Cognitive disorder and professional development by training: comparison of simulator sessions for anesthetists and for nuclear reactor pilots

Fauquet-Alekhine Ph. (1) (2), Geeraerst Th. (3), Rouillac L.(2)

(1) Nuclear Power Plant of Chinon, France – (2) Laboratory for Research in Science of Energy, Montagret, France – (3) Centre Hospitalier Universitaire, Toulouse, France

Summary

For many years, stress has been shown by researchers to be both a source of performance and a source of cognitive disorders. Studies have shown how to measure some of those parameters identified to be closely associated with the occupational stressed state of subjects, involving heavy medical facilities requiring specific devices, and specific software for analysis. We have here elaborated a simple protocol requiring basic metrology and simple straight data analysis, qualified through specifics tests and showing a Yerkes & Dodson (1908) relationship between stress and performance. Application for reactor pilots and anesthetists training sessions on simulator has led to identify cognitive disorder zone during training and suggestions have been made for improvement.

Materials and Methods

This study deals with a specific kind of mental stress, the short term occupational stress, versus performance of workers. On the contrary of sophisticated metrologies and elaborated software which need, thereafter, a careful data examination to be sure of the conclusions (Montano *et al*., 2009; Rohleder *et al*., 2009; Schubert *et al*. 2009; Bailon *et al*., 2010), we aim at a simple solution based on heart rate. Preliminary tests have shown that relevant parameters

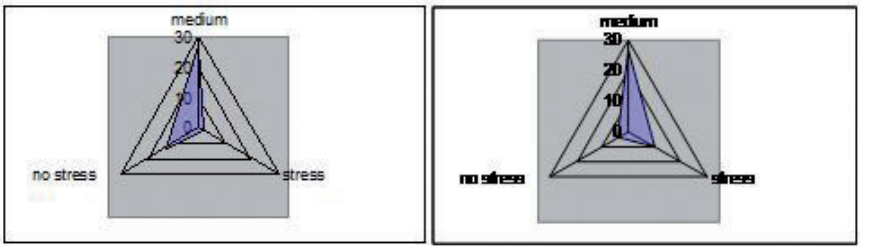

Fig. 1 a & b: the 3-LQS evaluation of the Stress-test conditions.

(measured using a Polar FS2c) would be, for this kind of stress, the mean heart frequency (HR_{mean}) and maximum heart frequency (HR_{max}) as shown before by others (see for example Schubert *et al.*, 2009).

A Stress-test made up of 12 questions has been first used to qualify the protocol and devices. It has been taken by French subjects (*N*=18; 50% male) healthy, same kind of academic background, about 25-35 yo, in two different conditions: No Stress and Stress Conditions (including stressful actions like the use of a clepsydra for time pressure). To elaborate the conditions, a 3-level qualitative scale (3-LQS) has been developed and applied based on work activity analysis, using stress variables within a 3-D source space (context, request or job demand (excluding context), subject's characteristics) close to previous works (McLean, 1976; Karasek, 1990, 1998) linked to a 3-D symptoms space (physiological, psychological, behavioral) as detailed in Fauquet-Alekhine (2011). The perception questionnaire of stress used for this experiment has been elaborated earlier in order to obtain a quantitative measure of the level of distress experienced, tested by several including in its French form (see Jehel *et al.*, 2005 and 2006).

After qualification of the protocol and device with the Stress-test, applications have been done to full scale simulation trainings for French nuclear reactor pilots (*N*>100) using the 3-LQS of stress, and anesthetist residents in a Paris district hospital (*N*=27) using the 3-LQS and physiological measurements.

Results

Using the 3-LQS of stress, two conditions of the Stress-test have been built up, No Stress and Stress Conditions, for which the following radar graphs show the obvious difference expected.

