

Report No. 1334

EFFICIENCY OF INFORMATION PROCESSING
AND ITS IMPLICATIONS REGARDING VULNERABILITY
TO ENVIRONMENTAL STRESSORS

S. Melamed

M. Sharon

Occupational Health & Rehabilitation Institute
at Loewenstein Hospital, Raanana

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Comprehensive Overview

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Individual differences in vulnerability to environmental stressors: Organizers vs. non-Organizers

The present study was designed to cross-validate and to test further derivatives of a theoretical model presented and confirmed in a previous study (OHRI Report No. 1322). This model accounts for individual differences in vulnerability to stress factors; the analysis suggested for this purpose refers to distinct modes of information processing, and examines their relative efficiency and the amount of economy in processing-resources involved in their usage.

A cognitive style characteristic of subjects highly vulnerable to environmental stressors (Such as noise, humidity, bad odours, vibrations)- referred to as "Organizers" - has been introduced. The Organizers were those showing efficient handling of a large amount of information. This was demonstrated by high level of Dual-task performance - performing two tasks simultaneously, which necessitates attention and efficient coping with information stemming simultaneously from two distinct sources.

It has been postulated that the Organizers have higher capacity than the non-Organizers for activation of higher cortical functions, which is expressed in *efficient* and highly *economical* patterns of processing (In "Group Pay-Off System, Group Performance and Hostility", 1975, I defined *efficiency* as output/effort ratio, assuming that "When 2 individuals invest at a given moment the same amount of effort in a specific task, then the one with the higher task-relevant abilities 'produces' more" - page 4). These processes are reflected in forming and employing a variety of cognitive organizing "devices", like strategies, chunks, spatial patterns and abstract categories, serving for a massive decrement of the information involved in cognitive control of performance of daily tasks and activities. The totality of these devices may be included under the category of "organizing schemata", that the capacity for their continuous generation and inter-shifting as well as the reliance upon the massive decrement of environmental or internal information/stimulation which they enable - characterize Organizers more than non-Organizers.

Hence, the Organizers presumably differ from "non-Organizers" by their heavy reliance, tendency and capacity for massive decrement of the information involved in control of performance of the various tasks confronted in every-day coping. The activation of organizing schemata depends, according to the model, on the availability of high

cortical processes that are assumingly reflected by high level of cortical arousal. Level of cortical arousal was measured, in the present study as well as in the previous one (1981), by the Critical Flicker Frequency threshold (CFF Test), regarded in the literature as reflecting higher cortical functioning, and *Frontal Lobe* activation in particular (See Zlody, 1975).

The claim as to the role assumed by higher cortical processing in activation of the processing modes characteristic of Organizers, was supported in the previous study (1981) by the finding that the Organizers (identified by high dual-task performance) showed in general significantly higher cortical arousal (about 20% more, $p < .01$) than the non-Organizers.

Furthermore, in that study, high performance level of dual-task (during four sessions) was followed with Organizers by a significant increase in CFF level ($p < .05$), whereas non-Organizers showed a decrease tendency in CFF, following dual-task performance.

Environmental stressors (such as heat, humidity, industrial noise, vibrations) do not allow this mode of processing; for their random structure does not enable an adept cognitive restructuring (that is, organization in the sense analyzed above), which depends upon detecting regularities and solid patterns in the stimulation comprising the environmental stressors.

In the previous study ¹(1981) Organizers, working under conditions of exposure to industrial noise, showed significantly more stress symptoms than non Organizers; these symptoms included somatic complaints (headaches, sleep disturbances, etc.), exhaustion after work-shift, sickness absences, disruption in cortisol excretion cycle and decrease in level of cortical arousal (examined by the CFF test).

Cortisol excretion pattern as well as CFF level and reported fatigue improved with Organizers following usage of ear protectors. Non-Organizers showed the reverse tendency.

2

Modes, efficiency and economy of processing differentiating Organizers from non-Organizers

¹ This study was conducted in a textile factory, on 25 workers exposed to industrial noise ranging from 75 to 95 dB(A). The experimental manipulation involved noise attenuation through the use of ear protectors.

