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# From Sensory Strain to Mental Fatigue: Advancing Unified Cognitive Ergonomic Benchmarks for Contemporary Workplaces

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Dear Editor,

Contemporary occupational settings can impose substantial demands on workers' cognitive processing capacity. As systems incorporate dynamic automation and dense information streams, task complexity and procedural factors are often considered when evaluating errors and fatigue. Suboptimal visual or auditory input may add to these demands in some settings, but the available evidence does not establish that degraded sensory input consistently causes cognitive overload or mental fatigue across occupations (1-3).

Four related concepts should therefore be distinguished. Sensory strain refers here to the additional perceptual effort required to interpret difficult-to-see or difficult-to-hear information; it does not denote sensory injury. Mental workload is the cognitive demand experienced while performing a task and may remain manageable. Cognitive overload is a situation in which concurrent demands exceed the cognitive resources available at a given moment, potentially compromising performance. Mental fatigue refers to a reduced ability or willingness to sustain cognitive performance over time; it may develop during prolonged demanding activity or monotonous tasks without necessarily being preceded by overload. These concepts may interact, but they are neither interchangeable nor inevitable successive stages (1, 4, 5). We propose that sensory conditions be considered alongside task demands as a potential contributor to cognitive strain, rather than as a universally established cause of overload.

Neuroergonomics offers methods for examining cognitive demands in task-specific settings (1). In a simulated industrial human–robot interaction task, electroencephalography (EEG) measures varied across levels of task difficulty (6). Separately, multimodal research has examined how perceptual and cognitive processing demands relate to mental workload (2). These findings support considering sensory and cognitive demands together; however, a change in EEG activity alone cannot establish cognitive overload, predict an error, or demonstrate that degraded sensory input caused fatigue (1, 6, 7).

Visual ergonomics provides a practical example. In a controlled study of medication prescription reading, lighting intensity and font size were associated with differences in reading errors (3). The study did not directly assess mental workload, cognitive overload, or mental fatigue. Whether the additional effort involved in reading less-legible information contributes to those outcomes under workplace conditions remains a question for direct investigation (3, 4).

Auditory conditions warrant similar attention. In a study of female university students, greater use of hands-free devices was associated with differences in measures of cochlear function; the study did not establish a causal effect or directly characterize an occupational workforce (5). In work tasks requiring speech understanding or alarm recognition, degraded auditory input may increase listening effort, depending on signal quality, task demands, and individual resources (5, 8). Evidence is not yet sufficient to infer that such changes necessarily produce cognitive overload or subsequent mental fatigue in safety-critical workplaces.

Rather than assuming a single sensory–cognitive pathway or a universal neurophysiological threshold, occupational assessments could examine whether sensory

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conditions and task demands interact in specific jobs. We propose three complementary priorities:

1) Upstream sensory optimization: Assess legibility, contrast, and acoustic intelligibility during workstation and interface design.

2) Job-relevant sensory assessment: When appropriate, consider voluntary visual and auditory screening alongside evaluation of the work environment, with clear safeguards for confidentiality and accommodation.

3) Task-specific workload evaluation: Where feasible, combine validated subjective, performance-based, and, when justified, physiological measures to assess whether design changes improve working conditions (6, 9, 10).

## Limitations and Conclusions

Much of the evidence relevant to this proposal comes from controlled or simulated tasks and population-specific samples. Moreover, the cited studies do not collectively test whether degraded sensory input causes cognitive overload and subsequent mental fatigue across occupational settings. Workload measures and physiological signals are context dependent, and mental fatigue may occur without preceding overload (6, 7). Field studies that separately measure sensory conditions, workload, overload-related performance changes, and fatigue are needed before integrated operational benchmarks can be established.

In conclusion, considering sensory conditions alongside cognitive task demands may improve how workplace risks are investigated and managed. The proposed approach is a framework for evaluation and future validation, not evidence that a single causal pathway or universal benchmark has already been established. Any sensory screening or neurophysiological monitoring should follow applicable privacy and data-governance requirements and be used to support ergonomic accommodation, not punitive performance appraisal.

## Footnotes

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