AI Companion for Attentional Fatigue: Detection of Facial Features to Anticipate Attentional Fatigue Coupled With Sonic Stimuli to Mitigate Inattention

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Attentional fatigue reduces cognitive performance, increases reaction time variability, and increases error rates, especially in environments where safety is critical. This study developed an AI system to detect signs of attentional fatigue by analyzing facial micro-expressions and then deliver adaptive sonic cues to maintain attention. A mixed experimental design combining independent groups with repeated measures was conducted with 105 participants using a 10-minute continuous performance task and three conditions: no stimulation (baseline), continuous binaural sound, and an adaptive condition in which sound was delivered only when the system detected signs of fatigue. To monitor attentional state, participants' facial features were extracted using MediaPipe Face Mesh and matched to reaction-time percentiles. Several machine learning models were trained to classify engaged versus fatigued states, and XGBoost performed best, achieving an ROC-AUC of 0.97 and an F1 score of 0.91. Based on the analysis, the AI-intervention resulted in significantly lower (~20% reduction) average reaction time than baseline or continuous stimulation, with lower variability and more stable performance over time, along with fewer lapses in attention. Based on the independent facial feature analysis, fatigue state showed increased blink rate, gaze instability, brow furrowing, and head and lip movements, supporting parameters of deteriorating cognitive control. Overall, these findings suggest that attention can be supported more effectively when interventions are delivered only when needed rather than continuously. This approach offers a practical, non-invasive way to support attention in real time, with applications in classrooms, hospitals, driving, and other safety-critical environments.

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American Psychological Association: Complimentary student affiliate memberships
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