The present study was conducted on 36 weaving (textile) factory workers exposed to industrial noise ranging from 84 to 89 dB(A) at the worksite. The experimental manipulation consisted of noise attenuation by means of ear protectors (for a period ranging from 2 to 4 weeks), with the purpose of examining:

- 1) The net effect of noise on stress responses; and
- 2) differential effects of noise attenuation on Organizers vs. non-Organizers.

Level of performance of divided attention test (dual-task) served as a basic criterion for classification of the two cognitive styles. High Performance on this task depends upon efficient handling of information-load stemming from two distinct sources simultaneously.

It is claimed that such performance demands organizing processes; for these processes suggest organizing schemata controlling the performance of each component alone, being adjusted by higher-order unifying schema. The activation of such higher-order schema presumably leads to uniform and integrative continuum of smooth flow of schemata, controlling the allocations of attention and motor acts necessary for high task performance ².

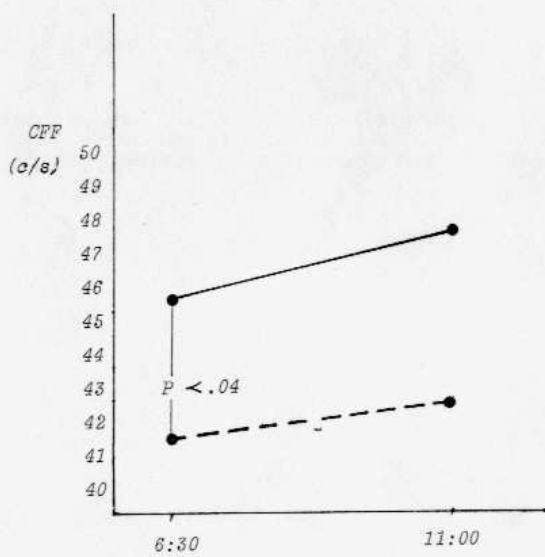
It should be noted in this regard that the role assumed by high-level cortical activation in organizing processes was demonstrated in the previous study (1981) where it was found that high performance of dual-task was followed by a significant increase in level of cortical arousal, reflected by CFF thresholds ³. Low performance, on the other hand, involved a decrease in CFF threshold.

Furthermore, the present study, like the previous one (1981), provides evidence for high-level cortical activation shown more intensely by Organizers than by non-Organizers: the high dual-task performers as a group, demonstrated significantly higher CFF threshold (see Fig. 2). Consideration of the claim presented by some researchers, about CFF as reflecting level of *frontal lobe* activation, as well as a study conducted in OHRI in which frontal patients demonstrated low CFF thresholds and low level of dual-task performance - may elucidate the role assumed by the frontal lobe in organizing processes.

² High dual-task performance can be observed to involve regularity, automatism and smooth "flow" of task-relevant acts and motor movements.

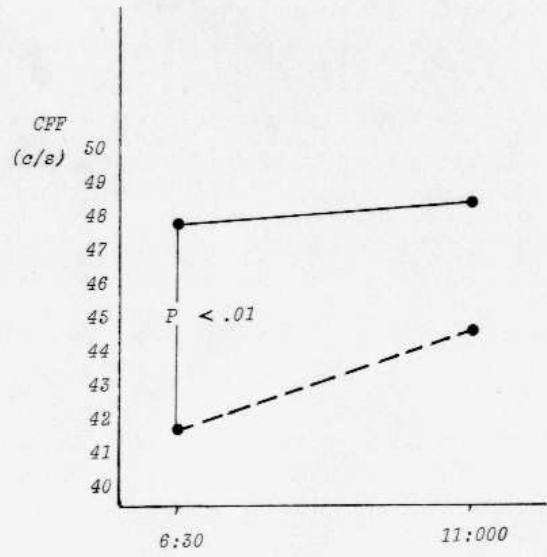
³ Critical Flicker Frequency (CFF) is the threshold at which flickering spot of light is perceived as stable. This test is widely accepted in literature as indicating cortical arousal level. In our studies, CFF threshold was tested by the descending method with a computerized system developed in the OHRI.

