Contributions to Driving Ergonomics and Fatigue Assessment Studies

All of the core characteristics of the B-Alert wireless-EEG headsets and software make them ideal for driving ergonomics and fatigue assessment studies. In addition to the medical-grade, dependable signals delivered in portable, ease-to-use and comfortable-for-hours designs, here are some key features to consider:

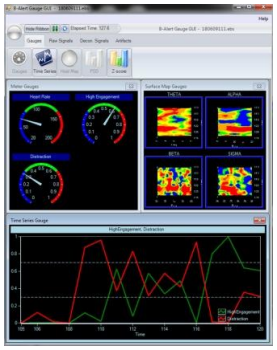
1) **The B-Alert Cognitive State Metrics**
2) **Previous Examples of Research & Outcomes**
3) **Extensive Synchronization & Integration Capabilities**

B-Alert X4

1) The B-Alert Cognitive State Metrics

All B-Alert headsets run the second-by-second, real-time Cognitive State Metrics which classify each subject's level of engagement, distraction and fatigue. Researchers can integrate the Metric outputs directly into their own analysis and/or custom algorithm research. There are peer-reviewed and validated publications from internationally accredited scientific journals which outline how the Metrics were developed and tested across large and diverse subject populations. [1]

The Cognitive State Metric classifications constitute a continuum from highly engaged & processing sensory inputs on down to fatigue onset. The Metrics reflect how subjects are processing visual stimuli by assessing a combination of their alertness & focus levels plus the presence of a stimulating environment. High Engagement reflects how comprehensive motor skill and executive resources are being exercised. Low engagement occurs when the amount of sensory scanning & processing decreases (e.g. when driving a long monotonous road). Distraction occurs with disengagement from active sensory processing; typically resulting from boredom or fatigue-related inabilities. Drowsy and Sleep Onset occur when subjects exhibit EEG signs of fatigue.



B-Alert Cognitive Metrics Software GUI

To be clear, there are four total classification and the combined probabilities of all them added up to equal 1 (i.e. 100%). The model was built by sampling EEG during a variety of highly engaging (mostly visual) & boring tasks during fully-rested and sleep-deprived conditions, so each subject's EEG is matched against the database to estimate states. There is always an interaction between the current state of the subject (how rested are they) and the environment or activity. For example, a sleep-deprived person given a stimulating gaming task may have some period of time where they return to high engagement before returning to a drowsy state.

B-Alert Large Payload Trucks Recordings South Africa - July 2011

2) Previous Related Research & Outcomes

B-Alert wireless-EEG systems have been used in several human performance research studies over the past decade. The first B-Alert product was a drowsiness alarm system for the long haul trucking community. Its development included multiple in laboratory simulation studies as well as several on-the-road field tests, funded through NIH initially, and later through ONR. Early studies utilized a standard EEG system to collect data on n=160 subjects while completing a series of tasks that required variable levels of attention and engagement, under both fully rested and sleep deprived

conditions. Using these data sets, along with data collected as persons were allowed to try to sleep, a four class model describing the alertness spectrum from sleep-onset to highly-engaged was developed. During this time, the first B-Alert portable, wireless system, requiring only 3 sensors, and 2 differential channels for the algorithm was also developed. The combined system was tested using a STISIM driving simulation that included a 45 min session partitioned into 20-25 minutes of monotonous driving and 20-25 minutes of complex driving, order counterbalanced across participants. Using the sleep onset and distraction probabilities of the B-Alert alertness algorithm, a metric of drowsiness was developed. When examining error rates in each driving session, the drowsiness probabilities correlated positively and significantly with errors occurring during driving. Driving errors included: collisions, lane departures, running stop signs, etc. In addition, alarms driven by the algorithm were developed that effectively delayed fatigue related errors by up to 30 minutes.

Mobile Roadside Assessment Capabilities

Research teams have conducted additional studies with commercial partners including Caterpillar, Daimler, and Yellow Trucking in parallel to leading several other internal driving simulation studies. Caterpillar utilized the B-Alert algorithms and EEG monitoring system to optimize safety interventions and monitoring during use of their mining equipment. The Yellow Trucking studyled to the development a fatigue management program designed to elucidate the potential causes of driver fatigue and mitigate the impact of fatigue on driver safety. Because Yellow drivers were primarily middle-aged men (average age = 51) with high BMIs, the most important aspect of the program was to identify and treat those with chronic fatigue resulting from sleep apnea. Daimler executed several studies utilizing B-Alert capabilities. Their work found that the B-Alert Cognitive State Metric increased with monotonous driving on The Autobahn. They followed this with a close range, 30 km driving range study to examine how drowsiness effected detection of irregularly placed, rare events on the course [2].

Live Flight Recording with B-Alert

Internally, Advanced Brain Monitoring has continued to apply B-Alert systems with STISIM and other colleagues in other driving, flight and other transportation category studies. At the University of Iowa, the National Advanced Driving Simulator lab, we examined the effects of drugged driving on performance as well as fatigue and long distance driving for up to 4 hr. With STISIM, through several SBIRs and DoD contracts, we are examining the neuroergonomics of simulation versus real-world flight, as initial evaluation of the ecological validity of simulations. Finally, we are collaborating with the HIV Neurobehavioral Research Program at the University of California- San Diego to examine how B-Alert may add explanatory value in evaluation of driving capability in the HIV population that develops cognitive deficits (up to 50%), as simulations alone have been found inadequate to determine capabilities.

In 2012, a team of researchers at Nissan Automotive purchased multiple B-Alert systems for their internal car ergonomics development studies.

3) Extensive Synchronization & Integration Capabilities

The B-Alert systems always include the complete Software Developers' Kit (SDK) for integrating raw and processed signals across existing platforms. The systems were designed around the philosophy that EEG adds the most value when it can make sense relative to all data and stimuli so we provide all tools available to researchers. BMW synchronized B-Alert's second-by-second outputs with over ***400*** other real-time data points acquired in an everyday 3-Series card during their 6 hour real-world highway driving studies. If the integration tool you need is not yet available, our engineers will work with you to create it.

[1] *Johnson RR, Popovic D, Olmstead RE, Stikic M, Levendowski DJ, Berka C. Drowsiness determination through EEG: development and validation. Biol Psychol. in press March 2011.*