TOWARD A PORTABLE, SELF-ADMINISTERED CRITICAL FLICKER FREQUENCY TEST

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HEPATIC ENCEPHALOPATHY (H.E.)

Occurs in people with end-stage liver disease

    Normal function of liver impaired

    Toxins build up in the blood (e.g., ammonia)

    Increased concentration of toxins affects cognitive abilities

WEST HAVEN CRITERIA FOR HEPATIC ENCEPHALOPATHY

Stage	Level of Consciousness	Intellect & Behavior	Neurological Findings
0	Normal	Normal	Normal examination; if impaired psychomotor testing, then MHE
1	Mild Lack of Awareness	Shortened attention span; impaired addition or subtraction	Possible mild asterixis or tremor
2	Lethargic	Disoriented; inappropriate	Obvious asterixis; slurred speech
3	Somnolent but arousable	Gross disorientation; bizarre behavior	Muscular rigidity & clonus; hyper-reflexia
4	Coma	Coma	Decerebrate posturing

IMPACT OF LATE DETECTION OF H.E.

Reduced quality of life and affects everyday tasks

Increased risk of road traffic incidents

Increased hospitalizations

Increased mortality

COST OF LATE DETECTION

If detected early, easily treatable (Stage 0-1)

Affordable, effective home medications to clear toxins

If detected late, not easily treatable (Stage 2)

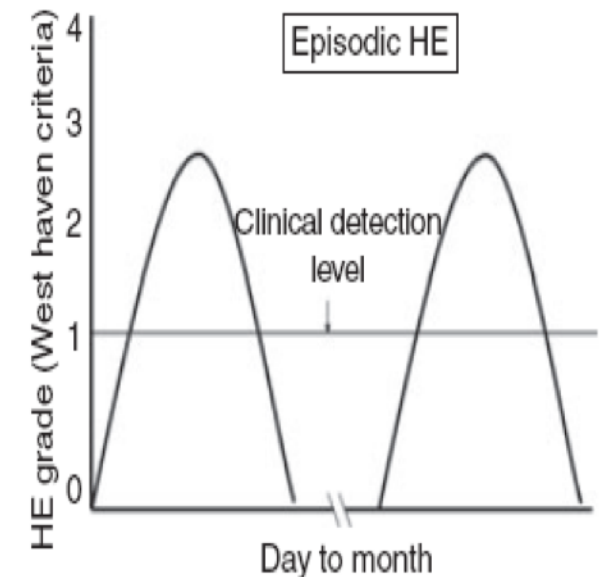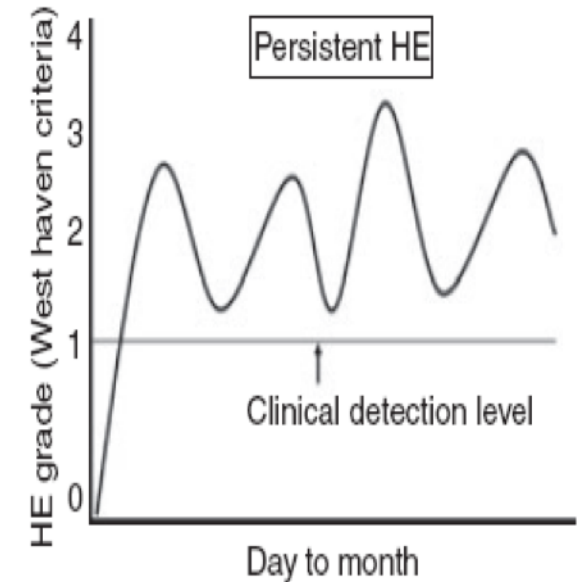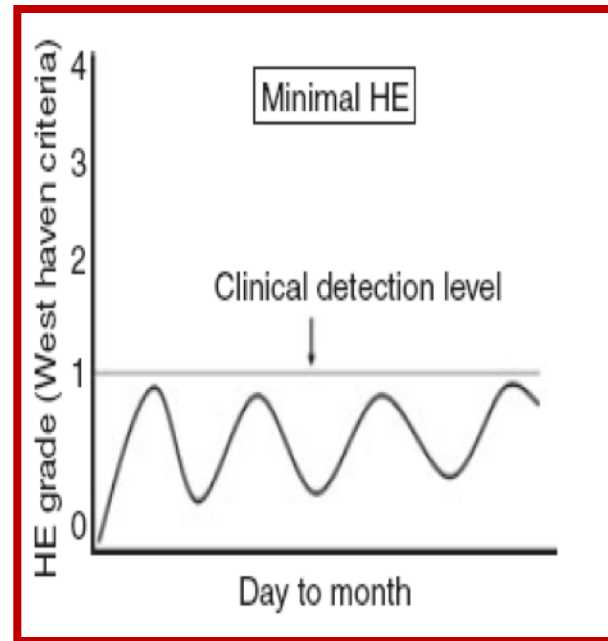Requires hospitalization for intravenous and enema medications