Organizers _____ מארגנים
 Non - organizers - - - - - לא מארגנים



Condition 1 תנאי

Work under noise exposure - חשיפה לרעש



Condition 2 תנאי

Work with ear protectors - עם מגיני אוזניים

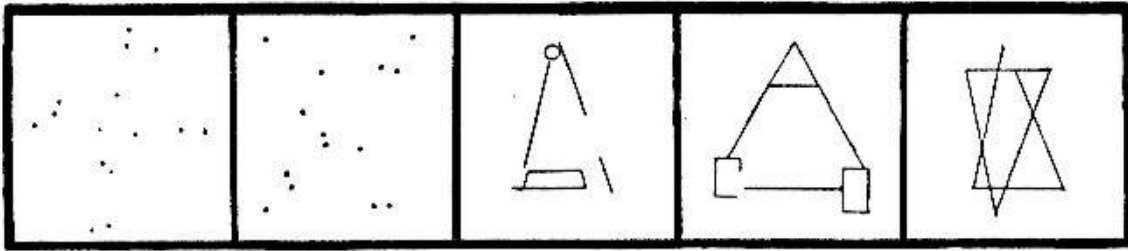
Fig. 2 - CFF thresholds in both experimental conditions

תרשים 2 - סיפי ה-CFF בשני מצבי המחקר

Classification into Organizers and non-Organizers was therefore based on a combined criterion of both dual-task level of performance and CFF thresholds (the median serving as a cut-off point).

Analysis of modes of information processing involved in performing two laboratory tasks presented in the present study (apart from dual-task), portrayed Organizers as mastering the ability to form control schemata that activate almost exclusively the allocations of attention and motor acts most necessary for appropriate high performance. This involves the capacity for smooth flow and task-turns shifting of control schemata, in correspondence with moment-to-moment variations in task demands due to task's distinct components.

Non-Organizers' performance, on the other hand, was demonstrated to be partly controlled, at any moment, by cognitive sets (or schemata) triggered in the course of performing previous components of the task. Those sets were manifested in abundance of redundant and task-irrelevant responses.



תרגום 1 : תבניות לדוגמא ממבחן ה - Pattern Reconstruction

Fig. 1 : A sample of designs used in the Pattern Reconstruction test

One of the tests referred to above is the *Pattern Reconstruction* test, which was designed by M. Sharon in the OHRI. This test demands reconstruction (by drawing) of a series of designs presented tachistoscopically for 0.2 seconds each.

These designs consist of non-redundant continuous patterns partially distorted and dotted patterns with various degrees of masking (see Fig. 1). It is claimed that information overload presumably caused by short exposure time leads to projective exposition by subjects of characteristic processing patterns involved in handling high information-load.

In performing this test, non-Organizers demonstrated significantly more than Organizers distorting tendencies resulting in inferior level reconstructions. These distortions included the following:

- 1) Perseverations of components of a given design.
- 2) Intrusions of **components** of a given design into other locations besides the valid one, or intrusion into the next design.
- 3) Transfer (or mapping) of partial **patterns** of the design to inadequate locations or to the next design (Besides the adequate restructuring of components "belonging" to this pattern).

These three modes of distortion have been termed "inertic tendencies" in the present context.

- 4) Positioning components linearly "side by side" - Juxtaposition - while ignoring their overall organization.
- 5) Failure to detect the dotted masked patterns.

The "inertic tendencies" mentioned above reflect dominance of *data-driven* cognitive processes in controlling non-Organizers' performance. For non-Organizers failed in fully replacing schemata *triggered by stimuli* involved in previous stages of the task with new control schemata demanded for current stage. On the other hand, "top-down"

control allowing smooth passage from one schema to another, thus enabling appropriate reconstruction in response to ongoing task demands - appeared to be the capacity behind the organizer's superior performance.

Is there evidence for the existence of differential modes of processing for handling information, as implied in the present framework?

Review of the literature may indeed point towards two cognitive modes of coping with information load: The first is more apt to be activated and controlled by *external stimulus* (data-driven processes), and is effective in particular in "concrete"-level tasks. Whereas the second is characterized by the presence of high level control (top-down processes) and organizing patterns (such as imposition of chunking) in processing information in the course of task performance, and addresses information strata that are beyond the concrete-level properties of the task-related stimulus (See Melamed, Sharon Grushetsky and Kaufman 1981).

The *realm of effectiveness* of this mode is portrayed as tasks that enable imposition of organizing schemata. An example is high recall by master and good chess players of a *meaningful* chess configuration (displayed for 5 seconds), as contrasted to poor recall of *random* dispersion configuration of chess pieces (De Groot, 1965; Chase & Simon, 1973).

