

How can Insights from Cognitive Ergonomics and Brain Research inform our assessment of the work environment?

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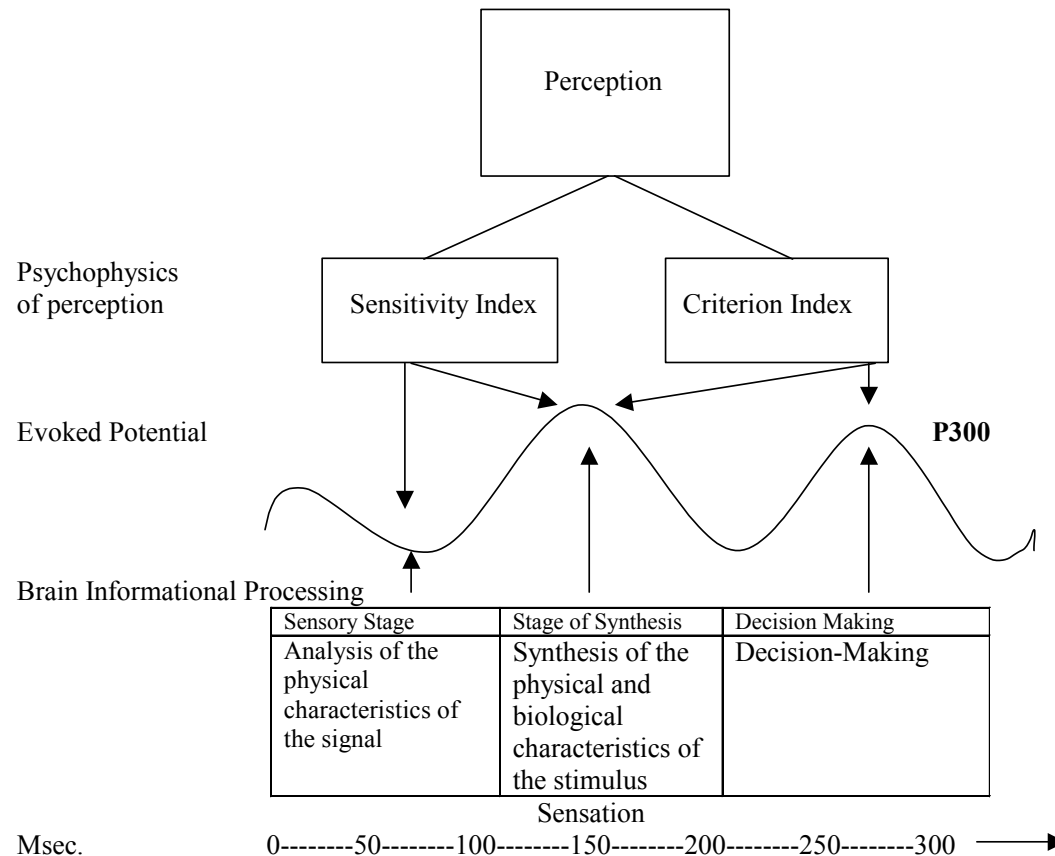
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”Spectacular advances have been made in our understanding of how the human being--via the Central Nervous System (CNS)--handles information, transforming it into productive output of various kinds.

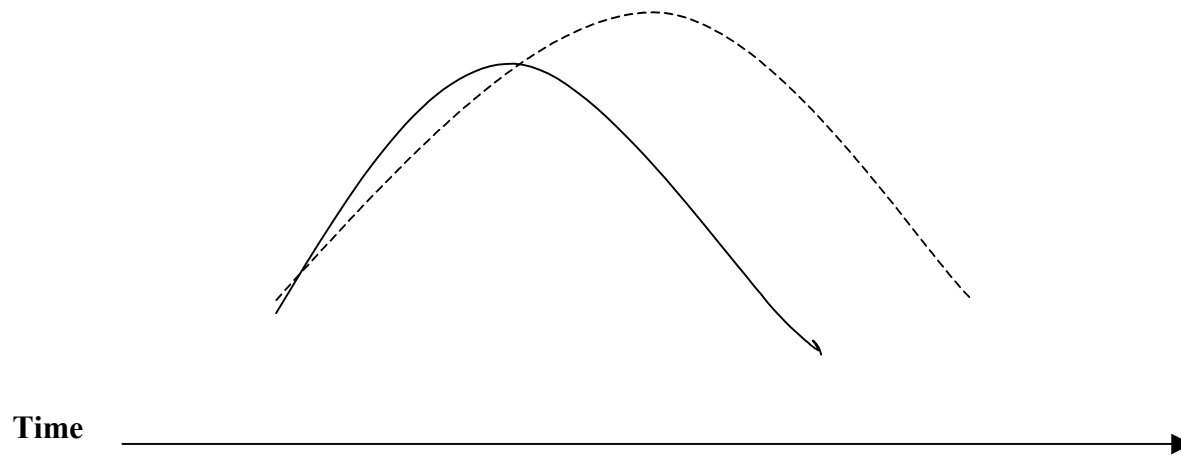
How can that knowledge be harnessed to inform us in our quest to organize work so that it becomes in better harmony with human needs and capacities?”