If detected *really* late, can be life-threatening (Stage 3-4)

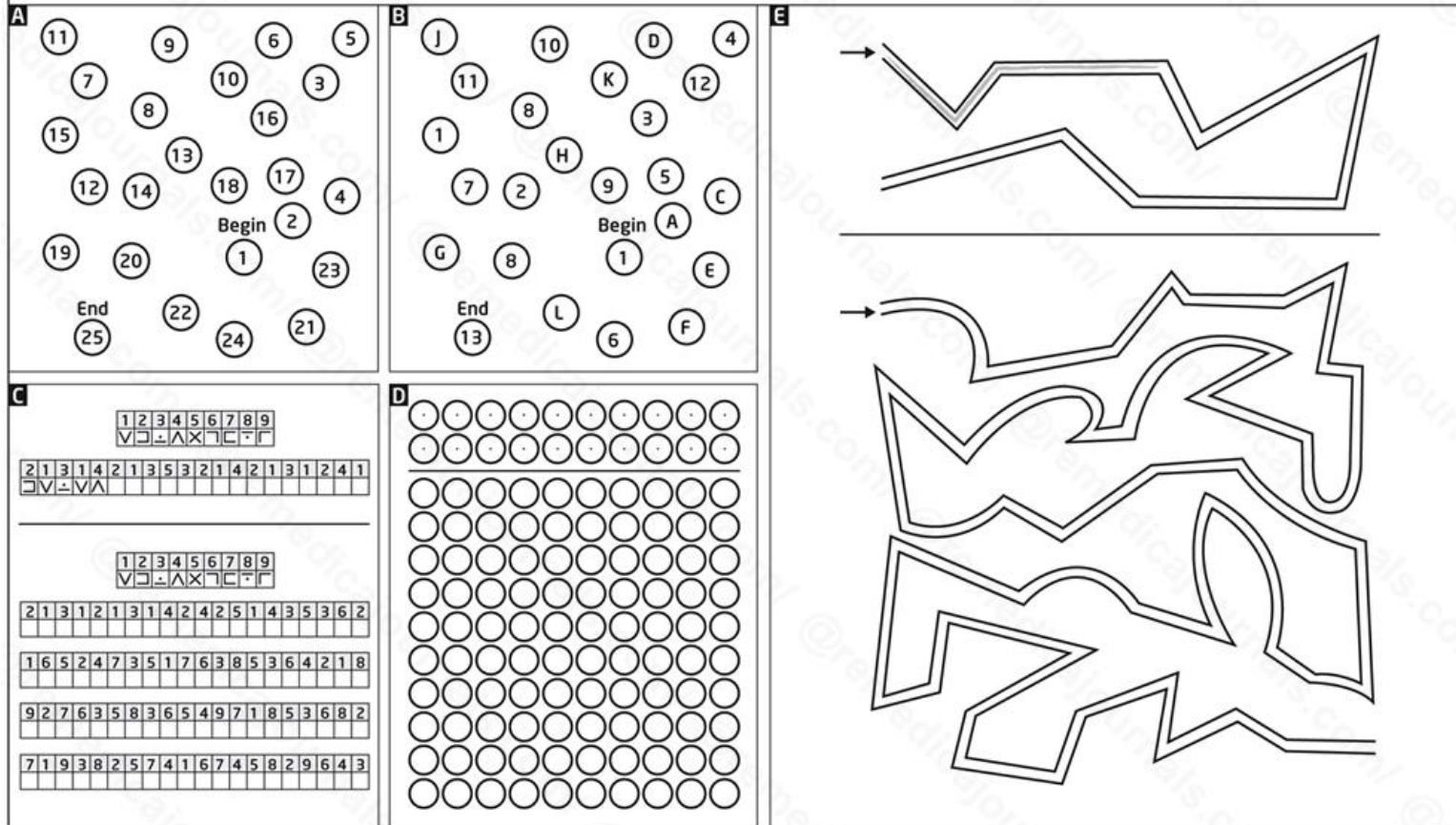Requires intensive care unit with airway protection (e.g., intubation)