There is an evidence indicating that these modes of processing are *antagonistic* to one another, such that an activation and leaning on one mode decreases the effectiveness of the other. For example, it has been found that under stress - for which there is ample evidence as impairing high-level cognitive processing (e.g., Hockey, 1979; Jones & Broadbent, 1979; Schwarz, 1975; Smith, 1980; Schroder et al., 1967; Streufert & Streufert, 1978) effectiveness of handling concrete-level tasks is increased. Another evidence is that under condition of sleep deprivation - for which there indications for hampering high level creative processes (e.g., Lewin & Glaubman, 1975); or for hampering processes of organization and control of behavior (e.g., Bartlett, 1947), there is, on the other hand, an improvement in performance of recall tasks of digits displayed in a way that prevents organization (Hamilton et al., 1972)

It may therefore be postulated that the non-Organizer that massively relies on activation of the data-driven processing mode, performs tasks contingent on attentional organization at a lower level, that is, those tasks may comprise his realm of ineffectiveness. The reverse holds towards the Organizer, having the higher tendency and capacity for activating the processing system characterized by dominance of top-down processes (for a partial review of the relevant literature, see Appendix 2).

Lower ability for forming organizing structures - such as spatial patterns - is claimed to be involved in non-Organizers' failure to detect overall patterns (distorting tendencies, 5 and 6 above). For detecting these patterns demands, again, forming a new schema (while shifting off "old" ones)- representing isomorphism to the pattern presented.

Such schema formation is claimed to be facilitated by avoiding control of attention by "old" schemata (formed in response to previous task demands) that could *induce masking into the detection process*.

Another test is the *running memory* task in which the subject is asked to repeat the last five digits out of a series of random digits (presented through earphones), the presentation of which for each trial ends when a click is heard (a procedure not allowing anticipatory cognitive set-up for the last 5 digits).

Non-Organizers recalled correctly usually 2,3 digits. The other digits they mentioned were - significantly more often than with Organizers - the 2,3 digits preceding the last five.

Organizers, whose performance was significantly more correct, did not show intrusion of previous digits. Their responses also reflected significantly more than the non-Organizers' the *original order of presentation*.

Organizers' performance is again demonstrated here as reflecting their basic tendency for organization resulting in economy of processing-resources due to focusing almost exclusively on most necessary task-relevant cues while neglecting the others. This is presumably achieved by employing *strategies* that allow decrease in processing resources allocated to stimuli the more task irrelevant they are *perceived* to be. More specifically, these strategies presumably decrease, at any given moment, the processing impact of digits-stimuli preceding the last five, in triggering and shaping the schemata that control task-relevant storage and retrieval in memory.

It can, therefore, be concluded that Organizers master the capacity to employ strategies (or high-order organizing schemata) that allow smooth shifting of subordinate control schemata. The higher-order schemata in turn, shift into more efficient ones, where better strategies are formed. This capacity for maintaining smooth shift of organizing structures at all levels of hierarchies of control schemata - towards better and more efficient structures - brings forth decrement of information load involved in daily tasks.

This economy is due to processing-resources being allocated *more and more exclusively* towards the most necessary cues demanded for proper performance. This focusing is achieved through the dynamic process of identifying more and more task-involved stimuli-areas which allow further and further diminishing of processing resources allocated to them (where efficient cognitive organization renders these stimuli-areas inessential for proper performance).

The inability of frontal patients to maintain shifting of control schemas, referred to by Milner (1963) as lacking in "the capacity for shift" and reported by Luria (1973) as "pathological inertia", provides further evidence for frontal lobe function in high organizing processes.

Economy of processing and capacity for severance of schematas. It has been claimed that the massive decrement of information related to coping and control of every-day tasks by the Organizers is contingent on forming efficient organizing schemata.

Yet the economy in amount of processed information will be attained only where the more efficient organizing schemata are *exclusively* activated in task performance, that is, where traces of previous (and less efficient) motor or perceptual control schemata will not be sustained. Those previous schemata may be activated simultaneously with the novel schemata and add "excess baggage" of motor acts or attention allocations included within the "old" schemata, thus bringing forth additional information-load which is not task-related (Since the more efficient organizing schema enables task performance within attention focusing to lower number of information units than the preceding schemata - being less efficient).