Ivanitsky's Scheme of the 3 periods of Perception

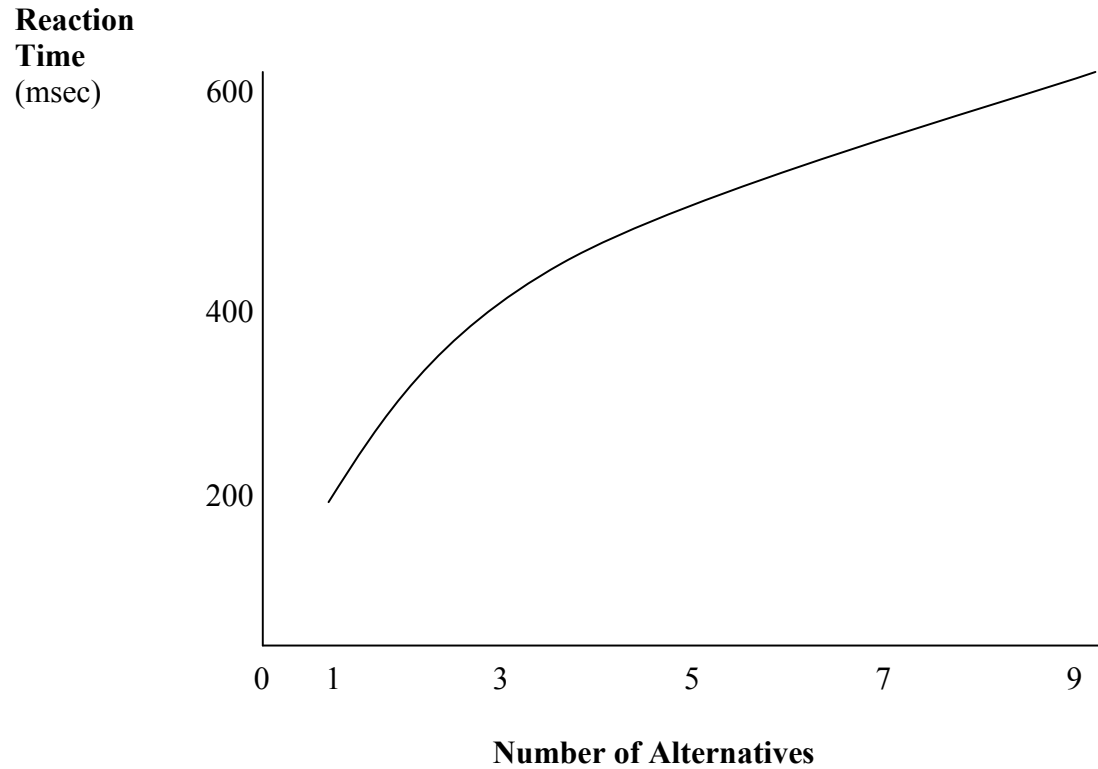


Prolonged Latency of P300

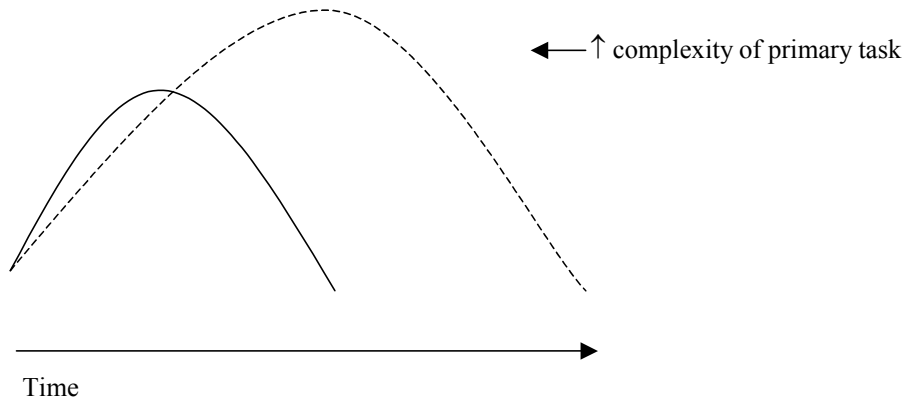
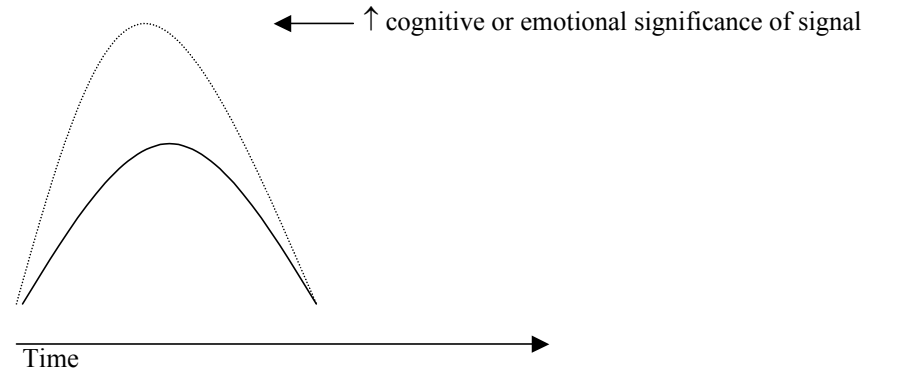
with increased time needed to evaluate the signal



