# Sentinel

A solution to mitigate the hazard of drowsy driving:
Small-n user testing of an interface prototype

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# Background: Pedestrians at Risk

**Many pedestrian crashes are the result of unsafe motor vehicle driver and pedestrian behaviors.**

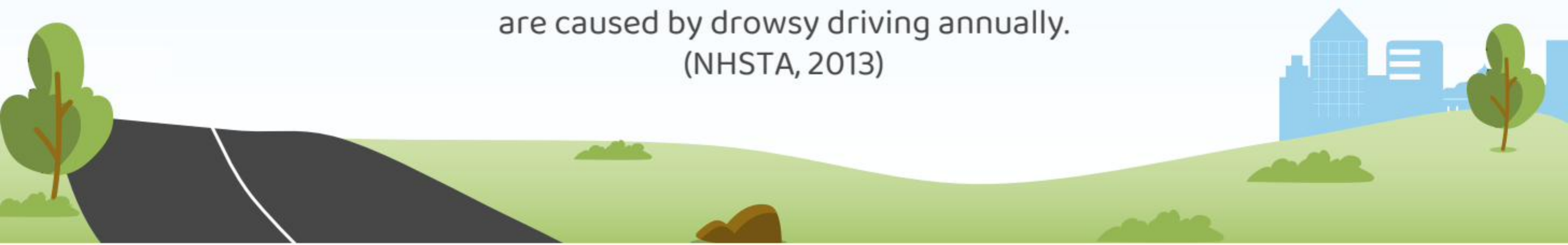
(United States: Transportation Department: Federal Highway Administration, 2009)

# 72,000 crashes

# 44,000 injuries

# 800 deaths

are caused by drowsy driving annually.
(NHSTA, 2013)



We need to move from the “blame the victim” approach to road crashes and casualties.

**– The Vision Zero Handbook (Edvardsson Björnberg et al., 2023)**

# Background: Safety Strategy

**"The target when using a more holistic view on the safety strategy is primarily to cut the chain of events leading to a crash as early as possible and to, hopefully, totally avoid a serious situation and the crash."**

– **The Vision Zero Handbook**
**(Edvardsson Björnberg et al., 2023)**

- This is one value promoted by Vision Zero, a strategy aimed at eliminating all traffic-related deaths and accidents.
- Originating in Sweden in the 1990s, this approach has been effective throughout Europe and is now expanding to other countries, including the US (*What Is Vision Zero*, n.d.).

Source: NHSTA, 2024

# Drowsy Driving Accidents

## When?

Most often between 12am and 6am or late afternoon

## Where?

Rural roads and highways

## Who?

Single drivers without passengers

## Why?

Times when people experience dips in their circadian rhythm

## How?

Running off the road at a high speed with no evidence of braking

# What is Drowsy Driving?

(Edvardsson Björnberg et al., 2023) categorizes Drowsy Driving as a type of **driver restricted attention**:

"Insufficient or no attention to activities critical for safe driving brought about by something that physically prevents (due to biological factors) the driver from detecting (and hence from attending to) information critical for safe driving e.g., **due to drowsiness or fatigue, driver dozes off momentarily, with eyes closed, and almost hits a pedestrian crossing the street ahead."**

# Driver Monitoring Systems

- Driver monitoring systems are widely studied in literature as a potential mechanism to support driver awareness
- Many newer vehicles are designed with built-in monitoring systems to track facial features, such as eye closure, for fatigue or drowsiness
- Many drivers operate vehicles which lack integrated technologies (such as Automated Vehicles), and often rely on personal smartphones for any additional features: such as maps, streaming music, and making calls
- However, there is a lack of Apple iOS-compatible apps which are intended for the purpose of tracking driver fatigue or drowsiness

# Proposed Solution: Problem Statement

Design the interface of an app for detecting and alerting driver drowsiness.