In other words, an efficient and economical activation of organizing schemata necessitates a **capacity for severance** (separation, detachment or disconnecting) from previous perceptual or motor performance-control schemata. Smooth and efficient performance of the consecutive daily tasks by the organizer necessitates constant generation of cognitive structures (or schemata) involving smooth and fluent detachment from previous ones - that is, smooth and continuous *flow* of structures ever shifting into one another (In a process not unlike Jazz improvisations). The relevance of the capacity for severance or detachment in performance of complex tasks has already been demonstrated by the work of Tresselt & Mayzner (1960) indicating an increase in switching cognitive sets while solving complex problems.

We may demonstrate the significance of switching (or severing) sets as follows: While identifying a possibility of more efficient performance of a given task through identifying the *shapes* of objects, then attention allocations will be directed by a novel abstracting control-schema that exclusively refers to contour of objects. This involves detachment from the perceptual schemata *spontaneously* activated by the contour stimulus, that activate in turn allocation of attention to the rest of the visual and sensual information (like the color or texture of objects), included with the contour in a sort of perceptual "package deal" within the "natural" schema.

The sheer drive for such efficient utilization of *abstractions*, conditioned on detachment from previous perceptual schemata, may be larger with Organizers. Hence, it may be assumed that Organizers are more efficient than non-Organizers in *complex tasks*. This, since the passage from an efficient performance of one task-component to another (What is concerned here are complex tasks, having multiple components) is contingent on a shift of performance-control into the novel structure, while disconnecting from the inertic tendency of the structure that controlled previous component performance.

In general, the production output of Organizers is assumed to be higher, since due to their efficient usage of *economical* organizing schemata they allocate lesser time and attention than non-Organizers to task-irrelevant information, while performing the task with reliance on the minimal necessary environmental cues.

In addition, it can be asserted that the Organizers - due to their need and capacity for generating schemata that render task-performance efficient for diminution of performance-control information load - are those who over and over initiate suggestions for improving production processes in the factory. This tendency may fail

them in simple tasks not susceptible to organization or increase in efficiency, because they may resort to harmful short cuts out of no choice.

The attentional organization process can in numerous cases be regarded as an ever-diminishing reliance on environmental information in controlling a given task, whereas such information is replaced by internal representations belonging to the organizing schema. For example, control of performing a certain task based on a periodic signal is also enabled where an internal representation of the rhythm of the signal's appearance is formed. This allows performing the task while leaning on the schema and withdrawing from attention sustained towards the signal's emergence in the environment. According to Broadbent (1977), performance of a task mostly leaning on internal representations imposes much smaller load than the very same performance based attention and control turned towards the environment. Woodhead (1964) for example, demonstrated that digits that had to be read from a display imposed more workload than the same digits in memory, serving later for mental arithmetic. This, by showing that a bursting noise led to more errors in the reading stage than in the mental arithmetic stage.

The distinct contribution of each cognitive style to real life patterns of activities is elucidated by the **Supervisors' ratings** of workers' job performance across various dimensions. **The following characteristics of job performance are reported:**

1. *Production output:* Organizers' amount of production is significantly higher than non-Organizers.
2. *Effective initiatives:* Organizers show significantly more effective initiatives (54% more) than non-Organizers, in suggesting new and efficient procedures for improving production processes.
3. *Complex-job placement:* There were 3 times more Organizers than non-Organizers in complex tasks.
In simple tasks, on the other hand, non-Organizers were represented by 2.2 times more than Organizers (these differences are significant).
4. *Harmful initiatives:* It is claimed in this regard that complex multiple-stage tasks demand activation of organizing processes for smoothly shifting from one phase to another while avoiding control of schemas triggered during previous stages.
On the other hand, in simple tasks, presumably not susceptible to efficient organization, the Organizers' tendency of trying to render performance more efficient is rather inadequate: In simple tasks they were reported by supervisors as taking (significantly) more than non-Organizers, inappropriate initiatives (such as "short cutting" while relaxing various task demands) harmful to production.
This tendency reversed in complex tasks where non-Organizers were those reported as taking more harmful initiatives.

5. *Performance Satisfaction* with employee: Supervisors expressed more *satisfaction* with Organizers than with non-Organizers in complex jobs, but not in simple jobs.

