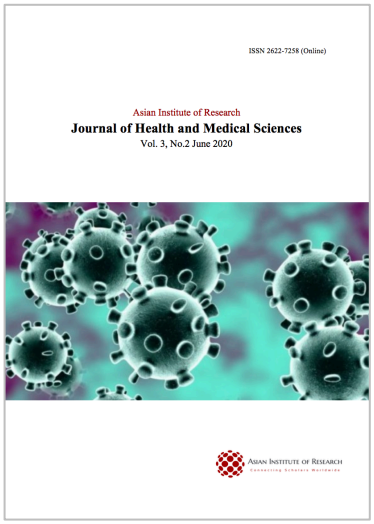

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Combined Effects of Occupational Hazards: The Impact of Combined Stressors on Health and Work Performance

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Abstract
There exists a significant body of evidence regarding the effects of occupational hazards. These effects are often considered in isolation, yet a significant proportion of the workforce is exposed to several hazards at a time. The purpose of this study was to investigate the combined impact of workplace factors on mood, cognitive performance and physiology. Participants completed a battery of objective measures before and after work, as previous research (e.g. Broadbent et al. 1989) has shown the difference between before and after work measures to be a good indicator of workload demands during the day. The test battery was performed on the first and last days of the working week. Subjective information regarding chronic and acute (i.e. daily) exposure to hazards was also collected. Mean composite 'total negative factors' scores were created for exposure to chronic and acute stressors (e.g. noise, exposure to hazardous substances, job demand): median splits of these variables were then entered into a series of ANOVAs where mood, simple reaction time and physiology served as dependent measures. Findings indicate that chronic exposure to negative factors results in increased susceptibility to fatigue, over the course of the testing session, working day and working week.

Keywords: Psychology, Occupational medicine, Epidemiology, Stressors, Combined effects

1. Introduction

It is often difficult to obtain measures of performance efficiency at work. One method that has been applied to examine this topic is to use interpolated artificial tasks to make inferences about changes in performance over the day. This approach has been used successfully to examine the effects of fatigue and noise (Broadbent, 1979), working hours (Monk and Folkard, 1985) and workload (Parkes, 1995). Similarly, such measures are sensitive to health-related behaviours (e.g. ingestion of caffeine – Brice & Smith, 2001) and health status (e.g. upper respiratory tract illnesses- Smith et al., 2000).

A number of studies have demonstrated the usefulness of a combined effects approach to occupational hazards. Smith et al. (2004) examined physical hazards (e.g. noise, exposure to hazardous substances) in combination with working hours (e.g. night work, unsociable or unpredictable hours) and found subjective

reports of health and well-being to be lowest in combined stressor conditions. In order to test the possibility that this relationship is essentially linear, Smith et al. (2004) summed the total number of potential hazards and examined the effect of this composite variable on self-reported health outcomes. The results showed that it is an accumulation of hazards, rather than any one hazard in isolation, that causes the greatest detriment to health.

Similarly, the effects of combinations of stressors have been found in studies of accidents at work (Simpson et al. 2004). There is also some evidence to suggest that combinations of factors lead to the greatest impairments in cognitive performance. For example, Smith et al. (2001) found that workers exposed to a high number of negative factors tended to be easily distracted. However, participants in this study were only tested at the end of the working day. In a similar study of the effects of noise and night work within the seafaring population, few additive or interactive effects were observed (see Wellens et al., 2002). This may be due, however, to the relatively small sample of night workers studied or it may be the case that factors other than the physical environment or working hours lead to additive combined effects.
Previous research has concentrated on exposure to chronic stressors. Smith et al. (1999) demonstrated that chronic fatigue may lead to increased susceptibility to acute fatigue (as measured by differences in performance between the start and end of a lengthy test session). The current study also examined daily exposure to stressors, in order to determine if the pattern of effects induced by acute hazards differs from that of chronic hazards.