# Design Pillars


## Safety

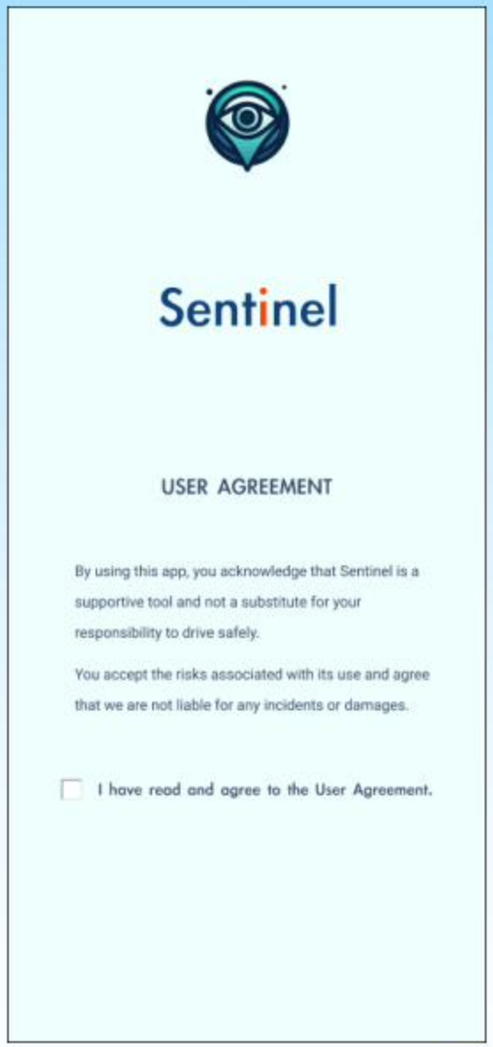
Ensure that the interface communicates trustworthiness and reliability, through both aesthetics and functionality


## Simplicity

Design a simple, intuitive layout for users to navigate, especially in the context of a dashboard phone holder


## Accessibility

Integrate accessible features, or enable the addition of them in further development

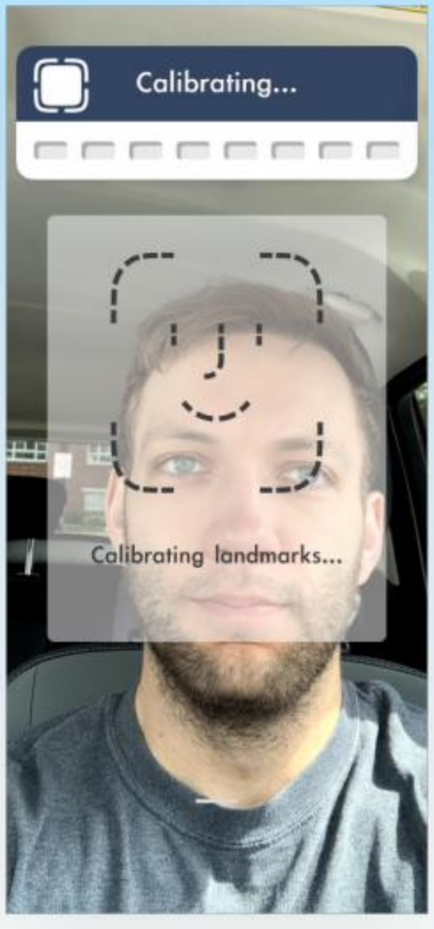



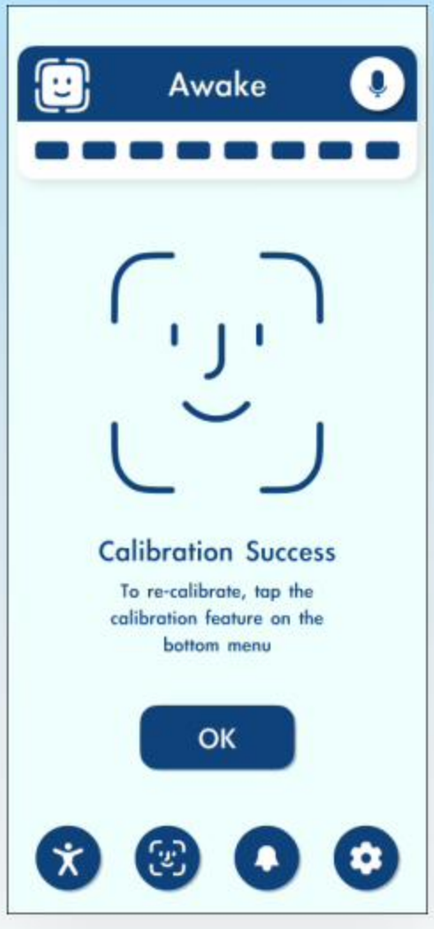

# Prototype:

# Sentinel – a drowsy driver detection app

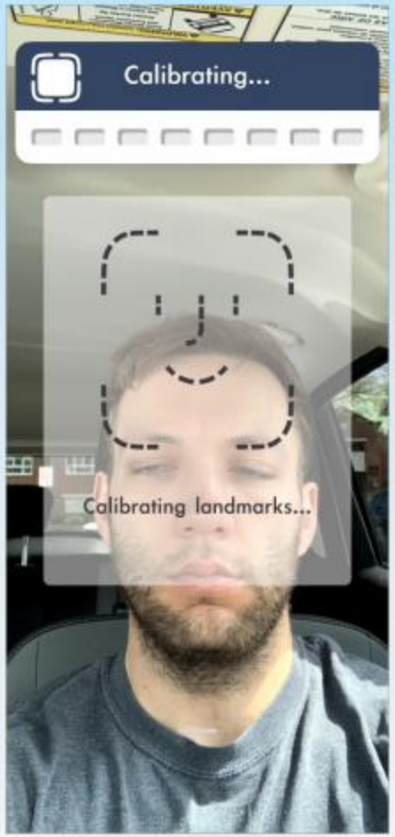
- Designed on Figma
- Link to Prototype: Awake Flow

