Mental Workload and Health: A Latent Threat

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The aim of this study is to investigate changes in cardiovascular activity associated with a high mental workload. The reported experiments, carried out in naturalistic settings, point to information load and information processing under time pressure as main risk factors. This kind of occupational stress had to be dealt with by two of the three groups under investigation: brokers and simultaneous interpreters; it was not experienced by lecturing university professors. The pattern of cardiovascular activity of the two former groups consisted of overmobilization of cardiovascular activity at the beginning of work, and only partial normalization of task-evoked changes in cardiovascular activity at the end of work. Substantial elevations of diastolic blood pressure and tachycardia, which followed earlier overmobilization, resemble a miniature copy of changes seen in the development of cardiovascular diseases.

1. INTRODUCTION

An excessive physiological response to environmental challenge has been thought to contribute to the development of cardiovascular disease (Charvat, Dell, & Falkow, 1964; Cohen, Evans, Stokols, & Krantz, 1986; Fredrikson & Matthews, 1990; Hines, 1940; Kasl & Cooper, 1987; Krantz & Manuck, 1984; Manuck, Kasprzowicz, & Muldoon, 1990). Recent biobehavioral studies have attempted to classify external demands in terms of their capacity to evoke large cardiovascular responses (e.g., Cohen et al., 1986; Fredrikson & Matthews, 1990; Krantz, Contrada, Hill, & Friedler, 1988; Quick, Nelson, & Quick, 1990). Such studies have also attempted to identify persons predisposed to excessive physiological reactivity (e.g., Eysenck, 1991; Friedman, 1990; Ranchor & Sanderman, 1991). The study reported here is concerned with classifying external demands.

Two kinds of evidence point to the important role of occupational stress in the etiology of cardiovascular disease, including coronary heart disease and essential hypertension. First, there are epidemiological studies comparing mortality rates for different demographic categories, such as age, occupation, education, sex, and so forth. Perhaps the most striking fact about cardiovascular diseases, in terms of their distribution among the Polish population, aside from their increase with age, is the degree to which they afflict white collar workers, but spare blue collar workers. Also noteworthy is the vanishing difference between men and women in the incidence of cardiovascular disorders (Klonowicz, 1971, 1993).

However, the observed difference between demographic categories in the incidence of disease is ambiguous with respect to the causal mechanisms that produce it. Demographic data are useful in suggesting hypotheses about the impact of occupational stress on heart disease, but a second type of research linking specific types of stress to cardiovascular functioning is...
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needed to establish a relationship between occupational stress and the development and progression of cardiovascular disease.

In occupational stress literature, several types of working conditions have been related to the risk of cardiovascular disorders. Evidence points out the overwhelming effect of job demands (Cooper & Payne, 1988; Elliott & Breo, 1984; Karasek, Theroell, Schwartz, Piper, & Alfredsson, 1982; Kasl & Cooper, 1987; Quick et al., 1990). Much research in the last 10 years has attempted to build on these foundations. However, Krantz and Manuck (1984) and Manuck et al. (1990) observed that most cardiovascular reactivity studies are performed in the laboratory, with very few using naturalistic settings. Moreover, Frankenhaueser (1975) suggested that the pathogenic factor is not only an excessive reaction to high demands, but also to the time of its normalization.

Klonowicz (1992a) discerned two waves of cardiovascular activity in simultaneous interpreters. An overmobilization registered at the onset of the work shift was followed by only partial normalization at the end of the shift. A question arises as to whether this pattern of cardiovascular activity is typical for those coping with high mental workload. To investigate this issue further, this study attempts to compare the cardiovascular responses of people performing three occupational tasks that are associated with a high mental workload: university professors (cf. French, Tupper, & Mueller, 1965), bank officers (cf. Karasek et al., 1982), and simultaneous interpreters (Klonowicz, 1992a).

2. METHOD

2.1 Subjects
Three groups ($n_s = 20$) participated in the study: university professors, brokers, and simultaneous interpreters. Subjects ranged from 28 to 40 years old ($m = 34.6$). The proportions of male and female subjects were equal in all three groups (46% male, 53% female). None of the subjects showed borderline hypertension, nor did any of them have a parental history of hypertension.

2.2 Design
The subjects were individually tested in an analysis of variance (ANOVA) with profession and time period variables. Each variable comprised three levels. There were three professional groups (university professors, brokers, and simultaneous interpreters) and three instances of measurement: a baseline and two measures of cardiovascular activity before and after a work shift.

