Stress and Workload

Human factors psychology
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A Representation of Stress Effects

Stressors
Direct (e.g., lighting, noise)
Indirect
Input

Experience
Health

Information Processing
Performance

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Stress

Stress - constraint, pressure, weight, violence (Webster’s dictionary)
Possible Effects of Stress

1. A psychological experience (e.g., frustration)
2. A change in physiology (e.g., increased heart rate)
3. Reduced efficiency of information processing
4. Long-term negative consequences for health (e.g., heart disease, G-I problems)

Environmental Stressors

- **Motion** - vibration, G forces & motion sickness
  - Whole body vibration:
    - 3-1 Hz - motion sickness, vomiting
    - 1-4 Hz - blurred vision, difficulty breathing, impaired psychomotor
    - 4-10 Hz - chest pain, rattling jaw
    - 9-12 Hz - backache
    - 10-20 Hz - headache, eye strain, speech disturbance, G-I problems
  - Limb vibration:
    - 40-300 Hz - pain in arm/wrist, arthritis, bone atrophy, WVF

- **Thermal stress** - body temperature, air movement, amount of physical work
  - Heat - drowsiness, fatigue, heat stroke, dehydration, sweating, vomiting
  - Cold - restlessness, lower alertness, numbness, shivering, hypothermia

- **Air quality** - anoxia (lack of $O_2$)

Acceleration

High G-force tolerances
- +/- 2 Gz - pressure on butt, drooping face, noticeable weight increase
- +/- 3-4 Gz - difficult to move, loss of fine motor movements, speech affected
- +/- 5.5 Gz - negative blood pressure -> GLOC or grayout (passengers may blackout sooner)
- Higher tolerances (>10) possible in Gx plane (forward acc) - weight on chest, difficulty breathing

Prevention/Protection
- G-suit - squeezes blood out of extremities - increases tolerance by 2 G
- Active Straining Maneuver (Blue Angels) - pull head down, slow forceful breathing, tensing of muscles - increase tolerance by 1.5 G

Note: Force of gravity $\approx 9.8 \text{ m/sec}^2$ or $33 \text{ ft/sec}^2$, therefore 5 G would be roughly equivalent to going from 0 to 112 mph in one sec
Heat Stress

- Small fluctuations in body temp greatly impact physical & cognitive performance
- Problems include:
  - +/- 6° C of core body is fatal (normal ~ 37° C)
  - Dehydration, heat exhaustion, heat stroke
  - Effects on continuous, low arousal tasks (vigilance)
  - Aggravated by sweating (slippery hands, sweat in eyes, heated metal equipment)
  - May create perceptual difficulties (e.g., mirages, visual distortion, optical illusions)
  - Carrying heavy protective gear contributes to heat stress (gloves, boots, body armor)

High Altitude

- Altitude Sickness
  - Loss of aerobic capacity by 10% for every 1000m over 1500 m
  - Neurasthenic Syndrome – fatigue, decreased motivation, psychosomatic symptoms + reduced visual ability
  - Paranoia, O-C, depression, hostility, decreased cognitive functioning
  - Cyclothymic Syndrome – alternating depression, elevated mood
  - Acute Organic Brain Syndromes – structural & functional defects in the CNS
  - Loss of aerobic capacity by 10% for every 1000m over 1500 m

Psychological Stressors

Resulting from the perceived threat of harm or loss of esteem, something valued, or of bodily function through injury or death.

1. Cognitive appraisal – person’s understanding / interpretation of the situation
2. Level of arousal – heart rate, pupil diameter, hormonal chemistry
3. Performance changes with overarousal – e.g., tunneling
4. Remediation of psychological stress – simplifiers in emergency situations
Yerkes-Dodson Law

- Optimal level of arousal differs for experts/novices and simple/complex tasks.
- Poor performance if too low (low motivation, boredom) or too high (test anxiety)

Effects of Psychological Stressors on Information Processing

- Narrowing of attention
  - may be positive or negative
- Diverted attention
- Working Memory Loss
  - Disrupts articulatory loop (subvocal speech)
- Perseveration
  - Revert to what people know best - implications for overlearning of emergency behaviors

Life Stress

- Causes lack of attention, distraction or diversion
  - e.g. Deaths in the family, financial problems
- Related to different aspects of attention
Adapting to Stress

How do people adapt to stress?
- Use more resources - Try harder
  - Work faster, speed/accuracy tradeoff, avoid Type A behaviors
- Remove stressor - leave environment
  - Earplugs, coping strategies (relaxation techniques)
- Change task goal - use simpler, stress-resistant strategy
  - Rely on pattern recognition skills, heuristics
- Do nothing - continue until stress takes its toll

Moderating Variables of Stress

- Interacting effects of multiple stressors
  - Noise & sleep loss both decrease performance, but effects not additive
    - Noise increases arousal, sleep loss decreases arousal
- Personality (individual differences)
  - Differences in locus of control, Type A behavior, etc.
- Training
  - Experience may reduces negative effects of stress by:
    - Reducing anxiety
    - Increasing repertoire of responses
    - Increasing knowledge of situation and ability to create solutions