Given the evidence that the impact of combined stressors on subjective measures is essentially linear (Smith et al. 2001), the present study was designed to replicate this finding using objective performance measures. Furthermore, participants were tested both before and after work, in order to determine the extent of acute workload demands during the day. However, as exposure to hazards was relatively low within the current sample, a further aim was to determine whether changes in fatigue over a task or testing session were sensitive to levels of combined stressors.

2. Material and methods

2.1 Sample

One hundred and thirteen working volunteers from various occupations were recruited via internal and external advertisement. A number of participants were excluded from further analyses, due either to violation of the study criteria, or erratic working patterns, with the final sample consisting of 86 workers.

2.2 Measures

Mood and Performance:
Participants were required to complete a battery of computerised performance and mood tasks, in the same order, before and after work on the first and last day of the working week. [Test order: pre-test mood, simple reaction time, focused attention task, categoric search task, post-test mood.] Data are presented here from the mood and simple reaction time tasks because they allowed assessment of changes over the testing session and task. Two choice reaction time tasks measuring focused attention and categoric search (Broadbent et al. 1989) were also included in the battery.

Mood
Ratings of mood were taken using visual analogue scales. Participants were presented with 18 scales comprising a pair of adjectives anchored at either end of a linear scale - e.g. drowsy - alert. Participants were asked to move the display pointer, using the keys on a response box, to a position on the scale that was representative of their mood. Three main factors were then extracted from the results: alertness, anxiety and hedonic tone.

Simple Reaction Time (SRT)

A white frame was displayed in the centre of the screen and at varying intervals (1-8 seconds) a solid white square appeared inside the frame. Participants were asked to press a response key as soon as they detected the solid square. This task lasted approximately 3 minutes. Mean reaction times were calculated for the test as a whole, as well as for each minute of the task.

Physiological Measures

Salivary cortisol was measured at the beginning and end of the working day, on the first (day 1) and last day (day 5) of the working week. Systolic and diastolic blood pressure (BP) and heart rate were measured both before and after completion of the test battery on days 1 and 5 (both before and after work).

Measurement of Occupational Hazards

Participants were asked to complete a questionnaire detailing the nature of their work. Items referred to the following: hours worked, shift/night work, unpredictable hours, exposure to hazardous substances and noise, cognitive failures, minor injuries, general health, job demands, decision latitude, social support, (Karasek, 1979; Siegrist, 1986) and the home/work interface (HWI). Participants were also required to provide similar information for days 1 through to 5, in order that differences between chronic and acute exposure could be assessed.

3. Results

3.1 Demographics

The sample consisted of 41 (47.7%) males and 45 females (52.3%). The mean age of the sample was 37 years. All participants showed evidence of education, with all but 4 (4.7%) staying at school at least until the age of 16. Participants could be categorised into all six categories of the CASOC-derived social class based on occupation, although the vast majority, 66 (76.7%) were either non-manual or manual skilled workers.

3.2 Chronic Exposure to Negative Factors

A mean composite 'total negative factors' score was created, reversing items where necessary. Variables included in this score are shown in Table 1.

Table 1: Variables Included in Chronic 'Total Negative Factors' Score

Working Hours	Do you do night work?
	Do you do shift work?
	Do you work unsociable hours?
	Do you work unpredictable hours?
Physical Hazards	I am exposed to breathing fumes, dusts or other potentially harmful substances.
	I handle or touch potentially harmful substances.
	My concentration is disturbed by the level of background noise.
	I am left with a ringing in my ears or a temporary feeling of deafness.
Job Demands	I have to work very fast.
	I have to work very intensively.
	I have enough time to do everything I need to do at work.
	Do different groups demand things that are hard to combine?
Social Support	Do you get sufficient information from line management (your superiors)?
	Do you get consistent information from line management?
	How often do you get help and support from your colleagues?
	How often are your colleagues willing to listen to your work-related problems?

