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Editorial Open Access

Application of Human Physiology in Ergonomics

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Editorial

Ergonomics is widely used in manufacturing, transport, health care, office and other industry and service fields. For example, when we design machines and human-machine interfaces, or when we improve passengers and driver's safety and comfort, we should take human factors into account. Human factors include physiological factors, psychological factors, and other social factors. Human physiology should be widely applied in Ergonomics.

I got my PhD degree at Institute of Biomedical Manufacturing and Life Quality Engineering, School of Mechanical Engineering, Shanghai Jiao Tong University. During my PhD studies, I researched on application of human physiology and psychology in mechanical engineering, automotive engineering, aeronautics, and astronautics. I focused on humans physiological and psychological reactions when riding airplanes and elevators, including ear discomfort, aviation otitis media, vestibular dysfunction, vertigo, hyper-gravity and hypo-gravity physiology. To accomplish these research tasks, I also studied at Medical School of Shanghai Jiao Tong University and Department of Otolaryngology-Head and Neck Surgery, Shanghai Renji Hospital.

To evaluate the effect of atmospheric pressure changes in the elevator cars on humans hearing levels, pure tone audiometry and tympanogram, two basic tests in hearing physiology and clinical audiology, were adopted to evaluate the changes of human hearing levels and middle ear functions. In my research, the atmospheric pressure was changed from normal atmospheric pressure to 2000Pa below normal atmospheric pressure in 50 seconds. In pure tone audiometry test, three speech frequencies were used: 500Hz, 1000Hz, and 2000Hz. It was found that humans hearing levels were decreased after the atmospheric pressure was changed. Statistical difference was found in all of the 500Hz, 1000Hz, and 2000Hz ($P<0.05$). However, the differences among the three frequencies were not statistically significant ($P>0.05$). It could be concluded that the 2000Pa negative pressure change of the atmospheric pressure would result in the decrease in humans hearing levels. So, when passengers ascend in a 4-5 m/s elevator in a more than 50-storey building, there might be a short time decrease in humans hearing levels to some extent. I published an article on effect of the atmospheric pressure changes on humans eardrums when taking elevators [1].

Similarly, this ear discomfort is also occurred in airplane flights, for all of the pilots, air crews, and passengers. Eustachian tube can be opened automatically during ascending period in order to relieve the pressure difference across the eardrum. But on the contrary, Eustachian tube cannot be forced to open automatically during descending period. So, compared to ascending period, this ear discomfort is more likely to occur during descending period, including the ear-blocked sensation, the pain of eardrum, and the deterioration in hearings. These uncomfortable phenomenons are more susceptible to children, elderly persons or patients with colds and E.N.T. diseases. When we design high-speed elevators and airplanes, we should take ear discomfort into account.

I did my postdoc research at School of Aeronautics and Astronautics, Shanghai Jiao Tong University, and Department of Neurology, Shanghai Sixth People's Hospital, Shanghai Jiao Tong University. During my postdoc periods, I researched on physiological and biochemical evaluations of human mental workload. Physiological evaluations consist of peripheral physiological evaluations and central physiological evaluations. Peripheral physiological evaluations mainly include heart rate and Heart Rate Variability (HRV) recorded from ECG, blood pressure, respiration, eye blinks and skin potential. Central physiological evaluations mainly refer to the cerebral cortex, including EEG and ERP. They are all objective measurements to evaluate mental workload when conducting particular mental tasks [2].

Heart Rate Variability (HRV) describes beat-to-beat variation in heart rate or small differences in RR intervals, thus reflecting the function of the autonomic nervous system. In the spectral analysis of HRV, low frequency band (LF) represents mainly the cardiac sympathetic nervous activities and high frequency band (HF) shows the respiratory and cardiac vagal nervous activities. During the ascending and descending periods of airplanes, pilots are in the state of heavy mental workload, cardiac activity is controlled mainly by sympathetic nerves, while in normal cases, cardiac activity is controlled mainly by vagal nerves. This would cause an increase in LF and LF/HF but a decrease in HF during mental workload [2].

When hearing organs are stimulated by a sound with a certain intensity or frequency, there would be a sequence of electrical activities in hearing systems from the cochlear nerve to the cortex, which are named as Auditory-evoked-potentials (AEPs). According to the different length of latency, AEPs could be divided into short-latency AEP, middle-latency AEP, and long-latency AEP. Long-latency AEP contains the wave components of P1, N1, P2, N2, P3, etc. Recorded from the scalp, long-latency AEP is the electrical activities of auditory cerebral cortex, which is also called Auditory Event-related-potential (ERP). Mismatch negativity (MMN) is the negative component of ERP by subtracting the standard wave from the deviant wave, and usually peaking at about 100-200ms after the onset of stimulus. These components are used to evaluate the functions of hearing system, and are also closely related to the mental activities of cerebral cortex, such as attention, information processing, resource allocation and other cognitive activities [3].

In the fields of ergonomics and human factors, long-latency AEP components are used to evaluate mental workload during mental tasks such as flights with auditory events. As for pilots, during the ascending and descending periods of flights, with the introduction of mental tasks and increases in the difficulty of the primary task, more processing resources are allocated to the primary task, which is reflected on the decreases in amplitudes and increases in the latencies of long-latency AEP components [3].

Combined with my PhD and postdoc researches, to sum up, it could be clearly seen that in mechanical engineering, automotive engineering, aeronautics, and astronautics, human physiology should be applied in ergonomics and human factors to improve the safety and comfort of machines, automobiles, elevators and airplanes.

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