Journal of Ergonomics
ISSN: 2165-7556
He, J Ergonomics 2013, 3:2
DOI: 10.4172/2165-7556.1000e118

Editorial Open Access

Drowsiness Detection and Management

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Drowsiness disrupts work performance and increases the risks of accidents substantially, especially for performance-critical tasks, such as driving and piloting. Each year, 100,000 police-reported crashes are directly caused by driver drowsiness, which results in about 1,550 deaths, 71,000 injuries, and $12.5 billion financial losses, according to an estimation by the National Highway Traffic Safety Administration [1]. The National Sleep Foundation estimated in 2002 that 51% of adult drivers had driven a vehicle while drowsy and 17% had fallen asleep behind the wheel. Pilot drowsiness is an important factor in pilot performance and aviation accidents [2]. Pilot drowsiness can reduce alertness and attention and cause longer response times [3]. Drowsiness is also concerning because people's own judgment of their susceptibility to drowsiness is poor [4].

To mitigate the risks of drowsiness on driving and piloting, drowsiness detection technologies and drowsiness management programs are demanded. This article introduces existing and emerging technologies for drowsiness detection and drowsiness management strategies and calls for more research into the effects of drowsiness on task performance.

Drowsy drivers and pilots manifest their fatigue states in various ways, such as heart rate, respiration rate, blood pressure, head and eye movement and task performance. For a drowsy driver or pilot, the delta and theta components of electroencephalography increase significantly [5]; heart rate decreases [6]; respiratory rate decreases; blood pressure increases [7,8]; blood oxygen concentration is lower (under 18%) [9]; blink rate and eye closure exceeding 1 second increase [4,5,10]; head nods more often [11]. Moreover, drowsy drivers and pilots perform poorly and make more errors [3,11].

Drowsiness can be detected using a variety of sensors, including electroencephalograph (EEG), electrocardiogram (ECG), polyphysiograph, accelerator sensors, and oculographical measurements. The relative strengths of the EEG components, such as $(\theta+\alpha)/\beta$, $(\alpha+\beta)/\theta$, α/β, $(\theta+\alpha)/(\alpha+\beta)$ and θ/β, are commonly used to predict drowsiness [12]. Three-axis accelerators can be used to detect head movements, such as head nods. Infrared cameras or smartphone cameras can be used to monitor oculographical measurements, such as eye blinks and PERCLOS (Percentage of Eye Closure).

Different sensors have their own advantages and disadvantages. EEG is one of the most predictive and reliable techniques for drowsiness detection [13,14]. However, EEG sensors are often expensive, time-consuming to setup, and intrusive. Camera-based drowsiness detection often does not require users to wear a device, therefore less intrusive. However, it is hard to develop computer vision algorithms robust enough to detect faces and eyes of different skin colors, and under various weather and lighting conditions. Accelerator sensor is cheap but can only detect head movements.

New advancements in mobile technologies and sensors make drowsiness detection more feasible and affordable in real-world tasks. For example, Dr. He and his coworkers used Android and iPhone smartphones to detect visual indicators of driver fatigue, such as head nods, head rotation, and eye blinks. The increasing popularity of dry EEG sensors, such as Emotiv and Neurosky, makes it more affordable and convenient to collect EEG brain waves. Future research should consider predictability, reliability, affordability, and intrusiveness to detect drowsiness using various sensors or their combinations.

Besides the above-mentioned technologies for drowsiness detection, some management strategies can also be used to combat drowsiness [15]. For example, drivers and pilots should take a break or should take turns after working for a long period of time. However, temporary breaks from driving can only reduce time-on-task fatigue but not sleepiness [16]. Drivers and pilots can take caffeine, specifically slow-release caffeine, if they have to continue their work and there is no opportunity to take a break [17]. Long-time drivers and pilots should be informed about their tendency toward drowsiness and provided drowsiness management techniques.Future research should evaluate the effectiveness of different counter measurements to reduce drowsiness and improve task performance.

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Received August 05, 2013; **Accepted** August 07, 2013; **Published** August 10, 2013

Citation: He J (2013) Drowsiness Detection and Management. J Ergonomics 3: e118. doi:10.4172/2165-7556.1000e118

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