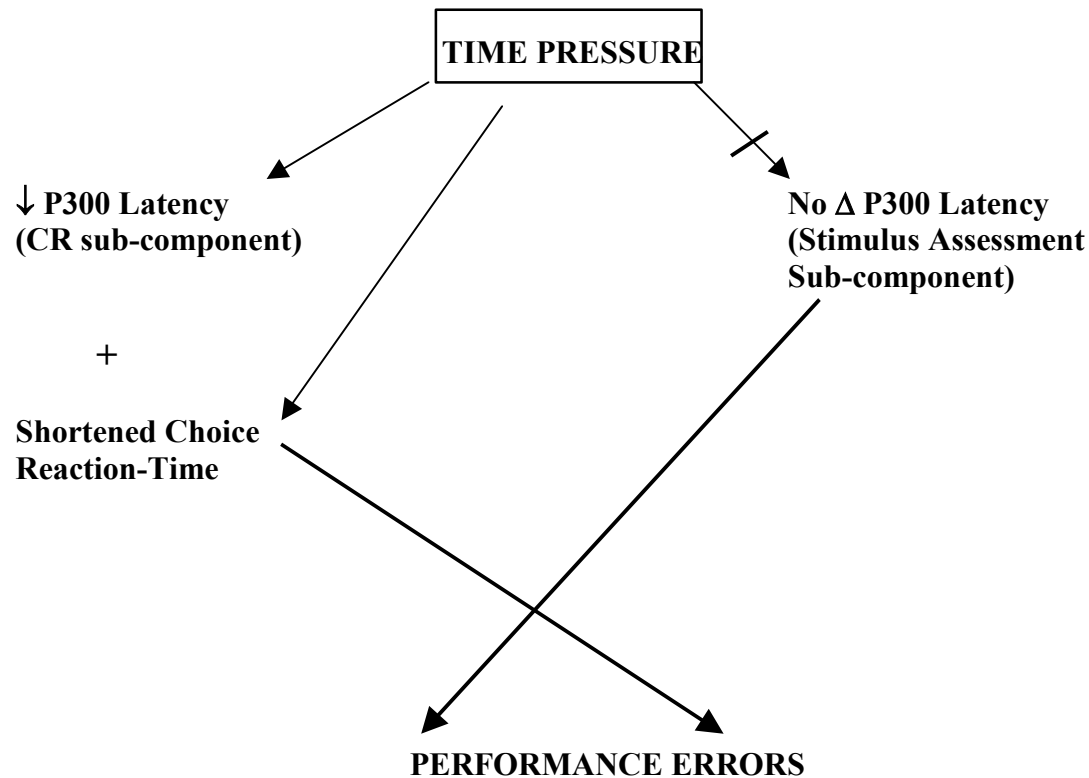
Merkel Curve



P300 amplitude and demands upon mental resources



A Neurophysiologic View of Time Pressure



Levels of Information Transmission

- Sensory input
- Central decision-making--information processing
- Effector output --task performance

