Operator functional state assessment and fitness-for-work prediction

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The **objective** of the project is to develop a method and models to increase the accuracy of assessment and prediction of human fitness for mental work, which can be used to improve a safety of operators' performance in power industry, space, aviation, etc. This method is based on prior developments of Ukrainian team namely the day-to-day control system for prediction of human fitness for work.

Methods*:* task performance measures should focus on rate and accuracy of information processing while various cardiovascular and other physiological parameters are employed to characterize the psychophysiological state. The operator's test performance consists in decision of the same type of cognitive tasks. The time and accuracy of each task performance are registered. Each task performance time produces during research time series, which contains sequence of values of separate tasks decision time. The further analysis of time series with periodogram, spectral etc. analysis permits to reveal the "waves" that are induced by the regularity of fluctuation of task performance time. In parallel they will be registered RR-intervals.

Potential results: we anticipated that information about rhythmic organization of cognitive performance during the course of this study will (1) inform future cognitive studies by elucidating differences and common features of temporal organization of cognitive performance and its physiological responses; (2) inform future cognitive studies by particular fluctuations in task performance and physiological responses; (3) provide a basis for planning of cognitive work in conditions of maximum time "strain"; (4) provide a basis for designing and control of some types of mental work (operators of transport systems, space, aviation, power industry).

Project Narrative

When considering the role of the human operator as an element of the human-technical system, human factors/ergonomics approach to the evaluation of an operator fitness for work have typically assumed that the functional characteristics of the human (e.g., his/her knowledge, skill levels, information processing capacity) are constant. Research efforts aimed at enhancing safety and reliability of the human-technical system have been focused, as a result, on the perfection of technical, environmental and professional skills.

However, reality shows that the required level of safety and reliability has often not been achieved in spite of improvement in operation procedures, personnel selection techniques and training. In complex technological systems (e.g., power plants, aviation) the human involvement in accidents is estimated at 40-60% and higher. This testifies to the inadequate evaluation of operator efficiency by existing techniques. Predictive reliability may be considerably increased by the simultaneous monitoring of all factors affecting functional operator levels; in particular, by the monitoring of psychophysiological parameters known to be related to effective skill use.

Prior research of Ukrainian team has been aimed to develop a psychophysiological monitoring system for the assessment of the psychophysiological state and prognosis of power plant operator (nuclear and fossil, hydroelectrostations, dispatchers of power grids) and cosmonauts (SPORO-approach), as well as for evaluating its validity during the performance of monotonous tasks under laboratory conditions, as well as in applied environment. The laboratory findings supported the notion that

variations in the correlation between oscillary components of task performance measures and physiological parameters provided a useful index of operator efficiency.

Preliminary results

Applied research, employing the SPORO-approach in a fossil power plant, has evaluated the validity of the predictions concerning operator effectiveness by correlating the prediction indices with expert ratings of operator effectiveness, as well as with operational output measures (e.g., fuel usage) on 38 power plant operators. Preliminary findings suggested that the approach may indeed be useful in predicting operator efficiency.

The systems use in real-life settings has shown:

1. The systems have demonstrated hands-on experience using the psychopgysiological indicators, and preventive steps must be developed to respond to adverse changes predicted by them.

2. Predictive models for fitness-for-duty that are build on the basis of individual approach allow to ensure the accuracy of prognosis not less 90% (for operators trained with the system and if accounting external factors impact, the accuracy arises to 97%) on the assumption of everyday monitoring.

3. Ability to design off-the-shelf models for a human fitness-for-duty prediction.

4. The computer system for assessment of an operator performance and mood using an algorithm and models developed ensures a high accuracy and reliability of assessment and prediction and can be utilized for assessment of operator performance in the fields of space, aviation, ground transportation as well as power industry.

Some parts of research and system of monitoring for operators performance were used in the «Operator» program (Customer - Institute of medico-biological problems Ministry of Health of the USSR, 1984-1985, 1988-1989); as industrial implementation of systems created by the authors (11 industrial implementations including 2 nuclear power plants). Some pilot results were obtained by authors under support of the NASA grant NN-28.

The following research tasks are considered to implement such approach by way:

- Development of an individual-based approach to evaluate psychophysiological state allowing to establish "norms" for the individual rather than for a group. We strongly believe that individual differences in psychophysiological response are so great that they preclude the use of a fixed battery of physiological measures.
- Development of objective methods to evaluate an operator current psychophysiological state based on individually referenced 'norms'.

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