User-Centered Design in Interactive Interfaces

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1 Interface Concepts and Design

At the start of the phase, we were tasked with creating an Interface that would aim to improve the life quality of the users in some countable manner or serve as an entertainment medium. My teammate and I chose to focus on the aspect of grocery shopping preparation, by creating a smart list application and a platform that would allow the users to simply analyze the macro-nutrient profile of food items.

To ensure the app meets the wants and needs of the users, we conducted extensive testing through an online questionnaire which included both open-ended questions, where users gave short written responses, and closed-ended questions in binary and multiple-choice formats.

The users' main requests centered around the speed and efficiency of the application. All users desired to spend less than ten minutes a day on the app, and 44% indicated they would stop using it if they found it complicated. These results highlighted the need to not introduce cluttering to the main screen and engineer the back-end to eliminate long loading times.

2 Task Design and AI Integration

As nutritional education is often overlooked, many people struggle to make informed choices. Additionally, nutritional profile maps can be difficult to interpret, making it challenging for people to select foods that meet their dietary needs and personal preferences. That is why I decided to create this platform[3] which is designed to simplify the selection process by providing accessible nutritional information.

With the hard-coded task[9], users can filter categories, search for items, and view key nutritional values. The AI version[8] extends categories through a language mapping model, addressing the problem of a single category per item. The model takes as input the name of the food item and outputs the categories which it believes to be a part of. The main feature is the Scoring system, a rule-based mathematical AI[7][2] model that uses weights and limits to assign values to food items based on their nutritional profiles. The values are proportioned and given an alphabetic representation from a scale of A to D, akin to the Dutch Nutri-Score system, prevalent in grocery stores[1].

As was referenced in the Introduction of this report, users placed a lot of importance on simplicity. To address this, I tested the learnability principle by observing the completion time of tasks of new users and asking them direct questions about their experience. A 5-point emotion Likert scale was also used after each practical session, to better understand the psychological and emotional state of the user, caused by the application, providing insights into the usability of the features.

The app is fully deterministic, ensuring both Consistency and Predictability from user input. Familiarity is achieved through the use of a search bar and check-boxes for filtering, employing common UI patterns. Synthesisability is clear as the state of the application is instantly updated with changes to the search bar and filters and Generalisability is minimal because the application holds focused functionality.

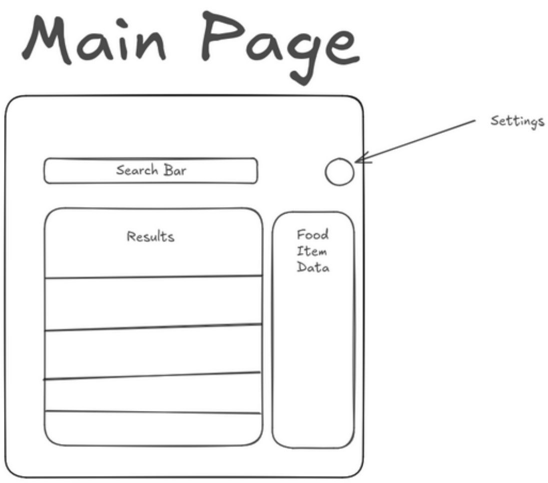

Figure 1: Low-Fidelity prototype of Application.

Figure 2: User-Interface of the finished application.

3 User Testing and Analysis

3.1 Testing Procedure

Throughout the development process, two questionnaires were distributed to potential users. One was shared at the start, meant for requirement gathering[5], the process of which was detailed in the Introduction, and another after completion of both versions of the Application. The latter[4] was intended to examine user perception and compare their ease of use.

The questionnaire starts with general demographic questions, such as age and gender, followed by ten questions aligned with the Big-5 model. Interpreting the answers to these questions, using a simple mathematical formula, generates a comprehensive overview of each subject's personality type, scoring Extraversion, Agreeableness, Conscientiousness, Neuroticism, and Openness on a scale from 2 to 10.

$$\text{Extraversion} = (5 - Q_1) + Q_6$$
$$\text{Agreeableness} = Q_2 + (5 - Q_7)$$
$$\text{Conscientiousness} = (5 - Q_3) + Q_8$$
$$\text{Neuroticism} = (5 - Q_4) + Q_9$$
$$\text{Openness} = (5 - Q_5) + Q_{10}$$

Figure 3: Equation for each trait.