High Demand on the Input Level

- Several sources of information
- Heterogeneous signals
- Visual modality primary
- High frequency of incoming signals
- All three sensory modalities
- Communication with persons essential

The Demand Dimension using the DCQ and OSI
Comparisons between Professional Drivers and Subway Guard Attendants

| | Professional Drivers | Level of Significance | Subway Attendants |
|-----------------------------|-----------------------------|------------------------------|--------------------------|
| <u>DCQ</u> | | | |
| High Demands | 11.9 ± 3.8 | ns | 12.3 ± 3.4 |
| <u>OSI</u> | | | |
| Input High Demand | 9.1 ± 1.2 | P < 0.001 | 3.4 ± 1.2 |
| Central High Demand | 2.0 ± 0.2 | P < 0.001 | 1.3 ± 1.4 |
| Output High Demand | 3.9 ± 0.5 | P < 0.001 | 1.0 ± 1.1 |
| High Demands (total) | 16.1 ± 2.1 | P < 0.001 | 6.4 ± 3.8 |

High Demand Among City Bus Drivers vs. Truck Drivers

| OSI | City Bus Driver (N=130) | Level of Significance | Truck Drivers (N=69) |
|---------------------------------|------------------------------------|----------------------------------|---------------------------------|
| Input High Demand | 10.0 ± 0.9 | P<0.001 | 7.9 ± 1.4 |
| Central High Demands | 2.0 ± 0.0 | n.s. | 2.0 ± 0.0 |
| Output High Demands | 4.0 ± 0.1 | P<0.001 | 3.0 ± 0.0 |
| General High Demands | 5.1 ± 1.6 | P<0.01 | 4.4 ± 1.8 |
| High Demands (Total) | 21.0 ± 2.0 | P<0.001 | 17.2 ± 2.1 |

Underload

Input

- Homogeneous signals
- Low frequency of incoming signals
- Working alone

Central

- Decisions follow automatically from input

Output

- Homogeneous tasks
- Simple tasks
- Nothing to do

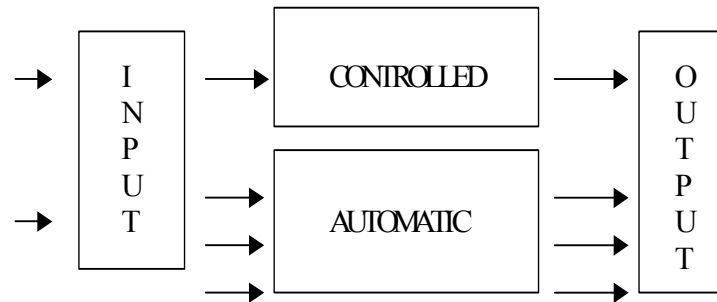
General

- Fixed pay
- Pay inadequate to meet one's needs

Controlled vs. Automatic Processing

- A critical distinction is between Controlled or Knowledge-based processing, for which there are limitations in human capacity, since it is performed *in series*. In contrast, the human capacity for automatic processing or "skill-based" is much less limited, and represents rapid, smooth, learned, highly integrated patterns, that can be performed in parallel.

