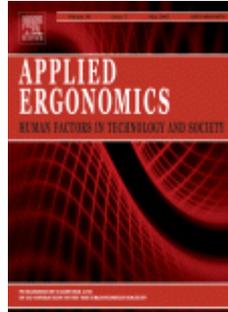


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L.J.M. Mulder, C. Dijksterhuis, A. Stuiver, D. de Waard. *Cardiovascular state changes during performance of a simulated ambulance dispatchers' task : potential use for adaptive support.* Pages 965-977.

Adaptive support has the potential to keep the operator optimally motivated, involved, and able to perform a task. In order to use such support, the operator's state has to be determined from physiological parameters and task performance measures. In an environment where the task of an ambulance dispatcher was simulated, two studies have been carried out to evaluate the feasibility of using cardiovascular measures for adaptive support. During performance of this 2–3 h lasting planning task, a pattern of results is found that can be characterized by an initial increase of blood pressure and heart rate and a decrease of heart rate variability (defense reaction pattern) followed by an ongoing increase of blood pressure counteracted by a decrease in heart rate. This pattern can be explained by an augmented short-term blood pressure control (baroreflex), which is reflected in an increase of baroreflex sensitivity. Additionally, in this latter phase heart rate variability (HRV) increases as a function of time, while blood pressure variability decreases. In the two studies performed, the baroreflex pattern was consistent for all the relevant variables.

In both studies there were periods with high and low workload. Effects of task load are mainly reflected in the variability measures, while in the second study, additionally, blood pressure level was higher during periods with high task demands.

The conclusion of the studies is that consistent cardiovascular response patterns can be recognized during this semi-realistic planning task, where variability measures are most sensitive to task demand changes, while blood pressure and baroreflex sensitivity are most informative with respect to cardiovascular state changes. These findings can be seen as a great potential benefit for future use in adaptive support applications.

- **Keywords:** Adaptive support; Short-term blood pressure control; Cardiovascular state

Sean D. Kristjansson, John A. Stern, Timothy B. Brown, John W. Rohrbaugh. *Detecting phasic lapses in alertness using pupillometric measures.* Pages 978-986.

Small, nonreflexive pupillary changes are robust physiological indicators of cognitive activity. In the present paper, we examined whether measures of pupillary changes could

be used to detect phasic lapses in alertness during a vigilance task. A polynomial curve-fitting method for quantifying parameters from single task-evoked pupillary responses (TEPRs) is described. The TEPR parameters associated with long latency responses (indicating low alertness) were compared to the TEPR parameters associated with normal latency responses (indicating an alert state) within a multilevel modeling framework. Three parameters, pupil diameter, linear pupil dilation rate and curvilinear pupil dilation rate, significantly differed between the long latency and normal latency response types. The results provide preliminary evidence that these parameters would be useful neurocognitive markers of operator state in a bio-behavioral alertness monitoring system.

- **Keywords:** Pupillometry; Alertness; Task-evoked pupillary responses; Multilevel modeling

Shinji Miyake, Shimpei Yamada, Takuro Shoji, Yasuhiko Takae, Nobuyuki Kuge, Tomohiro Yamamura. *Physiological responses to workload change : a test/retest examination.* Pages 987-996.

The purpose of this study is to examine the test/retest consistency of physiological responses induced by mental tasks. Fifteen healthy male university students were recruited as participants. They were instructed to perform a 5-min Multi-Attribute Task Battery (MATB) trial three times successively. The task difficulty level of the tracking task of the second trial was set as medium (M). The first one was set as more difficult (H) and the last trial was easiest (L). The difficulty levels of the other two tasks (resource management and system monitoring) of the MATB were identical for all three trials. The participants repeated this procedure on three different days separated by at least a 1-day interval. The order of the tasks was the same for all repeated trials, i.e., H-M-L. Tissue blood volume from the tip of the nose using a laser Doppler blood flow meter, skin potential level (SPL), ECG from three leads on the chest, systolic time intervals (pre-ejection period, left ventricular ejection time), and hemodynamic parameters (stroke volume, cardiac output) were recorded during the task trials and before and after 5-min resting periods. The participants reported their subjective workload via NASA-TLX after each task trial. Autonomic nervous system parameters derived from the above-mentioned signals, subjective workload scores, and performance indices of MATB were analyzed, and test/retest reliability was investigated. The results showed that a significant test/retest correlation was obtained for SPL for more participants than in the other parameters, although there were large individual differences.

- **Keywords:** Workload; Multi-attribute task battery; Skin potential level; Tissue blood volume

Amanda N. Elkins, Eric R. Muth, Adam W. Hoover, Alexander D. Walker, Thomas L. Carpenter, Fred S. Switzer. *Physiological compliance and team performance.* Pages 997-1003.