Analysis of measurements of heart rate HR (discrimination of conditions, modal analysis) and correlation with results of the per-

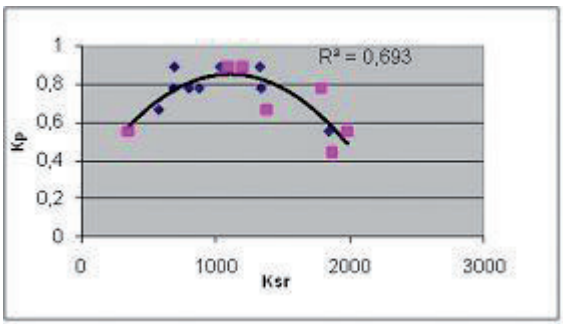

Fig. 2: performance coefficient K_p plotted vs reduced stress coefficient K_{sr} discriminates the No Stress Conditions (dark diamonds) and the Stress Conditions (clear scare).

ception questionnaire of stress (r=0.69, p<0.05) allow us to define a reduce coefficient of stress K_{sr} as :

$K_{sr} = HR_{mean} \cdot HR_{max\ ampl}$ where $HR_{max\ ampl} = HR_{max} - HR_{mean}$.

Plotting the performance coefficient of the Stress-test K_p vs K_{sr} gives a inverted U curve of Yerkes type with a correct discrimination of the stress conditions (R^2=0.69).

Application of the 3-LQS for the French nuclear pilots training in order to evaluate the appropriateness of learning conditions have led to the assumption that some difficulties could occur at the end of the training cycle; independent analysis of the trainees results shows the same but further studies are needed to know the stress contribution.

Application of the 3-LQS for anesthetist residents' training has detected stressful conditions. Application of the developed protocol (qualified with the Stress-test) gave the same result, showing that most of the subjects were in a cognitive disorder zone on a K_p vs K_{sr} graph of Yerkes type curve (see Fig. 3).

Comparison between both trainings, and analysis done for each, have led to suggest improvements for each profession. For anesthetists' training, the main point is to make them familiarized with the simulator before the training session itself, with a progressive approach of the simulator in several steps distributed on several days, including the familiarization with observers whilst working on simulator. For the reactor pilots, the main point concerns the means available in terms of documents: procedures must be reviewed and ergonomic design must be obtained. For both professions, trainees must be able to perceive their knowledge and skills sufficient for the task: this implies to create or manage differently the previous steps of their training.

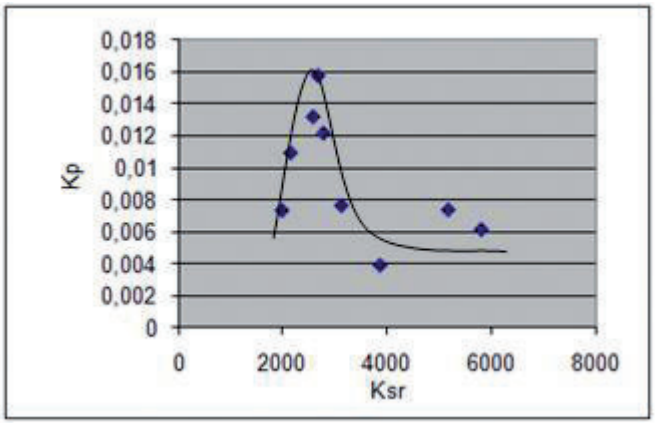

Fig. 3: performance coefficient Kp plotted vs the reduced stress coefficient Ksr in case of anesthetists' full scale simulator training.

Conclusions

Demonstration is made for i) an effective 3-level qualitative scale able to rate stress conditions with regards of qualitative variables, ii) a simple protocol and device able to evaluate short term occupational stress. Tests are successful and suggest a reduced stress coefficient K_{sr} as a relevant and accurate parameter for this kind of stress rating. The Yerkes and Dodson theory (1908) is matched. Application is done successfully with anesthetists' trainees and comparison with reactor pilots' training is done. For both professions, suggestions are made concerning the training improvement. Further applications are planned for both professions in the coming years.

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