2.3 Procedure
Experiments were carried out in natural settings. All measures were taken at least twice between 9 a.m. and 11 a.m., immediately prior and after a 30-min work shift. The duration of the work shifts of university professors was adjusted to be similar to those of simultaneous interpreters and brokers. All subjects were familiar with the procedure because two to three habituation sessions were run before the experiment. During the week preceding the experiment, cardiovascular readings of each subject were taken on three separate, mildly activating, semisocial occasions that involved speaking to, or talking with, others but were not associated with professional activity.

2.4 Apparatus
Cardiovascular activity measures were taken with a Timex automatic blood pressure and heart rate monitor. This is an electronic cuff device that gives a digital display of blood pressure and heart rate. The cuff is initially inflated to 140- to 160-mm Hg, which then deflates after arriving
at a systolic blood pressure (SBP). Subsequent readings give diastolic blood pressure (DBP) and heart rate (HR). The cuff was placed on the upper left arm. The monitor was checked as an accurate automatic measure of cardiovascular activity.

3. RESULTS

The results are shown in Table 1. ANOVAs performed on baseline measures revealed no significant differences for the three dependent variables \([F(2, 57) < 0.50]\). To test for the effects of profession and time period, sets of data for each variable were subjected to a \(3 \times 3\) (Profession \(\times\) Time Period) repeated-measures ANOVAs. Greenhouse–Geisser adjusted degrees of freedom were used to control for biased \(F\) tests.

For all three dependent variables, ANOVAs yielded only marginally significant main effect of time period (2.14 \(> F\)s < 2.67) but showed significant Profession \(\times\) Time Period interactions: (a) SBP, \(F(2, 100) = 4.62, p < .01\); (b) DBP, \(F(2, 103) = 3.27, p < .05\); and (c) HR, \(F(2, 101) = 3.81, p < .01\).

Pairwise comparisons more specifically localized the differences due to these interaction effects. Changes in cardiovascular activity were assessed by comparing the pre- and postwork readings with the baselines. The first set of comparisons consisted of an assessment of the mobilization wave (prework vs. baseline). In the second set of comparisons the normalization wave was assessed (postwork vs. baseline). Table 2 contains the \(t\) values and should be examined with Table 1, which shows the mean values.

As the data in Table 2 indicate, the mobilization wave does not occur in university professors, but it is apparent in all three measures of cardiovascular activity of brokers and simultaneous interpreters. Apparently, the issue of mobilization/normalization can be raised with respect to the two latter professions only. In these two groups the commencement of work causes significant elevations of SBP, DBP, and HR over baseline levels. Comparisons of cardiovascular activity at the end of work with baseline cardiovascular activity indicate that:

1. Normalization occurs systematically for SBP only (in neither of the two groups did \(t\) values reach the level of significance).
2. Postwork DBP is significantly higher than baseline DBP in simultaneous interpreters and marginally higher in brokers.
3. HR normalizes in brokers but remains marginally above baseline in simultaneous interpreters.

### TABLE 1. Means and Standard Deviations of Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), and Heart Rate (HR)

<table>
<thead>
<tr>
<th>Time period</th>
<th>Professors</th>
<th>Interpreters</th>
<th>Brokers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(M)</td>
<td>(SD)</td>
<td>(M)</td>
</tr>
<tr>
<td>SBP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>120.05</td>
<td>7.71</td>
<td>118.20</td>
</tr>
<tr>
<td>Prework</td>
<td>124.80</td>
<td>7.90</td>
<td>129.25</td>
</tr>
<tr>
<td>Postwork</td>
<td>123.95</td>
<td>9.60</td>
<td>118.75</td>
</tr>
<tr>
<td>DBP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>77.45</td>
<td>7.32</td>
<td>78.00</td>
</tr>
<tr>
<td>Prework</td>
<td>82.05</td>
<td>8.50</td>
<td>89.05</td>
</tr>
<tr>
<td>Postwork</td>
<td>82.00</td>
<td>7.78</td>
<td>85.70</td>
</tr>
<tr>
<td>HR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>68.30</td>
<td>7.00</td>
<td>71.50</td>
</tr>
<tr>
<td>Prework</td>
<td>76.65</td>
<td>7.80</td>
<td>92.35</td>
</tr>
<tr>
<td>Postwork</td>
<td>75.30</td>
<td>8.30</td>
<td>81.95</td>
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</tbody>
</table>
TABLE 2. Pairwise Comparisons (t Values) Illustrating the Profession × Time Period Interaction Effects on Three Measures of Cardiovascular Activity