After the demographic study, I tasked the users with completing the same four tasks to test the difference in functionality between the two versions. One such task involved looking up the same food item the respondent last ate, in the application, and finding an alternative that had an appealing nutritional profile(i.e. was healthier). Utilizing this method, we could see both the impact of the scoring system on the time taken to complete the task and the emotions felt during and after, where more positive emotions correlated with a higher satisfaction rate regarding both usability and the choices made by the subjects.

3.2 Data Analysis

3.2.1 Testing Results

At the end of the testing phase, I had gathered data on 13 individuals. Participants' ages ranged from 15 to 59, with a mean of 26 years of age. The gender distribution was almost balanced, with males being 58 and females 42 percent of the sample respectively.

Regarding the personality distribution, the Big Five traits for most participants centered around the midpoint of the scale. The means of traits such as Agreeableness, Conscientiousness, and Neuroticism clustered closely to the average, while Extraversion and Openness showed a minor increase in variability. These findings, along with the assessment of the normality status of each trait, helped provide a balanced overview of participants' personalities, though no extreme trends emerged that would significantly influence user behavior.

Personality Trait	Mean	Standard Deviation	Range	Normal (Yes/No)
Extraversion	5.5	1.9	3.6-7.3	Yes(p=0.6573)
Agreeableness	6.0	1.8	4.1-7.8	Yes(p=0.2233)
Conscientiousness	5.8	1.85	3.9-7.7	Yes(p=0.5772)
Neuroticism	5.75	1.8	3.9-7.55	Yes(p=0.1038)
Openness	6.75	1.7	5.0-8.5	Yes(p=0.2462)

Table 1: Summary of Big Five Personality Traits.

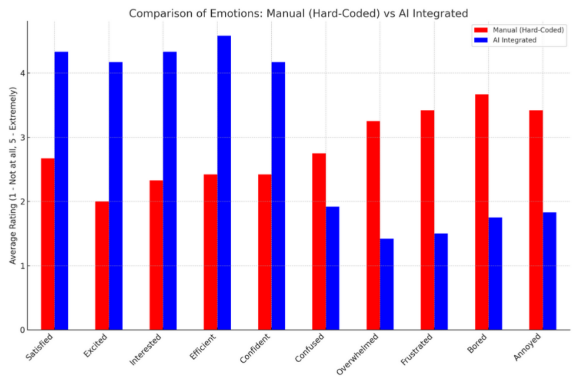

Figure 4: Mean Intensity of emotions tested separated by type.
The scale ranges from 1 to 5.

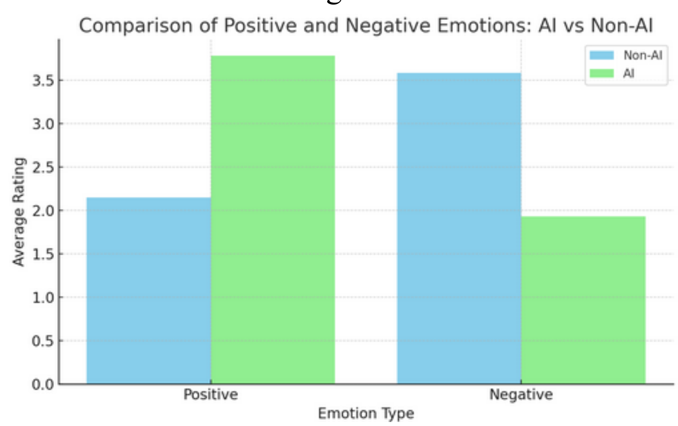

Figure 5: Generalized Intensity of all emotions separated
in categories of positive and negative groupings.

To assess the learnability principle, I conducted a comparison between the completion times of each task between the two versions. The hypothesis I adopted is that the usage of the AI-version would result in faster task completion, compared to the non-AI version. To test this I first statistically formulated the Hypothesis, assessed whether the task completion times followed a normal distribution, using the Shapiro-Wilk test once more, and then using the paired t-test compared the results of the test with the original hypothesis. We can use the paired t-test when both groups have the same number of elements and the data is normally distributed.

The hypotheses are as follows:

H_0 :There is no difference in task completion times

H_1 :Task completion times are faster in the AI version

Task	Normal Distribution	p-value
Non-AI Task-1	Yes	0.403
Non-AI Task-2	Yes	0.730
Non-AI Task-3	Yes	0.721
Non-AI Task-4	Yes	0.868
AI Task-1	Yes	0.280
AI Task-2	Yes	0.164
AI Task-3	Yes	0.099
AI Task-4	Yes	0.307

Table 2: Normality of data and p-value comparison for AI and Non-AI tasks.