Controlled versus Automatic Processing



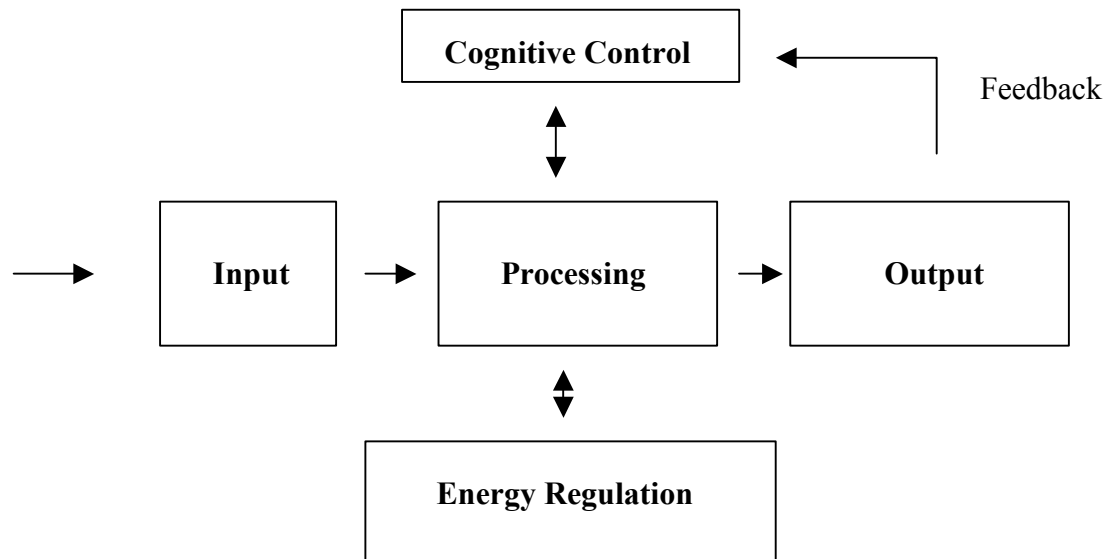
Examples of Controlled/Knowledge-Based Activities:

- **complex human interactions**
- **use of a new apparatus**
- **emergency operations**
- **apparatus failure**
- **dealing with irregularities**

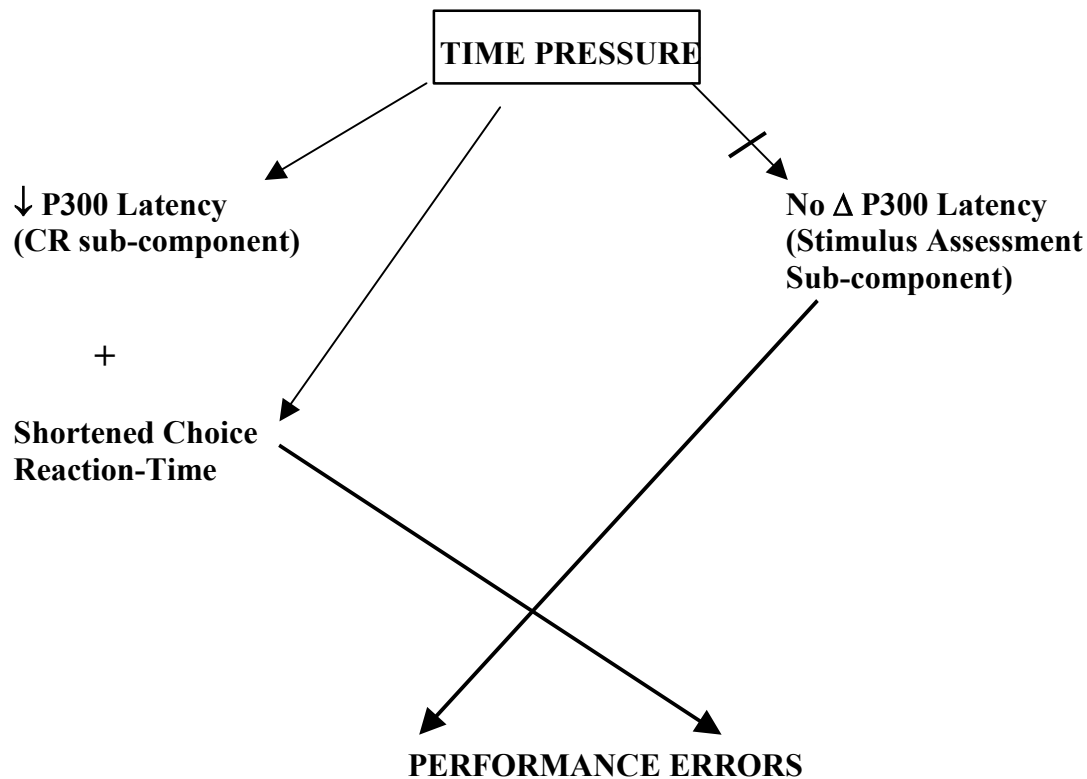
Harmonizing Tasks to Human Capacities:

- *The more actions to be executed in a period, the less knowledge-based actions are preferable”*