Physiological compliance (PC) refers to the correlation between physiological measures of team members over time. The goals of this study were to examine ways of measuring PC in heart rate variability (HRV) data and the relationship between PC and team performance. Teams were tasked with entering both real and simulated rooms and "shooting" individuals with a weapon and identifying individuals without a weapon. The linear correlation and directional agreement PC methods were shown to be the most sensitive to differences in performance, with greater PC being associated with better performance. The correlation method when applied to a measure of respiratory sinus arrhythmia (RSA) revealed a significant difference between high and low performers ($t[8] = -2.31, p = 0.03$) and the directional agreement applied to inter-beat-intervals and RSA revealed trend-level differences ($t[4.62] = -1.86, p = 0.06$ and $t[8] = -1.68,$

$p = 0.07$). These results suggest that PC may have merit for predicting team performance.

- **Keywords:** Teams; Heart rate variability; Compliance

R.A. Henning, A.G. Armstead, J.K. Ferris. *Social psychophysiological compliance in a four-person research team. Pages 1004-1010.*

continuous, non-invasive and objective measure of teamwork effectiveness could be very useful to the human factors design community. Social psychophysiological compliance (SPC), estimated by scoring the extent that heart rate variation was synchronous across team members, was explored as a predictor of teamwork effectiveness during 20 real planning meetings over a 6-month period. Speech activity and heart rate variability of all four (2 male, 2 female) team members were continuously monitored. Exploratory analyses tested if team member ratings of various aspects of teamwork effectiveness were predicted by SPC scored (1) over whole meetings, (2) during one team member's speech, (3) during periods in which two team members spoke in sequence or (4) over 30-s periods and averaging highest values. SPC during periods of sequential speech negatively predicted team members' ratings of *Team productivity*, *Quality of communication*, and *Ability to work together*. SPC shows potential as an objective, non-invasive means to monitor teamwork effectiveness but this relationship warrants further investigation and replication before use in ergonomics applications.

- **Keywords:** Psychophysiology; Teamwork; Behavioral cybernetics; Heart rate

G. Robert J. Hockey, Peter Nickel, Adam C. Roberts, Michael H. Roberts. *Sensitivity of candidate markers of psychophysiological strain to cyclical changes in manual control load during simulated process control. Pages 1011-1018.*

Complex systems are vulnerable to unpredictable breakdowns in operator performance. Although primary task goals are typically protected by compensatory effort, such protection may break down under fatigue and high strain. Detection of strain states would enable prediction of increased operational risk through adaptive automation, triggering a switch of control from human to computer. A simulated process control task was used to identify markers of strain under a cyclic loading procedure, which forced performance breakdown through stepwise changes in control load. Four trained participants provided data on control performance and a range of candidate psychophysiological markers of strain (two EEG power ratios and HRV). Within-individual analyses showed the strongest sensitivity for 'task load index' (TLI), an EEG measure based on executive control activity in frontal brain areas, though all measures were sensitive for some participants. The implications of such findings for the development of a closed loop system for adaptive automation are discussed.

- **Keywords:** Psychophysiological strain markers; Adaptive automation; Operator functional state

Karel A. Brookhuis, Cornelia J.G. van Driel, Tineke Hof, Bart van Arem, Marika Hoedemaeker. *Driving with a congestion assistant; mental workload and acceptance. Pages 1019-1025.*

New driver support systems are developed and introduced to the market at increasing speed. In conditions of traffic congestion drivers may be supported by a "Congestion Assistant", a system that combines the features of a Congestion Warning System (acoustic warning and gas pedal counterforce) and a Stop & Go system (automatic gas and brake pedal during congestion). To gain understanding of the effects of driving with

a Congestion Assistant on drivers, mental workload of drivers was registered under different conditions as well as acceptance of the system. Mental workload was measured by means of physiological registrations, i.e. heart rate, a secondary task and with the aid of subjective scaling techniques. Acceptance was measured with an acceptance scale. The study was carried out in an advanced driving simulator. Driving with the Congestion Assistant while in congestion potentially leads to decreased driver mental workload, whereas just before congestion starts, i.e. developing just noticeable, the system may add to the workload of the driver. Acceptance is generally high after experiencing the system, though not in all respects.

- **Keywords:** Automation; Human–Machine interfacing; Mental workload; Acceptance

Andrea Haarmann, Wolfram Boucsein, Florian Schaefer. *Combining electrodermal responses and cardiovascular measures for probing adaptive automation during simulated flight*. Pages 1026-1040.