By looking at the p-values of each category we notice that all the values are greater than 0.05, which is the lower limit that the p-value can take while still categorizing the data as normal. This allows us to proceed with the paired t-test, since one of the main requirements for it is the normality of the data.

Task	P-Value	Hypothesis Evaluation
Task-1	0.001	Reject Null-Hypothesis
Task-2	0.114	Accept Null-Hypothesis
Task-3	0.001	Reject Null-Hypothesis
Task-4	0.022	Reject Null-Hypothesis

Table 3: Comparison of P-Values and Results for Each Task.

3.2.2 Data Interpretation

In analyzing the task completion times, the results of the paired t-tests reveal that three out of the four tasks showed significant improvement in task completion times of the AI version over the non-AI version, leading to the rejection of the null hypothesis. We can with confidence conclude that the AI feature has a drastic and positive impact on the learnability and usability of the platform.

Only Task-2 rejected the null hypothesis, this is believed to be due to its nature of not relying on the AI feature as the main contributor to the solution of it. To further understand the disparagement more research has to be conducted.

Additionally, the emotional results followed a similar pattern. Users of the non-AI version reported mainly indifferent or negative feelings after using it, while the AI version led to positive ones. There was a reversal in the intensity of the emotions between the two versions, with negative ones being more intense in the non-AI version and positive ones less so. The inverse applies to the AI version.

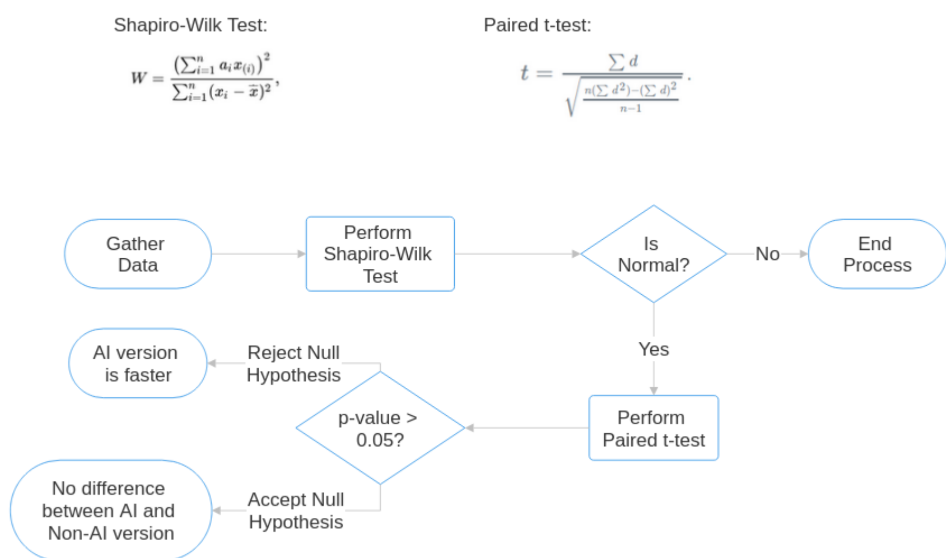

Figure 6: Flowchart containing logic and order of mathematical operations.

4 Enhancing User Experience through Technology

4.1 Technologies for Immersive Communication

An aspect through which the utility of the application could be improved, with modern technologies, is Augmented Reality(AR). With the AI scoring system implemented, searching is the most demanding part of the platform's usage routine. A database is only able to pair a food item with a small amount of names. This is caused by space constraints and the situation is further worsened by the imperfect nature of search algorithms, since even the most advanced search functions can only recognize a limited set of input variations. Consequently, users find it challenging to retrieve results quickly, and they may not be able to get any appropriate results.

A possible version of AR[6] could involve the user wearing a front-facing camera on their body. This camera would detect food items, such as groceries or packaged food, and then display the detailed view of that item, that we have already created, through a pair of glasses with an in-built display panel. This setup would enhance the user experience by providing real-time data about food choices, helping them make informed dietary decisions.

4.2 Explainability Techniques

To explain the inner workings of the AI model, we could utilize a similar architecture to Shapley additive explanations(SHAP). This approach passes data through a model and then uses straightforward mathematical techniques to illustrate the impact of each micronutrient and macronutrient on the final result. Because of the AI feature's underlying structure, which uses weights and absolute values for evaluation, the SHAP-like methodology is well-suited for providing a clear data overview.