Gaillard's Model of Energy Regulation



A Neurophysiologic View of Time Pressure- Revisited



Threat-Avoidant Vigilance

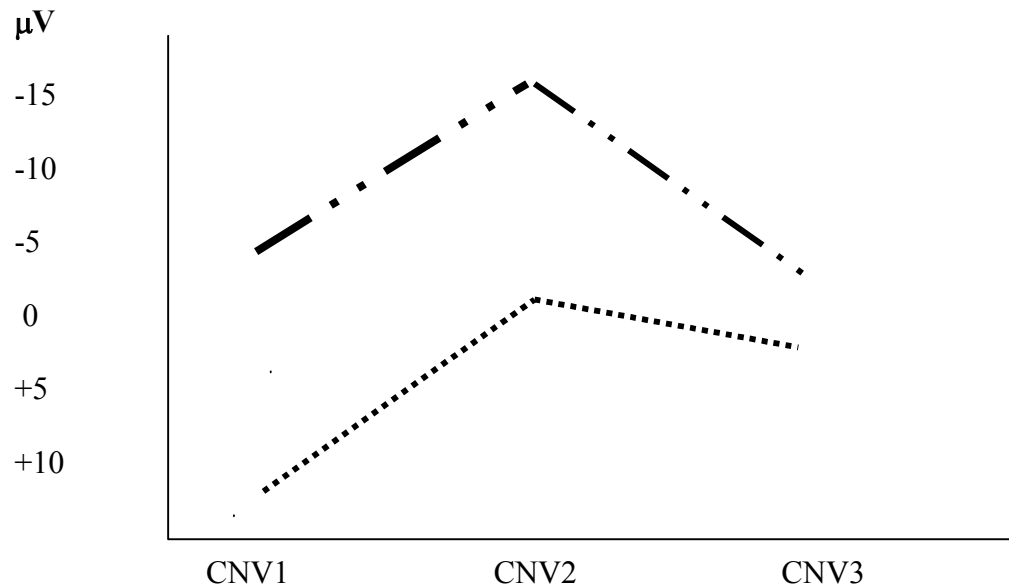
”The heaviest burden upon conscious attentional resources occurs when the human operator must continuously follow a barrage of incoming, predominantly visual signals to which he or she must be prepared to rapidly respond, whereby a momentary lapse, error or delay could have serious, potentially fatal consequences”

Preferential Attention to Threatening Stimuli

- Snakes
- Spiders
- Angry faces

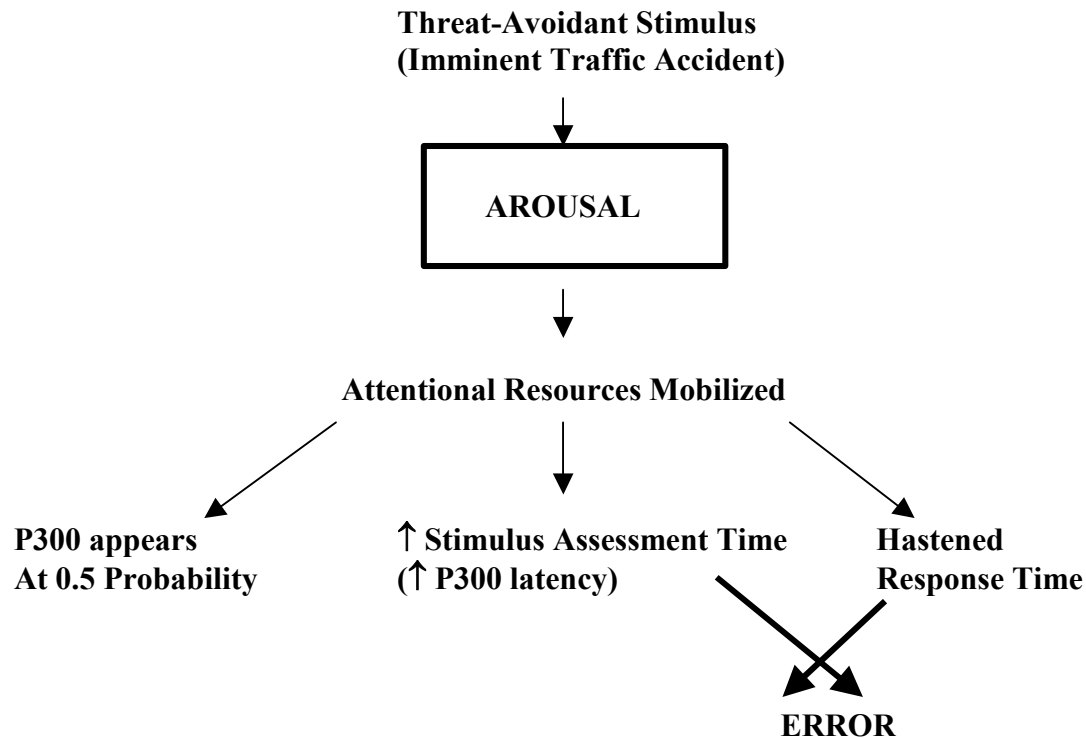
*When presented subliminally to normal human
subjects*

