Foods 2025 Conference
The 6th International Electronic Conference on Foods
28–30 October 2025 | Online
MDPI

Data Analysis and Machine Learning on Eye-Tracking Data to Interpret Consumer Behaviour for Yogurt Products with a Novel Edible Bio-Film

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INTRODUCTION & AIM

- Eye tracking records where and how long a person looks, revealing visual attention, cognitive processing, and emotional responses [1].
- It is widely used to assess consumer preferences for products and services [2].
- Recorded data include fixations, saccades, and pupil diameter, while Areas of Interest (AOIs) are identified through software or analysis tools [3].

Aim

- To develop and apply a data processing and preference prediction methodology using eye tracking data.
- Case study: Participants viewed two yogurt packages: One with a conventional transparent film and one with a brown, SCP-based edible film [4].
- AOIs were extracted using a clustering approach.
- The study explored whether consumer preference could be predicted from eye tracking variables.

METHOD

Python programming language and libraries

- Pandas (data analysis)
- Scikit-learn (clustering, machine learning)
- Matplotlib/seaborn (plotting)

Definition of AOIs

- Only fixations
- K-Means for clustering
- Silhouette algorithm for number of clusters

Machine Learning Model

- Prediction of preference from 26 variables
- Normalization with Standard Scaler
- Separation into train (70%) and test (30%) data
- 10 classification algorithms
- Accuracy as performance measure

$$Accuracy = \frac{Number\ of\ correct\ predictions}{Total\ number\ of\ predictions}$$

Statistical Analysis

- 13 variables for each film (control / edible)
- Two groups of participants according to preference
- Suitable mean test (t-test/Mann-Whitney U test / Welch's t-test) between two groups

RESULTS & DISCUSSION

Optimal number of clusters k= 6: product label, ingredients, film information, nutritional value up, nutritional value down, control/edible film respectively

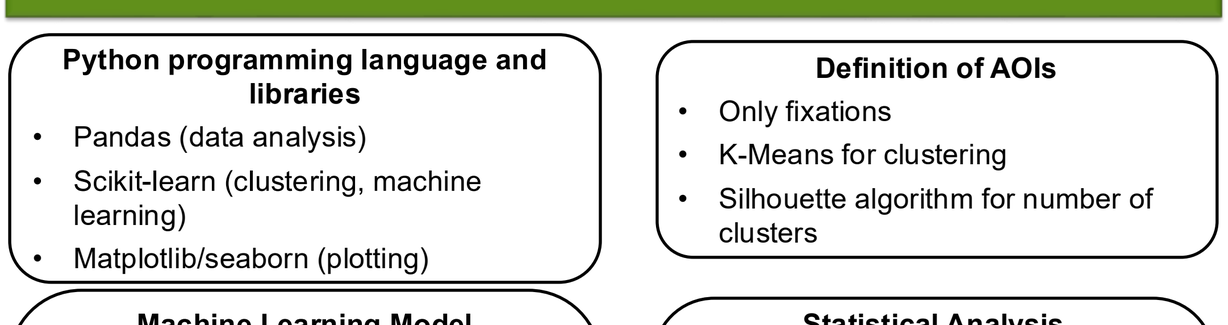

Figure 1: Heatmaps that present the process of defining AOIs using clustering for the control film (left) and the edible film (right).

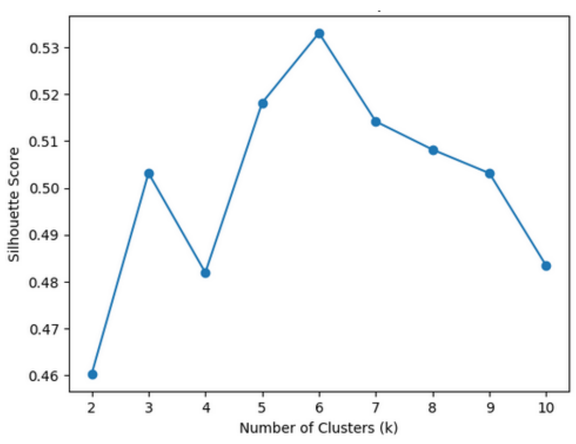

Figure 2: Silhouette scores for different cluster numbers (k = 2–10). The highest score at k = 6 indicates the optimal clustering solution