PROGRESSION OF H.E.

Worsening liver disease

First sign of an underlying infection, gastrointestinal bleeding, dehydration, etc.

CURRENT EARLY DIAGNOSTIC PRACTICES

Figure 1. The five paper and pencil tests that make up the Psychometric Hepatic Encephalopathy Score (PHES), which assesses attention, visual perception, and visuo-constructive abilities [6,19]. Number Connection Tests **A** and **B**: subjects are asked to join the numbers or numbers and letters in sequence as quickly as possible. The time taken to complete the task is recorded. Digit Symbol Test (**C**): subjects are asked to insert symbols in the blank squares below the numbers using the key provided. The exercise is timed and the number correctly completed in 90 s recorded. Serial Dotting (**D**): subjects are asked to place a dot in the center of each circle as quickly as possible. The time taken to complete the task is recorded. Line Tracing (**E**): subjects are asked to trace a line between the two guidelines as quickly and accurately as possible without moving the paper. The time taken to complete the task and the number of errors made are recorded.

PROBLEM SPACE

Early detection

Looking for small effects

Missing baseline measurement

Needs more frequent monitoring

We want to reframe as self-tracking instead of a clinical test

Treatment effective but can be objectionable
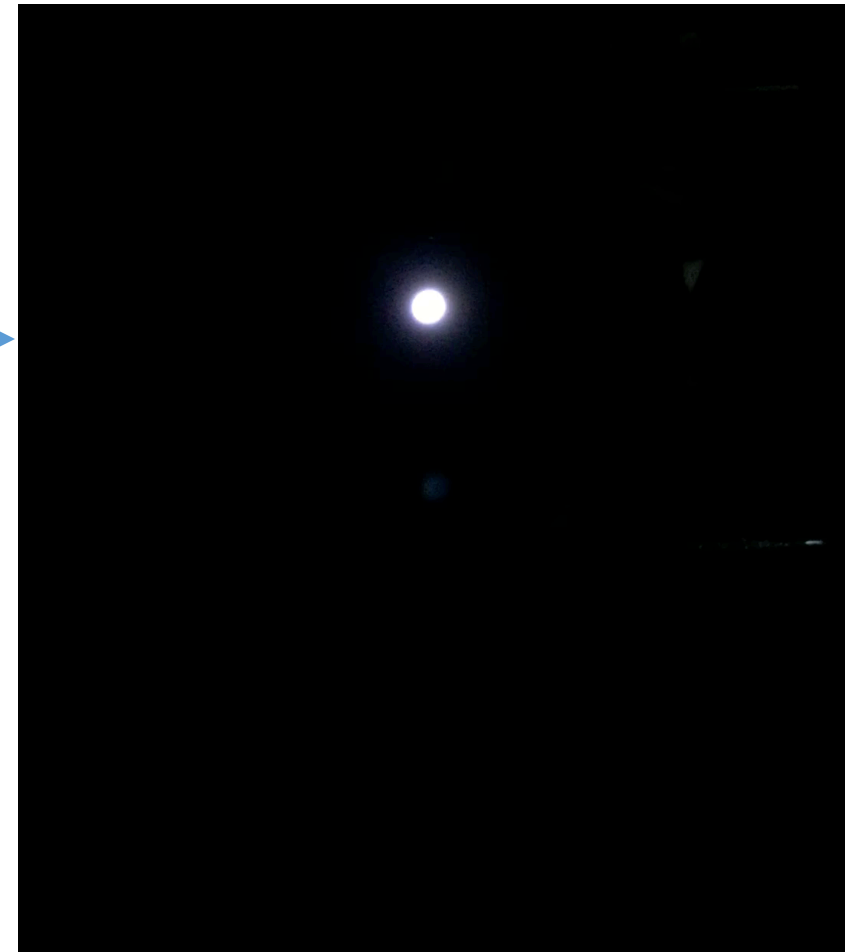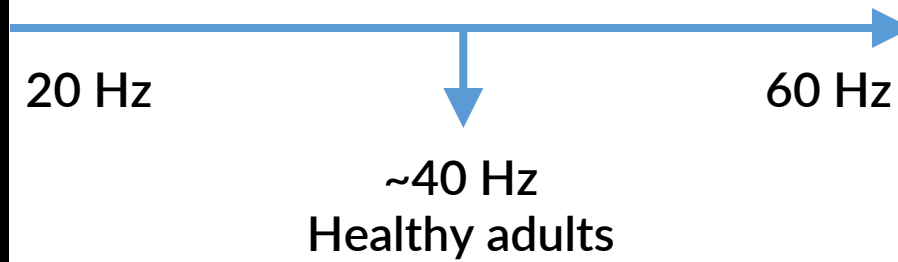
CRITICAL FLICKER FREQUENCY