By implementing the SHAP-like approach, we not only enhance the transparency of the AI model but also empower users to understand the reasoning behind its recommendations. This can alleviate concerns about the accuracy and reliability of the generations of the AI, making users more likely to approve of the use of the application. As users gain insight into how different nutrients influence their dietary choices, they might become more likely to be motivated to make healthier decisions and with enough time be able to make those choices themselves. Integrating explainability techniques into the application promotes informed and health-conscious behaviors.

References

[1] Chantal Julia and Serge Hercberg. Nutri-score: Evidence of the effectiveness of the french front-of-pack nutrition label. *Public Health Nutrition*, 20(8):1323–1325, 2017.

[2] Rachel Nelson Marko Jurgen, Katarina K. Tang. Ai nutrition recommendation using a deep generative model. *Scientific Reports*, 14(6):6789–6794, 2024.

[3] Amir Mohseni and Dimitrios Tsiplakis. Grocery list app, 2024. `https://github.com/Amir-Mohseni/grocery-list-app` Github Repository.

[4] Amir Mohseni and Dimitrios Tsiplakis. Testing questionnaire, 2024. `https://docs.google.com/forms/d/e/1FAIpQLSecy3sIGre3ukH0EqRI8M0IwQB9P6PHObzX55psOJXdd39qHQ/viewform?usp=sf_link` Google Form.

[5] Amir Mohseni and Dimitrios Tsiplakis. User requirement gathering questionnaire, 2024. `https://docs.google.com/forms/d/e/1FAIpQLSe1RkOG5JClVk8zvKbROGMWnSarbDNIVtZdH9N67009BE58wg/viewform?usp=sf_link` Google Form.

[6] Flavius Paraschiv, Corina Sas, Jeni Paay, Nicole K. Attwood, Andrew Viseu, and Cindy Hovenga. Extended reality technologies in nutrition education and behavior: Comprehensive scoping review and future directions. *Nutrients*, 12:3456–3467, 2020.

[7] Gupta N. Smith J., Lopez M. Ai-driven nutritional recommendation systems: A review of methods and applications. *Nature Scientific Reports*, 9(4):1234–1241, 2023.

[8] Dimitrios Tsiplakis. Ai version, October 14 2024. https://www.youtube.com/watch?v=1u5ZNasV0ac Youtube Video.

[9] Dimitrios Tsiplakis. Non ai version, October 14 2024. https://www.youtube.com/watch?v=X_we0BpnOpA Youtube Video.

Appendix

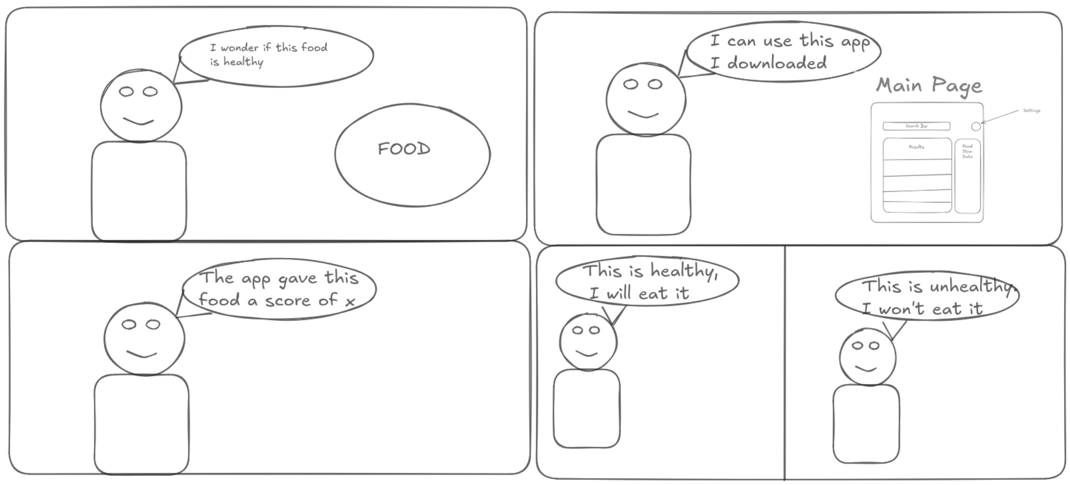

Figure 7: Low Fidelity Prototype in the form of a Story-Board

Application Manual

To download the application, follow these steps:

1. Clone the repository to your local machine by running the following command:

```
git clone https://github.com/Amir-Mohseni/grocery-list-app
```

2. Once the repository is cloned, navigate to the project directory and checkout the `AI` branch:

```
git checkout AI
```

3. To install the necessary Python dependencies, use the requirements.txt file inside the src folder:

```
pip install -r requirements.txt
```

4. Install `npm` on your local machine: If your machine uses the apt package manager use:

   ```
   sudo apt install nodejs npm
   ```

   For other platforms, refer to the official installation guide at `https://docs.npmjs.com/downloading-and-installing-node-js-and-npm`.

