Dusk – A GenAI-Powered Early Screening Platform for Neurofunctional Decline Disorders

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Millions suffer from Neurofunctional Decline Disorders (NFDs). Yet, current diagnostic methods often fail to detect their early onset, which involves subtle disruptions in cognitive, motor, and autonomic functions. This challenge is amplified in rural areas due to the lack of accessible, non-invasive tools, resulting in missed opportunities for timely intervention. We propose a digital screening platform that passively and interactively assesses early signs of NFDs using cognitive stress tests, eye-tracking, and HRV analysis. By capturing behavioural, physiological, and executive function cues, our system provides a comprehensive risk profile. Integrated with GenAI, the platform generates intuitive, personalized reports that empower clinicians and caregivers to act before irreversible damage occurs.

Our primary users include adults over the age of 40, who are especially vulnerable to neurodegenerative disorders, as well as healthcare providers and researchers. Caregivers and individuals seeking proactive health monitoring make up our secondary user base. In a landscape where specialized neurophysical tests are often out of reach, our solution stands out as an accessible and user-friendly alternative. In clinical settings, it can assist in patient triage, while at home, the same tests can be self-administered with ease. That’s how simple it is. Our affordable, hardware-light setup ensures it can be deployed effectively in both urban and rural environments.

Declining cognitive, motor, and autonomic functions are key indicators of Neurofunctional Decline Disorders (NFDs). To detect and interpret these changes through speech, we implement a GenAI-powered NLP Stroop test. Voice inputs are transcribed using Whisper (ASR) and analyzed by an LLM to assess accuracy, response latency, hesitation, and semantic anomalies. GenAI then generates personalized, natural-language reports that are easily interpretable by clinicians and users alike—transforming raw metrics into meaningful insights. Over time, the system tracks user data, compares performance trends, and flags subtle risk patterns in real time. This enables early detection and supports scalable, intelligent clinical decision-making. GenAI thus bridges the critical gap between raw test data collection and cognitive health understanding.

So, we present Dusk, a multi-modal cognitive screening system that combines HRV analysis, Stroop tests, and eye-tracking through a Streamlit-based interface.

1. HRV Analysis measures short ECG and pulse data using Arduino to compute SDNN and RMSSD, key biomarkers that reflect stress levels and autonomic nervous system function.

2. Stroop Test assesses visual attention and inhibition control. Using Whisper and GenAI, voice responses are transcribed and analyzed by a language model to evaluate accuracy, response delay, and signs of hesitation.

3. Eye-tracking tests, powered by OpenCV and MediaPipe, help us evaluate gaze deviation, fixation patterns, and pupil deviation simulation during the Stroop tests.

We will then proceed to fuse all the features—physiological, behavioral, and visual—using a Random Forest classifier to predict cognitive stress and attention risk. We use Generative AI for data interpretation. Our GenAI will generate a personalized, comprehensible summary of the test results.

Using a user interface built in Streamlit, the UI will support stepwise testing, real-time visualization, and voice-based interaction, allowing us to utilize these rapid and repeatable assessments.

Together, this framework ensures a smooth user journey, from data acquisition to AI-driven result interpretation.

Our system adopts accessible tools like Arduino-based sensors for HRV analysis, and Python libraries such as MediaPipe, Whisper, and Streamlit. Whisper forms the backbone of our GenAI-powered Stroop test by transcribing voice input, while an LLM API handles report generation. Data extraction, model training, and visualization are performed on lightweight, locally hosted or cloud-based services. Using a Random Forest classifier provides interpretable results, and by bypassing high-end GPUs, we ensure scalability. The mobile-friendly, remote-ready UI allows easy deployment in clinics and homes, all while operating in real-time and protecting user data.

We've built this in a way that it can work pretty much anywhere—rural or urban, at home or in a clinic. Because it doesn't rely on heavy hardware, it stays affordable, and since it's modular, it can plug into existing healthcare systems or even wearable devices if needed.

One of the best parts is that it can be used over time, so people can actually track how their cognitive health is changing. With mental health issues and age-related decline becoming more common, we believe this could help catch problems early, take some pressure off clinics, and make care more personal.

It's not just for hospitals either, this could be useful in research, for keeping an eye on therapy progress, or even in workplace wellness programs. The data it gathers could really push personalized medicine forward.

In the end, our goal is simple: we want to make sure brain health screening is as easy and normal as checking your blood pressure.

Our prototype - Dusk, is a scalable, AI-powered screening platform designed to address the urgent need for early detection of neurofunctional decline. By integrating HRV, voice, and eye movement analysis, and transforming complex biosignals into clear, actionable insights using GenAI, it delivers both precision and ease of use. Developed as a Minimum Lovable Product, it's designed to be not just functional, but immediately valuable to users. Its adaptable design enables deployment as a cognitive wellness app, a clinical triage tool, or a research-grade screening kit. By combining advanced analytics with everyday accessibility, this solution makes early brain health screening more approachable, scalable, and impactful—right where it's needed most.