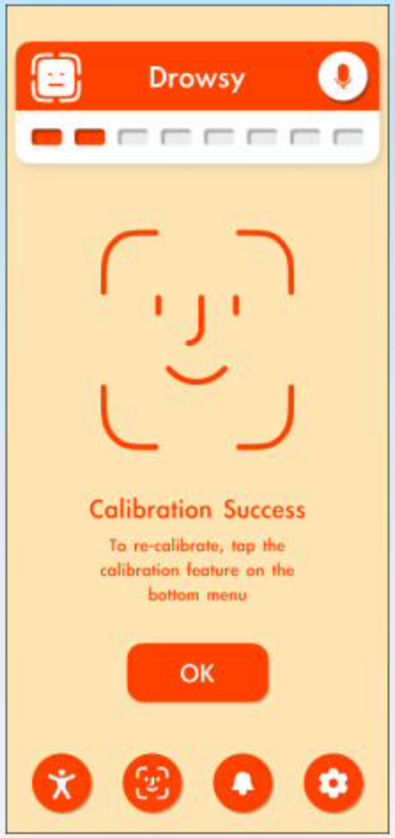
# Awake Detection Interface


# Drowsy Detection Interface




# Settings


Detection Paused
Alarm Settings
Volume
Haptics
Vibration Pattern
ON
1
2
3
Duration
1s
3s
5s
∞


Detection Paused
Settings
Voice Commands
Enable Voice Commands
ON
Preferences
Personal Data
Erase Data
History
FAQ


Detection Paused
Accessibility
Text
Text-to-Speech
ON
Increase Size
ON
Visual
Black & White
ON
Increase Contrast
ON
More Features

# User Testing

## Objective 1

Collect user feedback on the Sentinel app prototype interface.

## Objective 2

Compare the user interface between the prototype interface with that of an existing app (Keep Alert) on the iOS app store.

## Sample size

N = 3 is suitable for small-n analysis

## Assessment Tools

Task Metrics, Task List, and Overall Usability Questions to compare Sentinel vs. Keep Alert app

# Task Metrics

Metrics to evaluate the Sentinel interface were chosen to understand the temporal- and subjective-based ease of use and satisfaction.

| Task Metric | Description | Values | Measurement Type | Variable Type |
|---|---|---|---|---|
| **Task Completion** | Assignment of successful or unsuccessful completion, as determined by test moderator | 1 = successful, 0 = unsuccessful | categorical binary | boolean |
| **Time on Task** | Duration of task in seconds, from start to end | [seconds, to the hundredths place] | continuous ratio | float |
| **Error Score** | Number of errors during task, as determined by test moderator | [integer] | continuous interval | integer |
| **Ease Score** | User's subjective rating of how easy task is to complete with the interface | Likert scale:<br>1 = very easy<br>2= easy<br>3 = moderate<br>4 = hard<br>5 = very hard | continuous interval | integer |
| **Satisfaction Score** | User's subjective rating of how satisfying task is to complete with the interface | Likert scale:<br>1 = very satisfying<br>2= satisfying<br>3 = neutral<br>4 = unsatisfying<br>5 = very unsatisfying | continuous interval | integer |

# Task List

Scenario descriptions were provided to the subjects to avoid explicitly revealing the task goal. The purpose of this was to understand if the user interface features would be intuitive to a new user. The Flow Starting Points on Figma vary depending on task. The "Awake or Drowsy" option was chosen by a coin flip, to control for the state of wakefulness that the app presented.