	How often do you get help and support from your immediate superior?
	How often is your immediate superior willing to listen to your problems?
	My tasks are such that others can help me if I do not have time.
Decision Authority	I have a choice in deciding how I do my work.
	I have a choice in deciding what I do at work.
	Others take decisions concerning my work.
	I have a great deal of say in decisions about my work
	I have a say in my work speed.
	My working time can be flexible.
	I can decide when to take a break.
	I have a say in choosing who I work with.
	I have a great deal of say in planning my work environment.
	I can take my holidays more or less when I wish.
Skill Discretion	I have the possibility of learning new things through work.
	My work demands a high skill level.
	My job requires me to take the initiative.
	I have to do the same thing over and over again.
	Does your job provide you with a variety of interesting things to do?
	Is your job boring?

3.3 Acute Exposure to Negative Factors

Mean composite 'total negative factors' scores were created for the first and last days of the working week. Variables included in these scores are shown in Table 2.

Table 2**:** Variables Included in Acute 'Total Negative Factors' Scores.

Physical Environment	The work environment was very noisy today.
	I was exposed to fumes or dusts.
	I handled or touched potentially harmful substances or materials.
	I was left with a ringing in my ears or a temporary feeling of deafness.
	My concentration was disturbed by the level of background noise.
	I felt that the air temperature was too hot/cold to work effectively.
Job Demands	I felt I had too much work to do today.
	Did you find your job required a lot of effort today?
	How stressful did you find your job today?
	Did you find your job demanding today?
Social Support	I felt that I had good support from my fellow workers today.
	I felt that management were supportive today.
	Did you have a choice in deciding what/how you did your work?

Job Satisfaction/Health	Was your job boring today?
	Did you feel satisfied with what you did at work today?
	Describe your general health today.

A total acute 'negative factors' score was also calculated from means of scores on the above variables for days 1 through 5 of the working week.

3.4 Change Scores

In order to examine the extent to which performance may vary across the task, day and working week, the following change scores were calculated: post- minus pre-test mood and physiology for day 1 am, day 1 pm, day 5 am and day5 pm. For measures of simple reaction time, mood and physiology, the following change scores were calculated: day 1 pm minus day 1 am, day 5 pm minus day 5 am, and day 5 pm minus day 1 am. In the case of simple reaction time (SRT), 'Time on task' measures were also calculated for each session, by subtracting mean scores for minute one, from mean scores for minute three.

Preliminary Analyses

Preliminary correlational analyses indicated little evidence of the impact negative factors on raw mood, performance and physiological scores. However, where the change scores described above served as dependent variables, a number of effects were observed for mood and simple reaction time, indicating that fatigue increases over the duration of the tasks, working day and working week, as a result of high exposure to chronic negative factors. The pattern of results seen for the physiological measures was not as clear however. Exposure to acute negative factors appeared to have little impact on any of the outcome variables: this may be due to the low levels of acute exposure as compared to chronic exposure. For example, measurement of acute factors did not, unfortunately, take into account daily exposure to night work, and a number of other potential stressors.

Table 3 shows the mean exposure scores for chronic negative factors, and acute negative factors for day 1, day 5 and days 1 through to 5 of the working week.

Table 3: Mean exposure scores

	Mean	SD
Chronic exposure (maximum score = 52)	26.21	9.57
Acute exposure day 1 (maximum score = 35)	18.87	6.48
Acute exposure day 5	18.56	7.66
Acute exposure days 1 through 5 (maximum score =156)	91.07	22.80

3.5 Further Analyses: ANOVA

Analyses of variance (ANOVA) were performed, where day (i.e. 1 or 5), time (i.e. am or pm) and position (i.e. pre-or post-test) served as within subjects factors, and a median split of the chronic total negative factors score served as the between subjects factor. Alertness scores were taken as an example of the effects of chronic exposure to negative factors on mood. Means and standard deviations are shown in Table 4.

Table 4: The Impact of Chronic Exposure to Negative Factors on subjective alertness (higher scores = greater alertness).

