lightweight, pocket flicker apparatus that can be carried in a shirts pocket. At the start of the day the general state of fatigue was measured, using the Checklist Individual Strength and after the required study period at 17:00 ‘Need for recovery’ was assessed.

Repeated Measures with the SPSS General Linear Models (GLM) was used to test for differences within each study or break period. Paired T-tests were used to test for differences between study and break period. Pearson’s Correlation was used to test for the correlation of the aforementioned scales and CFFF within the all measurements and within each individual.

RESULTS

The decreases in CFFF during both study periods (9:00-13:00 and 14:00-17:00) were not significant. Subjective fatigue decreased significantly (p<0.05) from 9:00-13:00 and increased significantly (p<0.05) from 14:00-17:00. Subjective mental effort also increased significantly (p<0.000) from 14:00-17:00. During the evening the decrease in CFFF (19:30-22:00) was highly significant (p<0.000), however, mental effort and fatigue did not change significantly. See Figure 1.

As a light blinks faster and faster, it would eventually reach a rate where it would no longer be possible to detect that the light is flashing, it would look like a ‘solid’, or continuous light. The frequency at which this occurs is called the Critical Flicker Fusion Frequency (CFFF). The CFFF depends on a variety of physical and psychological factors. The CFFF is used mostly as a measure of cortical arousal and vigilance. Since mental fatigue is strongly related to cortical arousal, CFFF can be seen as an indirect indicator of acute fatigue. Although there is a large variability in the CFFF results, in general lower CFFF values are strongly related to higher subjective feelings of fatigue. CFFF is generally determined in an experimental setting, since differences in visual angle, environmental light and the distance from the blinking light to the eye can modify CFFF threshold. CFFF decreases during continuous mental effort, induced by for example calculating tasks. Moreover, CFFF tends to increase after a break.

An adequate and reliable measurement of fatigue that could easily monitor fatigue throughout the day could be beneficial in preventing the worsening of fatigue. In this study a portable Critical Flicker Fusion Frequency (CFFF) apparatus, the Portable Fatigue Meter, designed as a fatigue assessment tool, was tested in a field setting.

This study examines the relationship between CFFF and different measurements of subjective feelings of fatigue and mental effort during continuous mental effort. We hypothesised that during the continuous mental effort the CFFF would decrease and the subjective fatigue would increase, thereby confirming that CFFF, as measured with the Portable Fatigue Meter, reflects fatigue. Moreover, we hypothesised that after the break period the CFFF would increase, thereby reflecting recovery.

MATERIALS AND METHODS

Thirty students (29 women, age 20-27) were monitored during a day within two weeks before examination, at which they had to study (continuous mental effort) at the library. They were instructed to study from 9:00 till 13:00 and from 14:00 till 17:00 and had to take a break after 13:00 and 17:00. After 17:00 behaviour was not restricted by any instruction, except for two extra measurements.

At fixed times (9:00, 11:00, 13:00, 14:00, 15:30, 17:00, 19:30, 22:00 h) subjects were signalled by a programmable alarm watch, at which they had to measure their CFFF. After that, they had to fill in a diary to monitor their behaviour (study and break time, coffee and cigarette consumption) prior to each measurement.

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The increases in CFFF (both p<0.05) and decreases in subjective mental effort (both p<0.000) over the breaks were also highly significant. See Figures 2 and 3. In order to compare the different measures, all values were subjected to a z-transformation within subject. This procedure equated the means and the standard deviations across both subjects and measures.

Pooled Correlations between the 240 (30 subjects x 9 times of day) CFFF-Z values and those for each of the other measures were calculated. CFFF correlated only significantly with subjective fatigue (r=-1.34 (p<0.05)) and time spent not studying (r=1.72 (p<0.05)).

Pearsons Correlations were calculated for the aforementioned scales and CFFF within each individual. The results were hardly significant and not consistent at all. Of all 30 subjects only 7 showed a strong significant negative correlation between subjective fatigue and CFFF (r>0.7, p<0.05).

Nevertheless the change in CFFF during the study period (from 9:00 till 17:00) did correlate significantly with ‘Need for recovery’ (r=-0.375, p<0.05) and state of fatigue (r=0.383, p<0.05).

CONCLUSION AND DISCUSSION

Although CFFF has been claimed to be an index of fatigue, it does not reflect the subjective changes in fatigue during continuous mental effort. On the other hand, CFFF does reflect the general change in fatigue during the evening and the change in mental effort (but not fatigue) during the breaks. Moreover the overall change in CFFF from 9:00 till 17:00 did correlate with need for recovery at 17:00 and the state of fatigue at the start of the day. The general factor that is reflected in the CFFF might be recovery or need for recovery, with lower values indicating higher need. Ambulatory monitoring of CFFF might therefore be helpful in indicating need for recovery throughout the day.

ACKNOWLEDGEMENTS

Research supported by NWO, The Hague, Fatigue at Work Program (580-02-108) & Successful Ageing Program (014-90-001). The authors would like to thank Dr. T. Hosokawa for his generous gift of a portable fatigue meter.

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