3

Vulnerability to Stress Factors - suggested mechanism

The present findings may indicate the Organizers' *Realm of Ineffectiveness*:

1) A *Stimuli Area* or *Information-Region* (that must be coped with) not susceptible to either:

- a) Assimilation within economical organizing schemata or
- b) Integration (of its mental representations) in a consistent manner within the continuum of cognitive structures controlling task-involved activity at a given moment.

It is reasonable to assume that failure to activate organizing processes by the organizer while demanded to handle a given task (that is, having to act *outside his realm of effectiveness*) may result in *waste and burnout of processing-resources*. Hence an *autonomous need for organization* is suggested; i.e. a drive, heavy reliance and **tendency** of Organizers for activity within their realm of effectiveness (where organizing processes are activated).

The need for organization can be regarded as a special instance of the need for skill-utilization where a skill renders performance more efficient and economical in terms of resources utilized. In fact, the contribution of efficient strategies to the formation of skill as well as the adverse effects of under-utilization of skills (in terms of morbidity, for example) are well documented.

The suggested mechanisms for sensitivity and vulnerability to environmental stressors are as follows:

- a) **Frustration of need for organization:** Confronting a stimulus-area not susceptible to organization, that demands coping with, leads to more and more attention and processing resources directed towards it⁴. If these *organization efforts* still fail, the organizer will experience *annoyance* by these stimuli, which grows as frustration continues. Stress responses will concomitantly follow.

⁴ There is evidence to this effect pertaining to cognitively-complex people confronting ambiguous or uncertain situations. Yet Cognitive complexity is postulated to represent processing mechanisms only partly shared with those of attentional organization.

b) **Waste and burnout of resources:** Having to cope with a task "outside" the organizer's realm of effectiveness - where organizing processes fail to be activated - is another source for stress responses.

Both sources of stress are assumed to *act additively*.

The proposed model *linking modes of information processing and stress responses* has been confirmed in the present study (see Fig. 6). Indeed **stress responses** were found to be significantly more intense with Organizers. The stress responses were demonstrated in *subjective* reports by workers (In: reported fatigue; annoyance by noise; exhaustion; somatic complaints like headaches; sleep disturbances; tension and nervousness; and job dissatisfaction) as well as in *objective* manifestations such as: *sickness absences; disturbances in blood pressure; decrease in cortical arousal (CFF); and higher rate of work accidents.*

These two kinds of stress responses support argument *b*, which relates stress symptoms to failure to activate organizing processes: for there is a decrease in *cortical arousal* at the outset of work-shift as compared to either mid-shift or to the noise-attenuation condition (see Fig. 2).

The high rate of *work accidents* among Organizers may indicate as well sub-optimal level of cognitive control processes at least in some parts of the work-shift, although the overall picture of superior performance during the work-shift still sustains.