Workload

![Workload Diagram]

- Overload
- Normal
- Underload
- Fatigue
- Sleep Loss
- Sleepiness
- Circadian Rhythm
Work Overload
Time-line Model

“So much work to do, so little time”

- **Time-line model**
  - Workload percentage = Time required / Time available
  - Can have over 100% workload and handle it okay or less than 100% and not
  - Moderators of time requirement estimations:
    - Individual differences
    - Spare capacity
    - Level of automaticity
    - Shared vs. separate resources

Work Overload
Time-stress Effects

Under time stress, people tend to:

- restrict tasks to those believed to be more important
- restrict available info sources to those believed to be more important

Problem occurs when subjective evaluation of importance is wrong

e.g., trying to understand one difficult concept for a test, and not studying rest of material

Remediation
Eliminating Stressors at Work

- **Engineering solutions**
  - Sound absorbing materials, temperature regulation, glare shields, earplugs, vibration dampening
- **System design solutions**
  - S-R compatibility, automation, increased cue saliency, use of command displays (over status), redundancies
- **Training**
  - Train task management skills – prioritizing tasks
  - Train important procedures to automaticity
  - Stress exposure or inoculation training
**Effort and Workload**

- **Effort** – changes in workload related to demands other than time
  - Precision
  - Force
  - Discriminability
  - KSA requirements
  - Working memory requirements

**FLOW**

- Flow occurs when skills are consistent with the level of challenge (Csikszentmihalyi)

**Work Overload Prediction**

- When two or more tasks are carried out concurrently
- Predictions must account for differences in task automaticity & multiple resource competition
  - both of which will influence performance

Figure shows comparison of predicted to subjective and empirically tested workload.
Mental Workload Measurement

- Primary Task Measures
  - measures of system performance on the task of interest
- Secondary Task Methods
  - measures reserve capacity by looking at performance on a secondary or concurrent task
- Physiological Measures
  - e.g., measuring heart rate variability for mental workload & measuring mean heart rate to look at physical workload and stress
- Subjective Measures
  - done by asking the operator to rate workload on a subjective scale (e.g., NASA TLX)

Fatigue

- Due to effects of high or even moderate workload
- Can be mental or physical
  - e.g., observed during a military combat mission
- Symptoms - Feelings of weariness, faintness, sluggish thinking, reduced alertness, poor and slow perception, unwillingness to work, decline in physical and mental performance
- Measures
  - EEG – increased alpha & theta waves, decreased beta
  - Flicker-fusion frequency – lowered with fatigue

Vigilance and Underarousal

- Vigilance - Sustained attention to low stimulus-changing environment
- Low-arousal environments can be just as fatiguing as high workload environments.
  - e.g., seen in low-workload shifts for air traffic controller’s and on repetitive assembly line jobs
Vigilance Decrement
Causes

1. Time – longer duration of vigilance, increases chance of misses
2. Event salience – subtle events increase chances of error
   e.g., typesetting error
3. Signal rate – when signal events occur at low rates, likelihood of detection will be reduced
4. Arousal level – problems occur when there is little intrinsic task-related activity

Vigilance Remediations

1. Short work shifts – with frequent breaks
2. Salient signals
   e.g., by using signal enhancement
3. Use payoffs when miss rates are high or change the signal expectancy
   e.g., can introduce false signals
4. Increase/sustain level of arousal
   e.g., use of caffeine, music, noise, conversation

Boredom

- Boredom – the affective reaction to monotony
- Boredom proneness associated with: sensation seeking, job dissatisfaction, poor vigilance, ADHD, Type A behavior

- **Boredom proneness greatest for:**
  - People in state of fatigue
  - Not-adapted night workers
  - People with low motivation
  - Highly educated, knowledgeable people
  - Challenge seekers

- **Boredom proneness least for:**
  - Alert or fresh people
  - People who are still learning
  - People whose jobs suit their abilities

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Sleep Loss

Sleepiness blamed for over 200,000 auto accidents per year

- Caused by:
  - Purposely staying awake (all-nighter, night shift)
  - Trying to sleep during the day (against circadian rhythm)
  - Stimulants (caffeine)
  - Stress

- Aspects of performance that are most susceptible:
  - tasks requiring visual input, tasks involving judgment, learning, or storing new material

Remediation to Sleep Disruption

- Get more sleep!!! - even if it is only 3-4 hours per night
- Build up sleep credits
  - e.g., gain extra sleep prior to deprivation
- Napping helps
  - make sure you allow time for full mental recovery
- Sleep management
  - e.g., easier with more controlled jobs - the military

Desynchronization

Desynchronization - Occurs when the circadian rhythms are out of synchrony with the level of activity that one is trying to maintain

- Shiftwork - strategies to deal with the disruption of circadian rhythms
  - e.g., Assignment to permanently different shifts, continuous rotation, alter shift periods
- Jet Lag - analogous to shift changes (east-bound more difficult than west-bound)
  - Remediation - bring the body into the local cycle rapidly