Neuro-physiological phenomena

Measures the ability of the central nervous system to detect flickering light

Is directly influenced by cortical activity

CRITICAL FLICKER FREQUENCY

20 Hz

60 Hz

~40 Hz
Healthy adults

CFF AS AN EARLY INDICATOR

Moderate sensitivity (correctly identify those **with the disease**) of 61%

Good specificity (correctly identify those **without the disease**) of 79%

Effective in discriminating patients with MHE from those without MHE (screening).

DESIGN GOALS

Make the device portable

Reduce device cost / Enable easy replication

Enable self-administration

Improve threshold detection algorithm

APP ONLY DESIGN
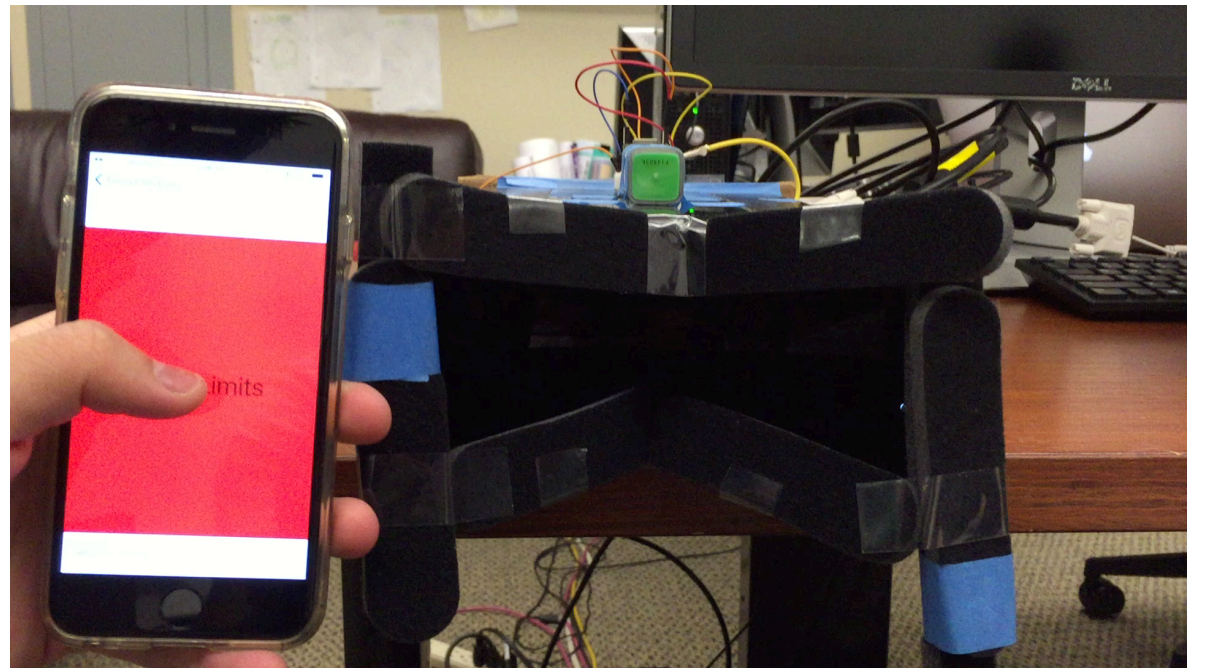
Limited by API access and hardware capabilities
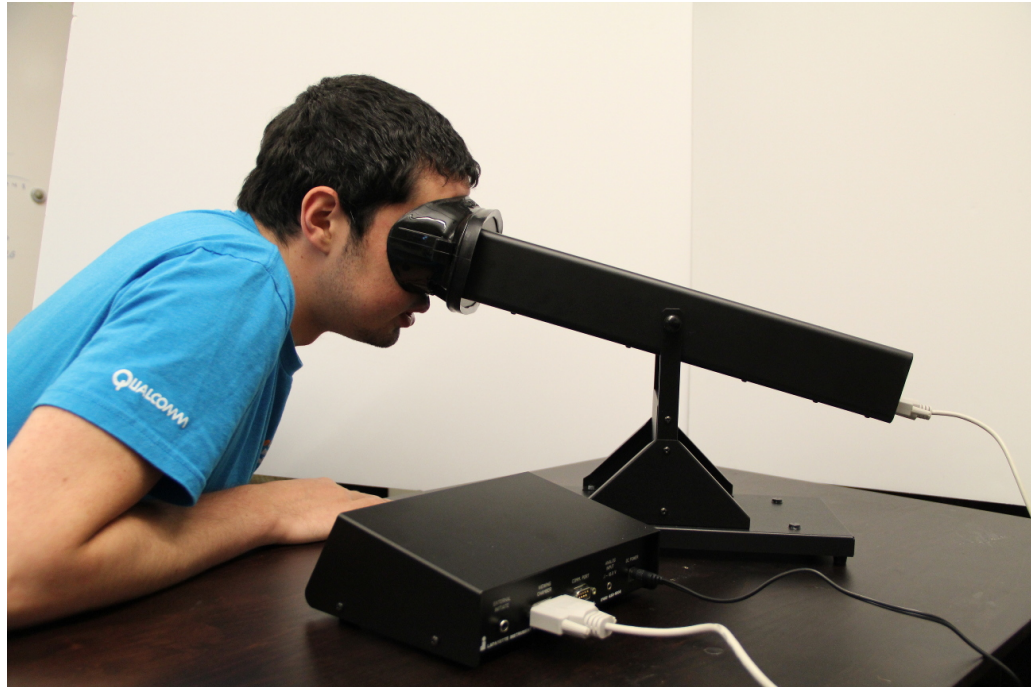
      LED flash as the light source

      Phone display as the light source

PERIPHERAL BASED DESIGN

First step, get the hardware working

VIEWING BOX DESIGN

PERIPHERAL BASED DESIGN

First step, get the hardware working

Next step, miniaturize the set up

HANDHELD DESIGN

NEXT STEPS

Step 1: Device Performance and Accuracy Testing
  Comparison to the reference device
  Impact of different test conditions (hopefully relaxing the test constraints)
Step 2: Usability Testing
  Understandability of the device operation
  Ability to self-administer the test by users
Step 3: Feasibility of Lifestyle Integration
  Understanding everyday challenges in applying the test

OTHER APPLICATIONS FOR CFF

Detect a broad spectrum of neuro-psychological abnormalities

 visual signal processing (retinal gliopathy)

 cognitive functions

Applied to the study of several neurological disorders

 multiple sclerosis

 Alzheimer's disease

CFF is particularly apt for the study of alterations in visual signal processing, and is also suitable for the detection of arousal or attention abnormalities.

DISCUSSION

Design priorities

viewing conditions

reaction time

motor impairment

identifying distractions

Designing for long-term self-monitoring

frequency of measures

DISCUSSION

Communicating results and ethical issues therein

      patients disbelieve or lie about results

      show / hide results from patients

      provide instructions based on result

      communicate uncertainty

      share with provider

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DUB DESIGN USE BUILD

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THANK YOU!

Discussion:

Design priorities

Designing for long-term self-monitoring

Communicating results and ethical issues therein

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