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Professors</th>
<th>Brokers</th>
<th>Interpreters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobilization</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SBP</td>
<td>0.08</td>
<td>2.53**</td>
<td>2.62**</td>
</tr>
<tr>
<td>DBP</td>
<td>0.27</td>
<td>2.61**</td>
<td>2.73**</td>
</tr>
<tr>
<td>HR</td>
<td>0.41</td>
<td>2.66**</td>
<td>4.11***</td>
</tr>
<tr>
<td>Normalization</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SBP</td>
<td>0.29</td>
<td>0.82</td>
<td>0.17</td>
</tr>
<tr>
<td>DBP</td>
<td>0.11</td>
<td>1.79*</td>
<td>2.23**</td>
</tr>
<tr>
<td>HR</td>
<td>0.16</td>
<td>1.47</td>
<td>1.96*</td>
</tr>
</tbody>
</table>

Note. Levels of significance were adjusted according to the Bonferroni statistics: $\alpha \times 2; df = 38$.

* $p < .10$.
** $p < .05$.
*** $p < .01$.

4. DISCUSSION

The main finding of this study is that the earlier described pattern of two waves—mobilization and (partial) normalization—cannot be generalized to all professions involving high mental workload. The data indicate that a considerable mobilization occurred in brokers and simultaneous interpreters but not in university professors. It was also shown that two parameters—SBP and HR—of cardiovascular activity normalize, whereas no normalization was demonstrated for DBP.

Three points should be raised in the discussion of these data. First, where does the established differentiation of the three professions under investigation originate? Second, what is the functional significance of these changes in cardiovascular activity? Third, what potential impact do these shifts in cardiovascular activity have on health?

Comparisons among the three professions permit us to rule out the possibility that elevations in cardiovascular activity could be ascribed to speaking in general and public speaking in particular (cf. Knight & Barden, 1979). All measures, including baselines, were taken in speaking probands. Both university professors and simultaneous interpreters appear publicly, but the patterns of cardiovascular activity of these two groups were totally different.

It seems that the common denominator of brokers' and simultaneous interpreters' tasks are active intake of new information and processing it under time pressure. Neither group has a certitude as to what the form and content of this information will be. Thus, the task can initially appear to be more difficult than it is appraised to be later. Recent studies have shown that the more ambiguous the task demands, the higher the anticipatory emotional and psychophysiological activity (Brener, 1987; Klonowicz, 1986; Sosnowski, 1991). In contrast, a university professor has little if any intake of new information during his or her lecture, and time constraints are dealt with "behind the curtain," that is, when planning the course. There is mainly, if not exclusively, a delivery, that is, a reproduction of something. Thus, the findings seem to fit the Sanders (1983) model for information-processing stages: greater mobilization precedes, and less normalization follows, the tasks involving more stages of information processing.

This brings us directly to the problem of the functional significance of a task-evoked mobilization/normalization pattern of cardiovascular activity. The issue has been discussed in detail elsewhere (Klonowicz, 1992a). Suffice it to say here that the elevations of SBP, DBP, and HR observed at the beginning of work most probably represent an active preparedness to face a challenge. Time on task is supposed to be the main factor in the adjustment of cardiovascular activity to real-task demands that are being discovered and mastered as work proceeds. Consequently, it may be concluded that the reported appearance of the normalization wave...
reflects a better match between demand and capacity, that is, of resources needed to cope with the task.

This study gives a better understanding of the risk of excessive cardiovascular response to job demands. It has been demonstrated that in brokers and simultaneous interpreters, who have to cope with enormous information intake under time pressure, SBP and DBP immediately increased prior to the work shift, and, over the course of the work, SBP dropped but DBP remained elevated. This patterning of blood pressure changes resembles a miniature copy of the time course of blood pressure changes often seen in the development of essential hypertension (Falkner, 1991; Pickering, 1991). It is also worth noting that tachycardia is an independent risk factor for the development of hypertension (Fredrikson & Matthews, 1990).

Moreover, it has been shown (Carruthers, 1980; Klonowicz, 1992b) that repeated exposure to demanding stimuli has been associated with the development of sustained elevations of blood pressure. A task that regularly overtaxes a mechanism responsible for the allocation of coping resources leads to a protracted reaction. Thus, the findings reported here may have clinical importance for the development and exacerbation of cardiovascular disease. The full clinical significance of these data remains to be demonstrated in a follow-up study. What appears to be more urgent is an investigation of the possibilities of counteracting the described pathogenic effect of work associated with a high rate of information processing under time pressure. Because little can be done with the tasks themselves, this research should be oriented towards time off task.

REFERENCES