| Task | Scenario Description | Flow Starting Point (Figma) |
|---|---|---|
| **Face Positioning** | You're a truck driver who drives long shifts, sometimes being days on the road at a time. You just downloaded this app from the app store, hoping it will help combat the late nights when driving through rural streets. You aren't sure how this app works, but you know you need to put your face in the camera. Open the app to begin this process. | Awake or Drowsy |
| **Navigation: Alarm Settings** | You are sensitive to noise, but you haven't used the app before. You want to see if you're able to mitigate the occurrence of any issues before they have the chance to begin. Find a solution on the interface. | Awake or Drowsy |
| **Navigation: Settings (general)** | Sporting the latest tin foil hat collection, you are an avid conspiracy theorist. Worried that the app is collecting data from you to send to Big Drowsy, you must find out the truth. | Awake or Drowsy |
| **Navigation: Face Re-calibration** | The app detects that you are drowsy, but you're wide awake. Perhaps the app face detection is malfunctioning? Find a solution on the interface. | Malfunction |
| **Navigation: Accessibility** | You are color-blind and unable to readily distinguish between the Awake and Drowsy states when the colors shift. Navigate to a solution to this on the app. | Awake or Drowsy |

# User Testing Tables

| User ID | | | | | |
|---|---|---|---|---|---|
| Flow Starting Point | | | | M | |
| Task | 1 | 2 | 3 | 4 | 5 |
| Task Completion | | | | | |
| Time on Task | | | | | |
| Error Score | | | | | |
| Ease Score | | | | | |
| Satisfaction Score | | | | | |

| Moderator Guide: |
|---|
| Randomize flow starting points for Tasks 1, 2, 3, and 5. (A or D) |
| Start timer before each task begins. |
| Record Task Completion and Error Score. |
| Ask participant for subjective Ease Score and Satisfaction Score. |

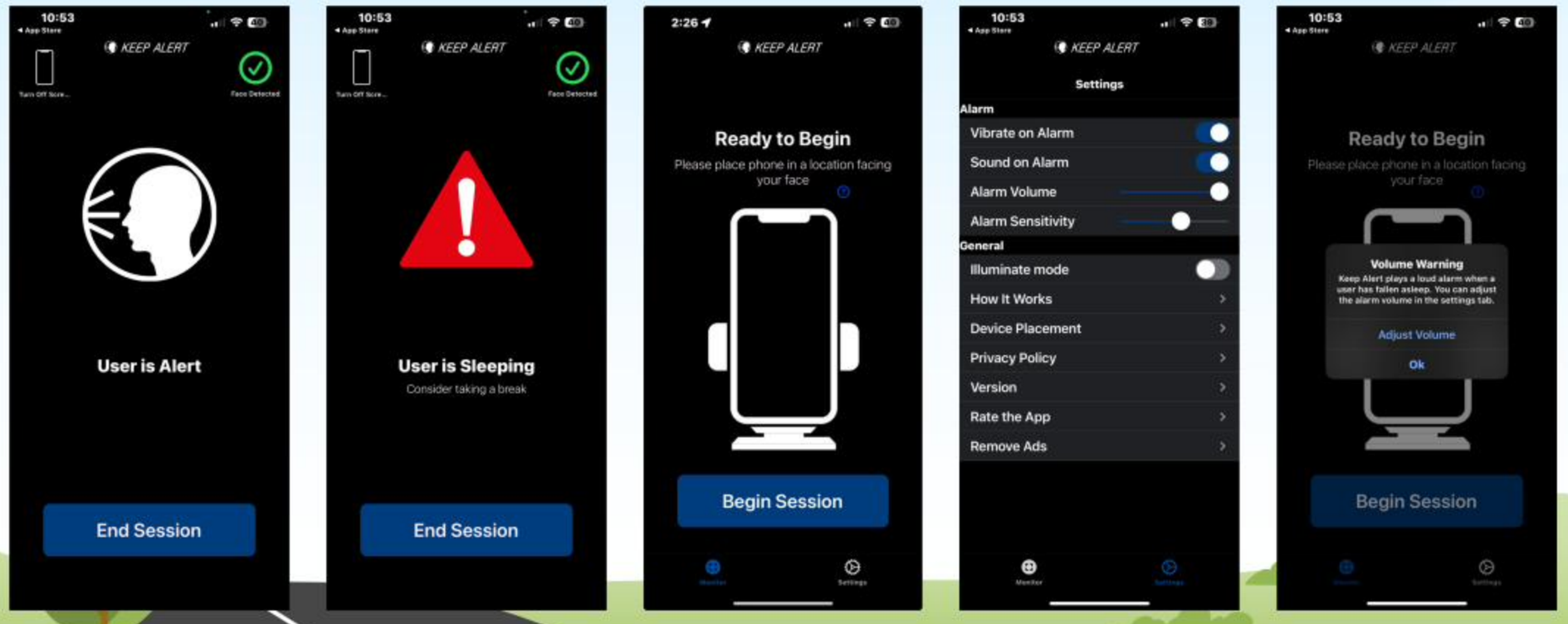
| Task | | Description |
|---|---|---|
| 1 | Face Positioning | You're a truck driver who drives long shifts, sometimes being days on the road at a time. You just downloaded this app from the app store, hoping it will help combat the late nights when driving through rural streets. You aren't sure how this app works, but you know you need to put your face in the camera. Open the app to begin this process. |
| 2 | Navigation: Alarm Settings | You are sensitive to noise, but you haven't used the app before. You want to see if you're able to mitigate the occurrence of any issues before they have the chance to begin. Find a solution on the interface. |
| 3 | Navigation: Settings (general) | Sporting the latest tin foil hat collection, you are an avid conspiracy theorist. Worried that the app is collecting data from you to send to Big Drowsy, you must find out the truth. |
| 4 | Navigation: Face Re-calibration | The app detects that you are drowsy, but you're wide awake. Perhaps the app face detection is malfunctioning? Find a solution on the interface. |
| 5 | Navigation: Accessibility | You are color-blind and unable to readily distinguish between the Awake and Drowsy states when the colors shift. Navigate to a solution to this on the app. |