	Chronic Negative Factors	Mean	SD
Pre-test alertness Day 1 am	Low	259.4	68.0
	High	228.3	64.2
	Total	245.7	67.8
Post-test alertness Day 1 am	Low	248.7	54.4
	High	230.2	54.5
	Total	240.5	54.9
Pre-test alertness Day 1 pm	Low	262.7	55.9
	High	250.9	49.8
	Total	257.5	53.3
Post-test alertness Day 1 pm	Low	235.7	62.9
	High	216.2	51.8
	Total	227.1	58.8
Pre-test alertness Day 5 am	Low	246.6	64.3
	High	218.8	60.3
	Total	234.3	63.7
Post-test alertness Day 5 am	Low	236.9	60.3
	High	214.6	63.6
	Total	227.1	62.4
Pre-test alertness Day 5 pm	Low	254.7	55.6
	High	244.9	54.1
	Total	250.4	54.8
Post-test alertness Day 5 pm	Low	242.6	58.0
	High	209.3	65.4
	Total	227.9	63.2

A significant main effect of high chronic exposure to negative factors was observed: $F(1, 84) = 4.99$, $p<.03$. Significant within-groups effects were also found for: position (i.e. pre-or post-test): $F(1, 84) = 31.74$, $p<.0001$; time (i.e. am or pm) x position: $F(1, 84) = 23.44$, $p<.0001$, and time x position x chronic exposure to negative factors $F(1, 84) = 7.58$, $p < 0.01$. These effects demonstrate that a high chronic total negative factors score leads to a decrease in alertness generally. Furthermore, it is evident that alertness decreases significantly over the time working, an effect that is particularly marked at the end of the working day. These decreases in alertness were larger in those exposed to a high number of negative job characteristics.

The same ANOVA was performed with simple reaction time as the dependent variable. Means and standard deviations are shown in Table 5. Although no main effect of high chronic exposure to negative factors was found/ the following within-groups effects were observed: day (i.e. day 1 or 5 of the working week) x time on task (i.e. minute 1 or minute 3) x chronic negative factors: $F(1, 84) = 4.73$, $p<.03$, and time of day (i.e.am or pm) x position x chronic negative factors: $F(1, 84) = 11.79$, $p<.001$. These effects show that participants generally demonstrate slower reaction times at the end of the working day and the working week than at the beginning of the week, and are slower at the end of the task (minute 3) than the beginning (minute 1). Furthermore, high exposure to chronic negative factors results in greater slowing over the task at the end of the week. Participants in the lower median group of chronic negative factors demonstrated slower reaction speeds at the beginning of the working day, whereas those in the higher median group showed a greater slowing in reaction speed at the end of the working day.

Table 5. The Impact of Chronic Exposure to Negative Factors on Simple Reaction Time- ANOVA Means (msecs).

	Chronic Negative Factors	Mean	SD
Mean SRT min 1 Day 1 am	Low	300	49
	High	314	67

	Total	306	57
Mean SRT min 3 Day 1 am	Low	322	58
	High	311	46
	Total	317	53
Mean SRT min 1 Day 1 pm	Low	318	49
	High	316	76
	Total	317	62
Mean SRT min 3 Day 1 pm	Low	320	51
	High	325	80
	Total	322	65
Mean SRT min 1 Day 5 am	Low	308	48
	High	322	82
	Total	312	65
Mean SRT min 3 Day 5 am	Low	316	49
	High	332	75
	Total	323	62
Mean SRT min 1 Day 5 pm	Low	327	62
	High	318	58
	Total	323	60
Mean SRT min 3 Day 5 pm	Low	326	54
	High	339	66
	Total	331	59

Analyses of the physiological measures failed to reveal significant effects of combinations of negative job characteristics.

4. Discussion

The results generally indicate that chronic exposure to negative factors, such as long hours and high job demand, results in increased susceptibility to fatigue over the course of the test session, the working day and the working week. The findings provide further support for the "after-effects" technique (Broadbent, 1979) in that the paradigm described in this study was shown to be sensitive to fluctuations in workload and demand. As discussed, a number of studies have provided evidence to suggest that the relationship between chronic exposure to negative factors and self-reported health and well-being is linear (e.g. Smith et al., 2001). The findings reported in this paper suggest that the relationship also exists between chronic exposure to negative factors and cognitive performance and mood.