Heightened Attention to Cognitively Relevant Signals among Professional Drivers



Professional Drivers - · - · - · -
Non-Driver Controls ······

A Neurophysiologic View of Threat-Avoidance Responses



Anticipatory Avoidance responses

Control over these demands requires enough time to make "**anticipatory avoidance responses**" :

To recognize the precursors to the potentially disastrous situation and to take appropriate measures.

E.g. in traffic: slowing down at a blind intersection to circumvent a potential collision with an unseen, approaching vehicle.

The Conflict Dimension

- "Task load is not a simple summation of the load of the individual processes. Interference between concurrent information processes increases task load". (Neerincx & Griffioen 1996)
- Conflict arises when untimely or inaccurate correlations disrupt work and its rhythm: "the difficult meeting of excitation and inhibition" (Pavlov 1951)

Conflict/Uncertainty - OSI

Input Level:

- Signal/noise conflict
- Signal/signal conflict

Central Decision Making:

- Missing information needed for decision
- Contradictory information
- Unexpected events require a change in work plan

Output Level:

- Conflicting demands in time and space
- External factors hamper task performance

General Level:

- Emotionally-charged work atmosphere (Interpersonal conflicts)

Physical Aversiveness

Input Level:

- Noise
- Glare

Output Level:

- Vibration
- Heavy lifting (isometric stress)

General Level:

- Cold
- Heat
- Noxious chemical exposures—gases/fumes/dusts

The Occupational Stress Index

Figure 1: The Occupational Stress Index

| Information Transmission | Stress Dimensions | | | | | | |
|--------------------------|--|---|---|---|---|---|--|
| | <i>Underload</i> | <i>High Demand</i> | <i>Strictness</i> | <i>Extrinsic Time Pressure</i> | <i>Aversiveness (Noxious Exposures)</i> | <i>Avoidance (Symbolic Aversiveness)</i> | <i>Conflict/Uncertainty</i> |
| | --Homogeneous incoming signals --Low frequency of incoming signals --Works alone | --Several information sources simultaneously followed --Heterogeneous signals --Visual modality primary --High frequency of incoming signals --Three sensory modalities --Communication essential for work | --Strict requirements for signal detection | --No control over speed of incoming signals | --Glare --Noise | --High level of attention (serious consequences of a momentary lapse) | --Signal/noise conflict --Signal/signal conflict |
| <i>Decision-Making</i> | --Decisions automatic from input | --Complex decisions --Complicated decisions --Decisions affect work of others --Need for rapid decision-making | --Limited number of decision-making strategies --Limited number of correct decisions | --Decision cannot be postponed | | --Wrong decision can have serious (potentially fatal) consequences | --Missing information needed for decision --Contradictory information --Unexpected events change work plan |
| | --Homogeneous tasks --Simple tasks --Nothing to do | --Heterogeneous tasks --Simultaneous task execution --Complex tasks --Need for rapid task execution | --Work must meet a strictly-defined standard | --No control over task execution rate | --Vibration --Isometric stress | --Hazardous tasks | --Conflicting tasks in space and time --External factors hamper task execution |
| <i>Day</i> | | --Piece rate --Overtime work --Holds 2+ jobs --Lack of rest breaks --Night work | --Fixed body position --Work in confined space | --Speed-up --Deadline pressure | --Cold --Heat --Noxious gases/fumes/dusts | --Work accident --Witness work accident | --Emotionally-charged work atmosphere (interpersonal conflicts) |

From: Belkic K, Savic C, Theorell T, et al. Mechanisms of cardiac risk among professional drivers.