| Flow Starting Point | Link |
|---|---|
| A = Awake | Awake Flow |
| D = Drowsy | Drowsy Flow |
| M = Malfunction | Malfunction Flow |

| Task Completion | Time on Task | Error Score | Ease Score | Satisfaction Score |
|---|---|---|---|---|
| 1 = successful<br>0 = unsuccessful | [seconds] | # [integer] | 1 = very easy<br>2 = easy<br>3 = moderate<br>4 = hard<br>5 = very hard | 1 = very sastisfying<br>2 = sastisfying<br>3 = moderately sastisfying<br>4 = sastisfying<br>5 = very sastisfying |

# iOS Competitor: Keep Awake

- To evaluate Sentinel's position in the iOS app market, participants were asked to review the app against a competitor
- The one app available on the Apple App store designed to monitor driver drowsiness is called Keep Awake
- Screencaps from the app on an iPhone were constructed as a simple flow on Figma
- Link to Figma: Competitor Flow



# Task List

| Score | Question | Sentinel | Keep Alert |
|---|---|---|---|
| **Interface Competency Scores** | This interface communicates a sense of safety. | | |
| **Likeliness to Recommend Scores** | I would recommend this interface to be applied as a real-world solution for drowsy driving. | | |
| **Ease of Usability Scores** | The interface was easy to navigate. | | |
| **Satisfaction Scores** | I was satisfied with the interface overall. | | |

Scores were rated on a 1-to-5-point Likert Scale:
1 = strongly disagree
2 = disagree
3 = neutral
4 = agree
5 = strongly agree

# Summary of Findings

## Objective 1: Usability Task Outcomes

**Time on Task:** The data indicates that complex tasks such as 'Navigation: Face Re-calibration' and 'Navigation: Accessibility' required substantially more time, with average durations of 28.43s and 26.29s, respectively. In contrast, simpler tasks like 'Face Positioning' were completed more swiftly.

**Error Score:** Tasks that demanded longer interaction times also registered higher error scores, suggesting a correlation between task complexity and the likelihood of user errors.

**Ease of Use:** Despite some challenges, the tasks generally received favorable ease of use ratings, with most tasks scoring above 3 on a 5-point scale, suggesting a reasonable level of user interface intuitiveness.

**Satisfaction Score:** Satisfaction ratings varied, with a tendency for lower scores in tasks that were more time-consuming or error-prone, highlighting areas where user experience could be enhanced.

# Summary of Findings

## Objective 2: Comparative Analysis

**Interface Competency Score:** Sentinel demonstrated superior interface competency, with a statistically significant mean difference ($p < 0.05$), indicating that our app communicates safety and functionality more effectively.

**Likeliness to Recommend Score:** The results favored Sentinel as a more recommendable solution for real-world application in preventing drowsy driving, with significant statistical backing ($p < 0.05$).

**Ease of Use Score:** Although both apps performed similarly in ease of usability, Sentinel marginally outperformed KeepAlert. This suggests slight advantages that might not be statistically robust but could be important from a user experience perspective.

**Satisfaction Score:** Satisfaction ratings varied, with a tendency for lower scores in tasks that were more time-consuming or error-prone, highlighting areas where user experience could be enhanced.

# Next Steps

**User Feedback Integration:** Digest the outcomes from the small-n analysis into a next prototype.

**Optimize Tasks:** Mitigate errors and time of task, especially for 'Navigation: Face Re-calibration' and 'Navigation: Accessibility'.

**Accessibility Improvements:** Research accessibility features to enhance the accessible use options.

**Scaling User Testing:** Increase number of users, varying recruitment efforts.

**Driving Research:** Understand laws, regulations, and in-context usage for the app.

# Refereneces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