Statistically significant difference in means between those who chose the control and those who chose the edible film for variables:

- Total fixation duration, Control, Total fixation duration Edible and Mean fixation duration Edible (p-value=0.01)
- First fixation duration Edible, Fixation Count Edible, Fixation count Control, Mean fixation duration Control and Std fixation duration Edible (p-value=0.05)

Parameter	Statistical Test	Control	Edible
Total fixation duration	Mann-Whitney U test	1401.5**	1438.5**
Mean saccade duration	Mann-Whitney U test	1116.0	991.0
Std saccade duration	Mann-Whitney U test	1164.5	888.0
Mean saccade velocity	Mann-Whitney U test	856.0	792.0
Std saccade velocity	Mann-Whitney U test	1023.0	955.0
Mean saccade pupil diameter	t-test (Student)	1.136	1.108
Std saccade pupil diameter	Mann-Whitney U test	1130.0	1096.0
Mean fixation pupil diameter	Welch's t-test / t-test (Student)	1.13	1.08
Std fixation pupil diameter	Mann-Whitney U test	1067.0	1248.0
First fixation duration	Mann-Whitney U test	1197.0	1327.5*
Fixation count	Mann-Whitney U test	1335.5*	1314.0*
Mean fixation duration	Mann-Whitney U test	1374.0*	1414.0**
Std fixation duration	Mann-Whitney U test	1256.0	1391.0*

*Table 1: Comparison of means of variables for participants who chose the control and those who chose the edible film. *: p-value=0.05 **: p-value=0.01*

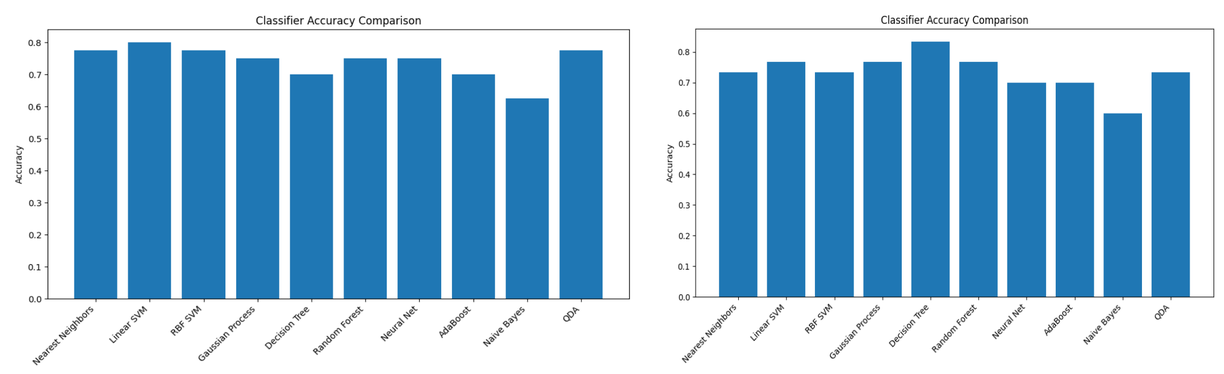

Figure 3: Comparison of classification algorithms with the evaluation measure of Accuracy for all variables processed (left) and 8 variables processed (right).

Performance of the classification algorithms

- **All variables**: Linear SVM (Accuracy=80%). K-Nearest Neighbors, RBF SVM and QDA (Accuracy=78%)
- **8 variables** (Total fixation duration Control/Edible, Mean saccade duration Control/Edible, Mean saccade duration Control/Edible, Mean fixation pupil Diameter Control/Edible): Decision Tree Classifier (Accuracy=83%), Random Forest, Gaussian Process and Linear SVM (Accuracy=77%)

CONCLUSIONS

- The performance of the classification algorithms is considered quite satisfactory,
- Variation in gaze behavior associated with preference.
- Automated AOI detection and gaze metric modeling can complement traditional sensory evaluation by providing objective, data-driven information about visual attention and product selection.
- Transferable to other sensory and consumer research contexts where visual attention is a key preference factor.

FUTURE WORK / REFERENCES

- Developing an automated variable selection process to increase model performance.
- Application to corresponding data with the aim of further evaluating it.

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