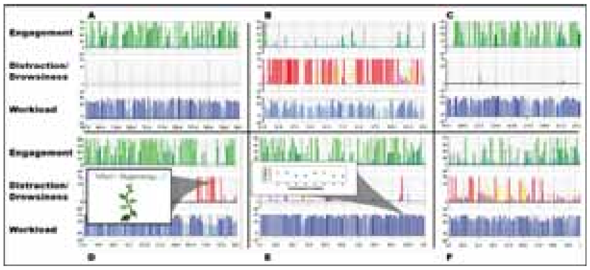
Psychophysiological Characterization of Learning and Skill Acquisition

Skill development occurs in stages characterized by distinctive amounts of time and mental effort required to exercise the skill: the initial cognitive stage of assembling new knowledge, the associative stage where newly assembled procedural steps gradually automate as they are practiced, and the autonomous stage where the task execution is automated and performed with minimal conscious mental effort. During the transition from cognitive to associative stage, speed and accuracy increase as subjects become less reliant on declarative representations of knowledge.

Over a training session, a trainee's overall performance will be influenced by how rested and motivated they are, how familiar they are with the task, and the context of the environment that they are performing in (i.e. high vs. low stress). Over a series of inter-related tasks during the training session, performance is influenced by how well the trainee understands the content and contextual linkages between tasks. Sometimes these linkages are automatic, but on other occasions searching for additional information is required. These change as skills are acquired. Within a single problem solving task, event-related metrics can inform whether the trainee understood the task or recognized and encoded important pieces of information. The transitions between these stages can be assessed with performance metrics, expert observations and subjective reports but these measures often lack precision and do not offer insight into the neurocognitive processes involved during learning.



Recent investigations have demonstrated that quantification of information processing including attention, memory and workload through the application of in EEG power spectra and event-related EEG are associated with stages of skill acquisition in simple and complex tasks. Technically, EEG-based cognitive load measurement offers the advantage of extremely high temporal resolution. EEG is collected at the millisecond level, in contrast to the longer time intervals required for traditional measures such as mouse clicks or user responses. This permits effective monitoring of workload fluctuations in very rapid decision-making processes that are unobservable using traditional methods.

From a neurophysiologic perspective, complex learning events in simulations for training math and science skills span a long time. EEG measures are particularly relevant during the transitions across single problem solving tasks within a series of inter-related tasks. The key outcome related to depth of learning and skill acquisition is the eventual decrease in mental effort required to perform the task, not just the accuracy of performance. If performance alone is used, no distinction is made between people who perform well but expend a significant level of mental effort and people who perform well with minimal effort.

Empirical classroom studies have shown that dynamic changes in of EEG-based Workload, Engagement and Distraction identify different temporal levels that can help pace training activities in different ways. This can be accomplished using a closed-loop feedback system where the output of the cognitive state analyzer can be used to provide information to the trainee, the trainer or via an automated adjustment in a computerized training simulation test bed.

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