It would appear therefore, that a combined effects approach to the study of workplace stressors is valid, as it seems to be an accumulation of negative factors, rather than exposure to any one hazard in particular, that causes the greatest impairments to health and performance. Of particular interest, is the fact that this approach to the measurement of combined effects is sensitive enough to predict the influence of relatively low levels of certain stressors. In this particular sample, the number of individuals who reported regular night or shift work, or exposure to harmful substances in the workplace, was negligible and levels of other negative job characteristics moderate.

Consistent with previous research (e.g. Smith et al., 1999) the current findings suggest that chronic problems result in greater susceptibility to acute fatigue. However, no discernable pattern of results was observed for acute exposure. This is more than likely due to the comparatively low exposure levels reported on a daily basis, as opposed to those reported generally (see Table 3).

Unfortunately, due to the design of the questionnaire, it was not possible to compile acute negative factors scores in exactly the same way as for chronic negative factors. It is of particular importance to note that no working hours measures were included in the acute negative factors scores. No effects were observed where physiological measures served as dependent variables: it may well be the case that only relatively extreme exposure to negative

factors (either chronic or acute), or exposure to particular types of stressor - for example night work - are necessary before changes in physiology are noted.

In conclusion, the study outlined in this paper highlights the need to consider workplace stressors in combination, if their true impact on performance and health is to be determined. Future research might wish to consider a similar experimental paradigm, with a more diverse sample, in order to determine the effect of negative factors on cognitive performance, as the current sample consisted largely of nine to five office workers. In addition, the current sample was rather small.

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References

Brice, C.F. & Smith, A.P. (2001). The effects of caffeine on simulated driving, subjective alertness and sustained attention. Hum Psychopharm, 16, 523-531.

Broadbent, D.E. (1979). Is a fatigue test now possible? Ergonomics, 22, 1277-1290.

Broadbent, DE, Broadbent, M.H.P. & Jones, J.L. (1989). Time of day as an instrument for the analysis of attention. Eur J Cog Psy, 1, 69-94.

Karasek, R.A. (1979). Job demands, job decision latitude, and mental strain: Implications for job redesign. Admin Sci Quart, 24: 285- 311.

Monk, T.H. & Folkard, S. (1985). Shiftwork and performance. In: Hours of Work: Temporal Factors in Work Scheduling. S. Folkard, T.H. Monk (eds), Chichester, Wiley. pp 239-252.

Parkes, K.R. (1995). The effects of objective workload on cognitive performance in a field setting: A two-period cross-over trial. App Cog Psy, 9, 153-171.

Siegrist, J. (1996). Adverse health effects of high-effort - low reward conditions at work. J Occ Health Psy, 1, 27-43.

Simpson, S.A., Wadsworth, E.J.K., Moss, S.C. & Smith, A.P. (2005). Minor injuries cognitive failures and accidents at work: incidence and associated features. Occupational Medicine, 55, 99-108.

Smith, A.P., Borysiewicz, L., Pollock, J., Thomas, M., Perry, K. & Llleweyn, M. (1999). Acute fatigue in chronic fatigue syndrome patients. Psy Med, 29, 283-290.

Smith, A.P., Brice, C., Sivell, S., Wadsworth, E. & Wellens, B. (2001). Combined effects of occupational factors on objective measures of performance and health. In: Contemporary Ergonomics. MA Hanson (ed), Taylor & Francis, London, pp 203-208.

Smith, A.P., Brice, C., Sivell, S. & Wellens, B. 2001. The combined effects of occupational factors on subjective reports of health. In: Contemporary Ergonomics. MA Hanson (ed), Taylor & Francis, London, pp 197-202.

Smith, A., McNamara, R. & Wellens, B. (2004). Combined effects of Occupational Health Hazards. HSE Contract Research Report, 287, HSE Books. ISBN 0-7176-2923-6.

Smith, A.P., Thomas, M. & Whitney, H. (2000). Effects of upper respiratory tract illnesses on mood and performance over the working day. Ergonomics, 43, 752-763.

Wellens, B.T., McNamara, R.L., Ellis, N. & Smith, A.P. (2002). Combined effects of shift work and occupational noise exposure on performance tasks in a seafaring population. ICEEF 2002