

Integrating Emotional and Neuropsychological Indicators to Improve Sleep Quality Classification Performance



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Objective

Sleep quality is intricately linked to anxiety and depression. However, the extent to which neuropsychological assessments offer incremental predictive validity over traditional self-report measures remains underexplored. This study investigated whether integrating neuropsychological indicators with emotional measures enhances sleep quality classification, thereby addressing a critical gap in multimodal psychological assessment.

Method

Data from an initial sample of 322 adults aged 18–65 years were analyzed. Sleep quality was categorized using the Pittsburgh Sleep Quality Index (PSQI), defining good (PSQI ≤ 5 , $n = 65$) and poor (PSQI ≥ 13 , $n = 63$) sleep quality. Based on these criteria, 128 participants were included in the final analyses ($M = 28.45$, $SD = 11.36$), including 99 males (77.34%) and 29 females (22.66%). Assessment tools included the Beck Anxiety Inventory (BAI), Beck Depression Inventory (BDI), Iowa Gambling Task (IGT), and Conners' Continuous Performance Test–Third Edition (CPT-3). A baseline model using BAI and BDI was compared with an augmented model incorporating standardized IGT and CPT-3 features using five-fold cross-validation.

Results

baseline logistic regression model achieved an AUC of 0.918 and 82.8% accuracy. Incorporating three specific indicators—IGT Deck B, IGT Deck D, and CPT omission errors—improved performance to an AUC of 0.931 and 83.6% accuracy. Notably, for the poor sleep group, the F1 score increased from 0.814 to 0.829, and recall improved from 0.760 to 0.810 (Table 1). These findings demonstrate that including IGT and CPT-3 metrics significantly refine the identification of individuals with poor sleep quality.

Table 1 Performance Comparison of Sleep Quality Classification Models

Model	AUC	Accuracy	F1 Score (Poor Sleep)	Recall (Poor Sleep)
Baseline (BAI + BDI)	0.918	82.8%	0.814	0.760
Augmented (+ IGT & CPT-3)	0.931	83.6%	0.829	0.810

Note. BAI = Beck Anxiety Inventory; BDI = Beck Depression Inventory; IGT = Iowa Gambling Task; CPT-3 = Conners' Continuous Performance Test–Third Edition. Bold values indicate the best performance.

Discussion

While emotional symptoms are effective risk indicators, cognitive metrics (IGT Deck B, IGT Deck D, and CPT omission errors) specifically capture deficits in decision-making, reward learning, and sustained attention. These impairments align with the impulsive and inattentive characteristics of poor sleep, providing critical insights beyond emotional scales. Ultimately, integrating neuropsychological indicators facilitates a more holistic understanding of sleep-related mechanisms and underscores the utility of multimodal assessment.

References

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