Efficiency of Information Processing

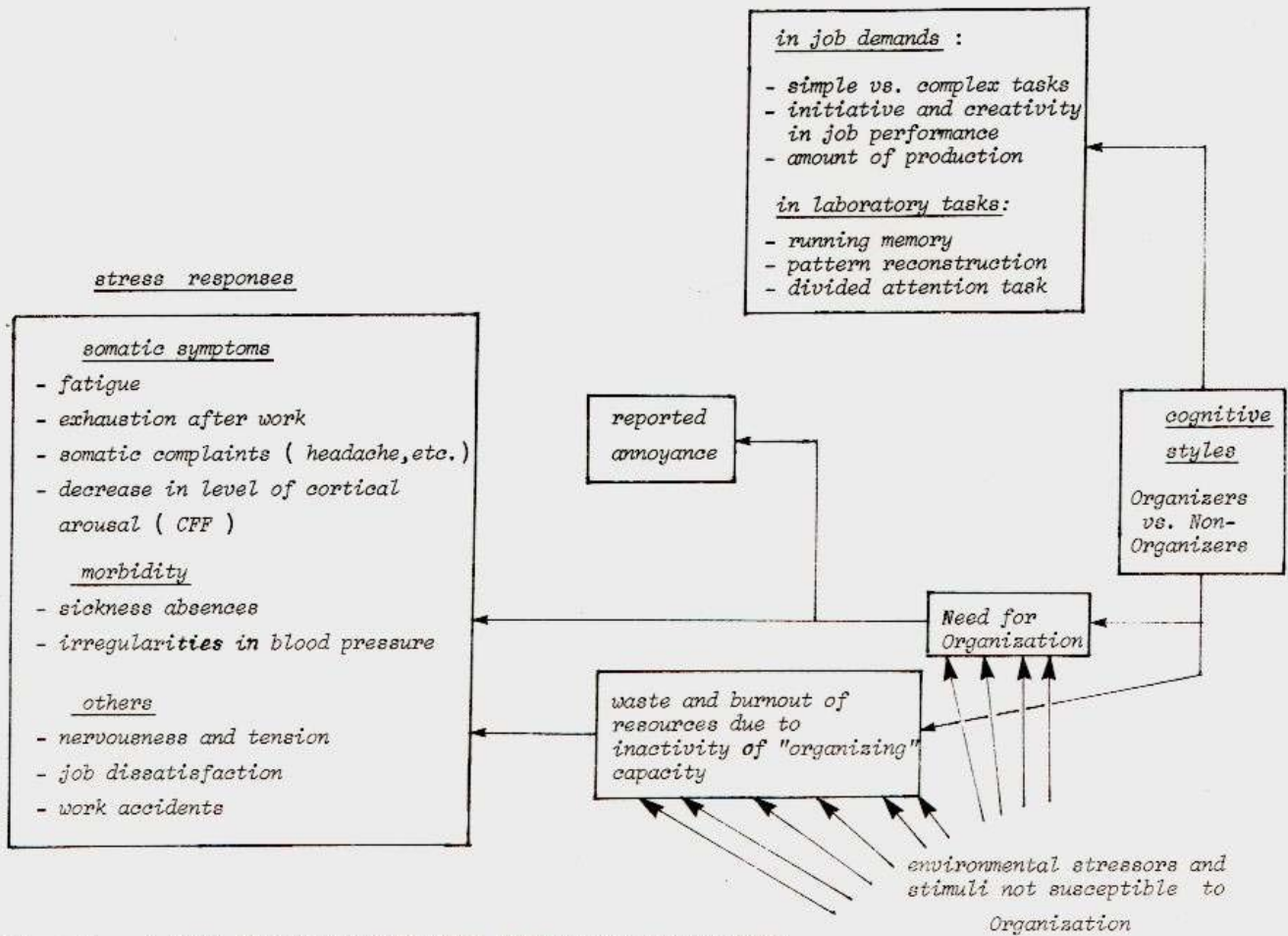


Figure 6 : A model describing individual differences in efficiency of information processing and sensitivity to environmental stressors

Type A personality trait. It was found in the present study (as well as in the previous one, 1981) that Type A⁵ assumes the role of modulating stress symptoms by increasing their intensity in Organizers (for example, in sickness absences, or in annoyance by noise or other environmental stressors).

However, no significant relation has been found in the present framework between stress symptoms and type A in itself.

The contribution of industrial noise to these stress symptoms was demonstrated by the experimental manipulation, where the usage of ear protectors led to decrease in stress symptoms, and to significantly more marked improvement -regarding those symptoms - with Organizers.

The postulated need for organization was manifested in annoyance - rated significantly higher by Organizers on annoyance scales - by inorganizable stimulation like industrial noise and also by other environmental stressors - humidity, unpleasant odors, wool, bus movements and heat, not necessarily present in the work environment. Hence a trait of general sensitivity to environmental stressors can be attributed to Organizers.

⁵ The personality type which highly susceptible and vulnerable to cardiovascular diseases.

The present study (like the previous one, 1981) may provide further evidence about *antagonistic tendencies or processes* in response to environmental stressors shown by Organizers vs. non-Organizers (for example, an increase in cortical arousal and decrease in reported nervousness and tension in Organizers, following noise attenuation; as compared to the reverse tendency, manifested by non-Organizers). The possibility of differential responses to various stressors shown by Organizers vs. non-Organizers may contribute to resolving the controversy in literature about the *general effects* of these stressors, and a comprehensive study of the subject may be proposed.

Another point to note is the evidence found in this study as well as in the previous one (1981), for frequent *fluctuations* in cortical arousal and organizing performance and activity following various daily experiences. Hence there is a need for developing a *personality scale* that will identify characteristic personality traits and preferences which are relatively stable in indicating these cognitive styles, for the sake of their assessment and classification. Such a scale is presently being developed by M. Sharon in the OHRI.

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