5. In the project directory, run the following commands to install React scripts and start the application:

   ```
   npm install
   python src/food_rater.py (To start the scoring system server)
   npm start
   ```

   The npm start command with open up the application in your default browser, then to use the application you will have to click on the right button. When in the application you can perform any actions discussed in the report.

Satisfied	Excited	Interested	Efficient	Confident	Confused	Overwhelmed	Frustrated	Bored	Annoyed
1	1	2	2	1	3	4	4	5	4
1	1	1	2	4	5	5	4	5	5
3	3	2	2	2	2	3	3	3	3
4	3	3	2	5	3	2	4	4	4
2	1	2	1	1	4	5	5	4	5
2	1	1	1	1	4	5	5	4	4
3	2	3	2	2	3	3	4	3	4
3	2	2	2	3	5	1	2	3	3
2	2	3	2	3	5	4	4	2	4
3	2	3	3	3	2	1	1	1	1
2	2	1	1	3	5	5	4	4	4
3	3	3	2	4	2	4	4	4	4
1	1	2	1	4	4	5	4	5	3
2	2	3	1	2	3	5	4	3	3

Table 4: Emotional responses from participants using the Non-AI application (1 - Not at all, 5 - Extremely)

Satisfied	Excited	Interested	Efficient	Confident	Confused	Overwhelmed	Frustrated	Bored	Annoyed
4	4	5	4	5	2	1	2	1	1
5	4	5	5	2	1	1	2	1	1
4	4	4	4	4	3	3	3	3	3
2	4	4	4	3	5	2	4	2	3
5	4	5	5	5	1	1	2	1	1
5	3	4	4	4	2	1	1	2	1
4	3	4	5	5	2	2	1	3	2
3	3	3	3	4	4	1	2	1	3
4	3	3	4	3	1	1	2	2	1
3	2	2	3	4	2	3	1	1	1
4	4	2	4	2	3	3	4	3	3
3	3	4	3	3	1	1	1	2	1
4	3	3	3	4	1	2	3	2	2
4	5	3	4	4	1	2	1	2	2

Table 5: Emotional responses from participants using the AI application (1 - Not at all, 5 - Extremely)

Participant	Reserved	Trusting	Lazy	Relaxed	Few Artistic Interests	Outgoing	Finds Fault	Thorough Job	Nervous	Active Imagination
1	3	4	3	2	2	4	4	4	4	5
2	3	4	2	4	1	2	3	4	4	4
3	3	4	2	2	4	5	1	5	4	3
4	2	4	3	2	1	5	2	4	4	5
5	2	2	1	2	1	4	5	5	3	3
6	3	5	4	5	2	4	2	5	4	5
7	5	5	3	4	4	2	2	4	5	4
8	4	4	4	3	3	4	3	3	3	3
9	4	3	4	2	1	2	2	4	5	5
10	4	4	5	2	3	4	4	3	4	4
11	3	4	3	4	3	3	2	5	3	5
12	2	3	4	4	4	5	3	2	2	4

Table 6: Participants' self-assessment on various traits (numeric values)

Age	**Gender**
19	Female
22	Female
21	Female
59	Female
15	Male
49	Male
19	Male
19	Male
19	Male
20	Male
24	Male
21	Female
32	Female

Table 7: Participants' Age and Gender Distribution

Task 1	**Task 2**	**Task 3**	**Task 4**	**Task 1 (AI)**	**Task 2 (AI)**	**Task 3 (AI)**	**Task 4 (AI)**
29	32	43	39	19	20	25	22
31	24	51	19	11	18	15	11
22	14	20	18	9	9	8	9
31	19	27	25	26	26	24	28
62	24	25	47	26	22	17	27
62	31	45	57	22	20	18	25
46	31	30	27	26	20	17	26
47	30	42	38	41	38	38	44
59	37	52	47	14	14	13	15
31	20	27	25	14	14	13	15
13	8	12	11	16	16	15	17
39	24	34	31	22	22	20	24

Table 8: Task completion times for Non-AI and AI versions across four tasks