Adaptive automation increases the operator's workload in case of hypovigilance and takes over more responsibility if workload becomes too high. Two consecutive studies were conducted to construct a biocybernetic adaptive system for a professional flight simulator, based on autonomic measures. Workload was varied through different stages of turbulences. In a first study with 18 participants, electrodermal responses of experimental subjects oscillated very close to the individual set point, demonstrating that workload level was adjusted as a result of adaptive control, which was not the case in yoked control subjects without adaptive automation. Combining electrodermal responses with heart rate variability in a second study with 48 participants further enhanced the adaptive power which was seen in even smaller set point deviations for the experimental compared to the yoked control group. We conclude that the level of arousal can be adjusted to avoid hypovigilance by combining autonomic measures in a closed loop.

- **Keywords:** Adaptive automation; Skin conductance; Heart rate variability

C. Collet, A. Clarion, M. Morel, A. Chapon, C. Petit. *Physiological and behavioural changes associated to the management of secondary tasks while driving*. Pages 1041-1046.

Sharing attention between two tasks requiring the same mental resources is supposed to increase the resulting strain. Phoning while driving may elicit cognitive interference between driving operations and conversation and consequently, may affect driving efficiency. The road scene cues may thus be perceived late or even omitted, increasing the probability to be involved in a critical situation. The aim of the experiment was to study how the additional strain elicited by a secondary task may change drivers' arousal with potential consequences on driving performance. Electrodermal activity, heart rate and reaction time (RT) were the dependent variables. Listening to the radio, holding an in-vehicle or a cell-phone conversation were the secondary communication tasks, performed by 10 participants during a driving sequence on a private circuit. Within nominal driving, each communication task was requested at random to prevent any habituation or anticipation. The cell-phone conversation made RT increase by about 20%, by comparison to the nominal driving condition. Nevertheless, the in-vehicle conversation impacted RT almost in the same proportion. Physiological data showed that arousal level increased as a function of dual-tasks requirements, the in-vehicle conversation eliciting the same strain as the remote conversation. With caution due to contextual differences between these two communication tasks, conversing with a passenger was thus as detrimental as using a cell-phone.

- **Keywords:** Electrodermal activity; Heart rate; Reaction time; Arousal; Strain; Dual-task; Shared attention

Akihiro Yagi, Kiyoshi Fujimoto, Kazumi Michihiro, Bevy Goh, Daniel Tsi, Hajime Nagai. *The effect of lutein supplementation on visual fatigue : a psychophysiological analysis.* Pages 1047-1054.

We used psychophysiological technology to examine the effect of an oral supplement, a combination of lutein, zeaxanthin and blackcurrant extract (LUT), on visual fatigue, within the context of a randomized, double-blind, placebo-controlled cross-over trial. The LUT supplement and placebo samples were randomly assigned to thirteen participants, who took the samples for two LUT (and vice versa) for another 2 week. Each participant completed visual proof reading tasks for 2 h during each of four testing sessions. Saccade tests were administered before and after the proof reading task, during which the participants moved their eyes back and forth between two targets positioned in the center of two checkerboards. We recorded EEG, EOG, heart rate, and facial muscle potential/performance during the saccade tests. Blood pressure was measured and subjective fatigue and stress scores were collected before and after the proof reading task. We averaged EEG starting at saccade offset in order to analyze eye fixation related potentials (EFRP). Our results suggested that the proof reading task induced visual fatigue. An analysis of EFRP and other psychophysiological data revealed significant differences between the LUT and placebo conditions. These results suggest that supplementation with LUT could help to reduce symptoms of visual fatigue.

- **Keywords:** Visual fatigue; ERP; Eye movement; Lutein

Egon L. van den Broek, Joyce H.D.M. Westerink. *Considerations for emotion-aware consumer products.* Pages 1055-1064.

Emotion-aware consumer products require reliable, short-term emotion assessment (i.e., unobtrusive, robust, and lacking calibration). To explore the feasibility of this, an experiment was conducted where the galvanic skin response (GSR) and three electromyography (EMG) signals (frontalis, corrugator supercilii, and zygomaticus major) were recorded on 24 participants who watched eight 2-min emotion inducing film fragments. The unfiltered psychophysiological signals were processed and six statistical parameters (i.e., mean, absolute deviation, standard deviation, variance, skewness, and kurtosis) were derived for each 10-s interval of the film fragment. For each physiological signal, skewness and kurtosis discriminated among affective states, accompanied by other parameters, depending on the signal. The skewness parameter also showed to indicate mixed emotions. Moreover, a mapping of events in the fragments on the signals showed the importance of short-term emotion assessment. Hence, this research identified generic features, denoted important considerations, and illustrated the feasibility of emotion-aware consumer products.

- **Keywords:** Short-term emotion assessment; Physiological signals; Statistical moments