MindTrack: Visualization Techniques in Cognitive Tests Results

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1 INTRODUCTION

Although Modern Cognitive Assessments have been around since the 1880s, with the advance of the internet, game-based technology and automated test result processing, this field of psychology is becoming increasingly more accessible to the curious public.

However, when searching for this type of service, it is possible to observe the lack of well-thought tests combined with complex visualizations, free platforms and easy access to the research that inspired the project.

With MindTrack, we aim to fulfill this gap by providing a service where users can, free of charge or ads, assess their cognitive abilities through games that are backed by comprehensive research. Furthermore, our open-source platform offers in-depth graphs that enable users to compare their results with others or track their own progress over time.

2 CORRELATED WORKS

Our first big influence for this project was Human Benchmark, a popular website where users can compare their cognitive test results with others online. However, while using the application, we were able to notice three main problems: only one simple visualization available, not allowing in depth results; lack of references of the research behind the tests, or any kind of literature available; lack of means to compare personal results with variables such as mood and sleep, which are known to affect cognitive abilities.

When searching for more robust, scientific and explorative alternatives, we encountered a different kind of problem: the tests became formal, business-oriented, expensive, extensive and saturated with medical claims. It was not a software for “curious minds” as we had hoped.

To create MindTrack, we draw our research primarily from Cognifit, a website renowned for its extensive collection of cognitive games supported by comprehensive scientific research and categorization, but no free way of taking the test and accessing the extensive report. In a way, we aimed to reach a balance between the rigor of CogniFit and the accessibility of Human Benchmark to achieve a free but scientific, researched but informal, and complex but user-friendly platform.

3 METHODS

The first step to elaborate the project was to conduct a research to pick the games that would be developed. More specifically, our selection was inspired by the following tests: *Equivalencies Test INH-REST*, *Simultaneity Test DIAT-SHIF*, *Concentration Test VISMEM-PLAN*, *Estimation Test EST-I* and *VIPER-PLAN Programming Test*.

Five games were developed, each designed to evaluate a specific cognitive ability: *Attention*, *Coordination*, *Memory*, *Perception*, and *Reasoning*. While the names assigned to the tests reflect the primary ability they target, it is worth noting that many of them encompass multiple cognitive domains.

The ATTENTION game aims to test the capacity to selectively filter out distractions and concentrate on important information and was based on the Stroop Test, published in the Journal of Experimental Psychology *(Stroop, 1935)*.

The COORDINATION game aims at the ability to execute precise and well-organized movements with efficiency, and the PERCEPTION, the ability to interpret and make sense of the sensory input received from the environment.

MEMORY relies on the ability to retain and utilize newly acquired information, as well as retrieve memories from the past - this game was based on the Corsi block-tapping test *(Corsi, 1972; Kessels et al., 2000; Wechsler, 1945)*.

At least, REASONING is about the capacity to effectively utilize and manipulate information obtained through various sensory channels. This game is inspired by the Porteus Maze test *(Porteus, 1950)*.

For the web page development, we utilized HTML as the foundational markup language. To enhance the visual design, we incorporated Tailwind CSS and adapted Tailwind's ToolBox Free Minimal Admin Template to align with our concept of what MindTrack should look like. Finally, to make the site accessible to users, we hosted it on GitHub Pages, ensuring easy access and availability, as well as open-sourceness.

For data storage and account management, we utilized Google's Firebase service. leveraging their JavaScript API to create real-time updating graphs.

With the D3.js library, we implemented a radial graph, representing the user's recent performance. We opted for this type of visualization as it allows readers to quickly compare their performance across five different areas, while also facilitating a comparison of their performance over the past five days. Interactively, we implemented a feature that enables users to hover their mouse over the captions, resulting in the corresponding line being highlighted within the graph.

For further accessibility, we ensured the color scale used in the graph is distinguishable for individuals with color blindness.

Our second graph is a parallel coordinate graph displaying the most recent grades of all users on the site. The primary objective of this graph is to enable users to explore potential trends within the grades, allowing users to reorder the axes.

On another page, we provide users with specific graphs for each of the five tests. Each game has its own color, creating a distinct visual identity for each cognitive ability.

The first graph on this page is a histogram that depicts the density of scores within each range. Users can select their best score, average score, or most recent score in that area to be represented by a vertical bar in the graph, illustrating how it compares to the rest of the public. To enhance clarity, the bins in the histogram corresponding to scores higher than the user's chosen score are displayed in a darker color.

We also offer the option to adjust the number of bins; however, the chosen number does not necessarily represent the exact amount displayed in the graph. This discrepancy arises from the use of D3's bin function, which requires the range to be an integer value, resulting in rounding and potentially altering of the number.

Our second graph is a time series illustrating the user's score in a particular area over time. Users can employ brushing techniques to zoom in on specific sections of the graph. Additionally, they can choose to view a line representing the global average and another line representing the global median. This allows users to track their progress and compare their performance with the updated global statistics.

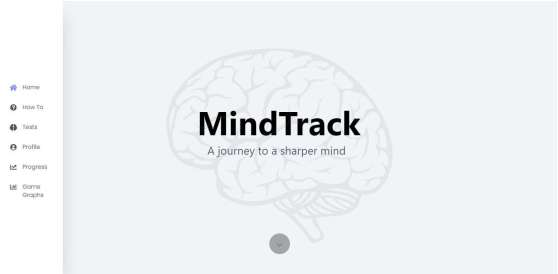
The final graph is a bar chart that presents average scores grouped according to three characteristics we asked users to provide before taking the tests: exercise amount per week, hours of sleep, and mood on the day. The objective of this visualization is to identify potential correlations between these characteristics and overall performance on specific tests.

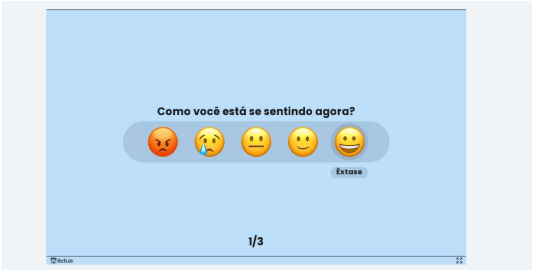
The game tests were developed using the open source Godot game engine, with the aim of creating a smooth and light experience for web browsers. It’s important to note that they all underwent meticulous gameplay tests and feedback before reaching their current state. As an example, more than five sets of colors for the attention game were tested before settling on one which we found to be the best balance of challenge and fairness for the user.

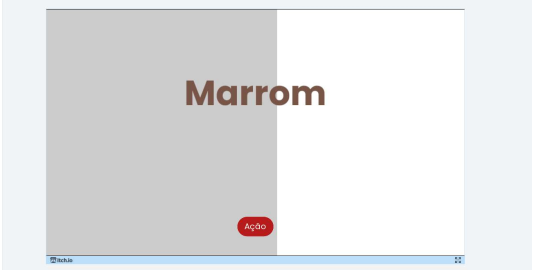
4 RESULTS

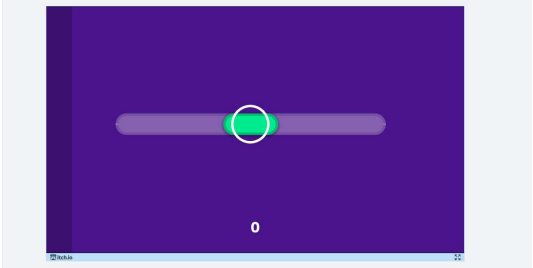
Due to the limited dataset, conclusive analysis of the data is not currently feasible. To obtain reliable results, we need a larger sample size with increased participation and therefore, further data collection is necessary before drawing meaningful conclusions.

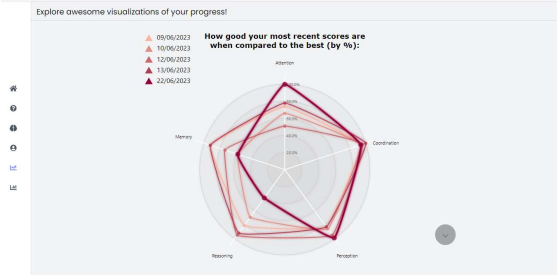
As for results regarding the application itself, some images can be looked at below.

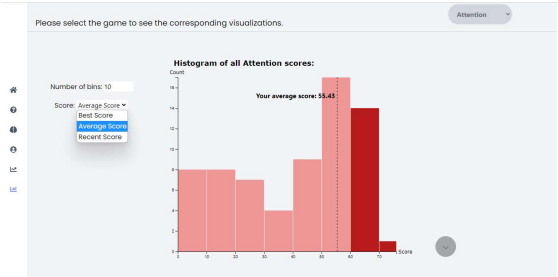












5 DISCUSSION

As users continue to engage with the platform, they gain the ability to track their temporal data and evaluate their progress over time. They can analyze whether their skills are improving and identify patterns in their performance, such as the correlation between playing well and getting sufficient sleep.

In addition to self-assessment, users have the opportunity to compare their performance with that of other players. This comparative analysis allows them to gauge their skill level relative to others and provides a benchmark for their progress.

6 FUTURE WORKS

Looking ahead to the future of the project, our objective is to make the website even more complete. Through further research, we hope to implement more tests that fall into different subcategories of the cognitive capabilities. We also wish to give the data feedback with a wider range of visualizations and different analysis utilizing daily variables to determine when the users are at their best capability. For the web application itself, we aim to make it more integrated and less segmented into blocks.

Furthermore, we enthusiastically welcome public critique and suggestions. We value the input and insights of our users, as it allows us to continually improve and refine MindTrack.

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