

Emotional-Physiological Dynamics: Cluster Analysis

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Case 2 in 02582 Computational Data Analysis

1 Introduction

Using clustering techniques, we analyze how experiment phases, seasons, time of day, and participant roles influence emotional-physiological responses. Our dataset includes heart rate, temperature, electrodermal activity metrics, and self-rated questionnaire responses.

Research questions

- How do the self-rated questionnaire responses vary amongst phases?
- How does the season (winter or fall) influence the metrics recorded from biosensors?
- How do the physiological features vary among morning and evening sessions in the fall?
- How do the self-rated questionnaire responses vary among the participant roles in each phase?

2 Methodology

We conducted our analysis across five distinct datasets: one for each biosensor metric and one comprehensive dataset encompassing all metrics. With data preprocessing and dimensionality reduction methods, like PCA and ICA, we reduced the complexity of the data and we used K-means, hierarchical clustering, and Gaussian Mixture Models to identify patterns.

3 Discussion and Results

Phases For each clustering method, we get that the optimal choice 2 clusters.

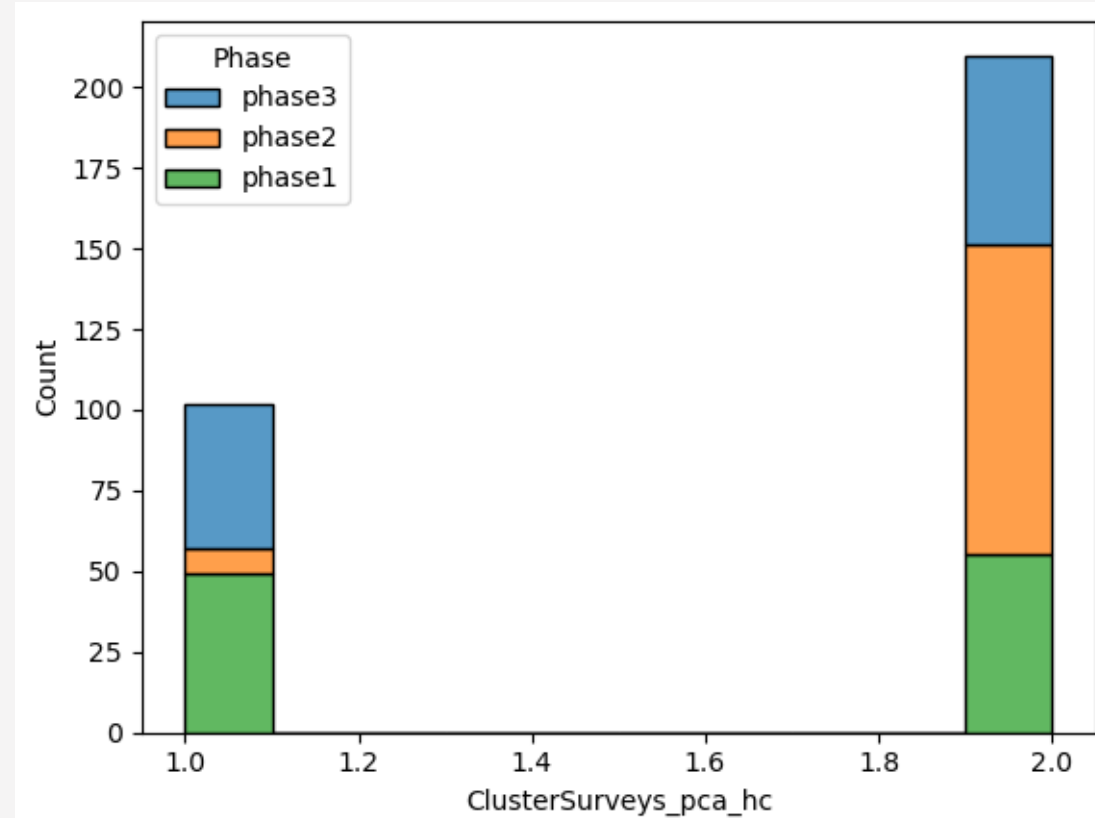


Figure 1: Hierarchical clustering results

The results obtained showed there was some separation between phase 2 and the other two phases.

	Cluster 1	Cluster 2
Frustrated	1.303922	2.371429
alert	1.411765	2.571429
inspired	1.421569	2.542857
attentive	1.774510	3.271429
active	1.382353	3.119048
determined	1.941176	3.376190

Table 1: Average responses - HC

The emotions with significant differences between the clusters are in Figure 1. Phase 2 shows higher responses for emotions such as frustration, alertness, inspiration, attentiveness, activity, and determination, suggesting that individuals in Cluster 2 experience these emotions more intensely or frequently than those in Cluster 1, but still spread over the 2 clusters. This indicates that Phase 2 is associated with higher levels of stress, motivation, or challenge, like during puzzling activities.

Seasons

- Temperature** Insights: Clusters that predominantly included winter participants, were characterized by a significantly lower mean temperature and smaller temperature variance compared to fall participants in the same cluster.
- Electrodermal** Activity: Across all clustering methods, one cluster consistently included participants from both seasons, while others were mostly fall participants, suggesting distinct physiological trends unique to the fall.
- Heart Rate** Variability: Clusters with higher HR skewness primarily included fall participants, highlighting a specific heart rate behavior pattern mostly of this group.

Sessions The results come from Figure 2.

- K-Means: Cluster 1 predominantly represents morning sessions, while Cluster 0 leans towards evening ones.
- Hierarchical: Cluster 1 mainly capturing Evening sessions and Cluster 2 showing a more balanced profile.
- GMM: Cluster 0 evenly distributed, while Cluster 1 slightly favors Evening sessions.

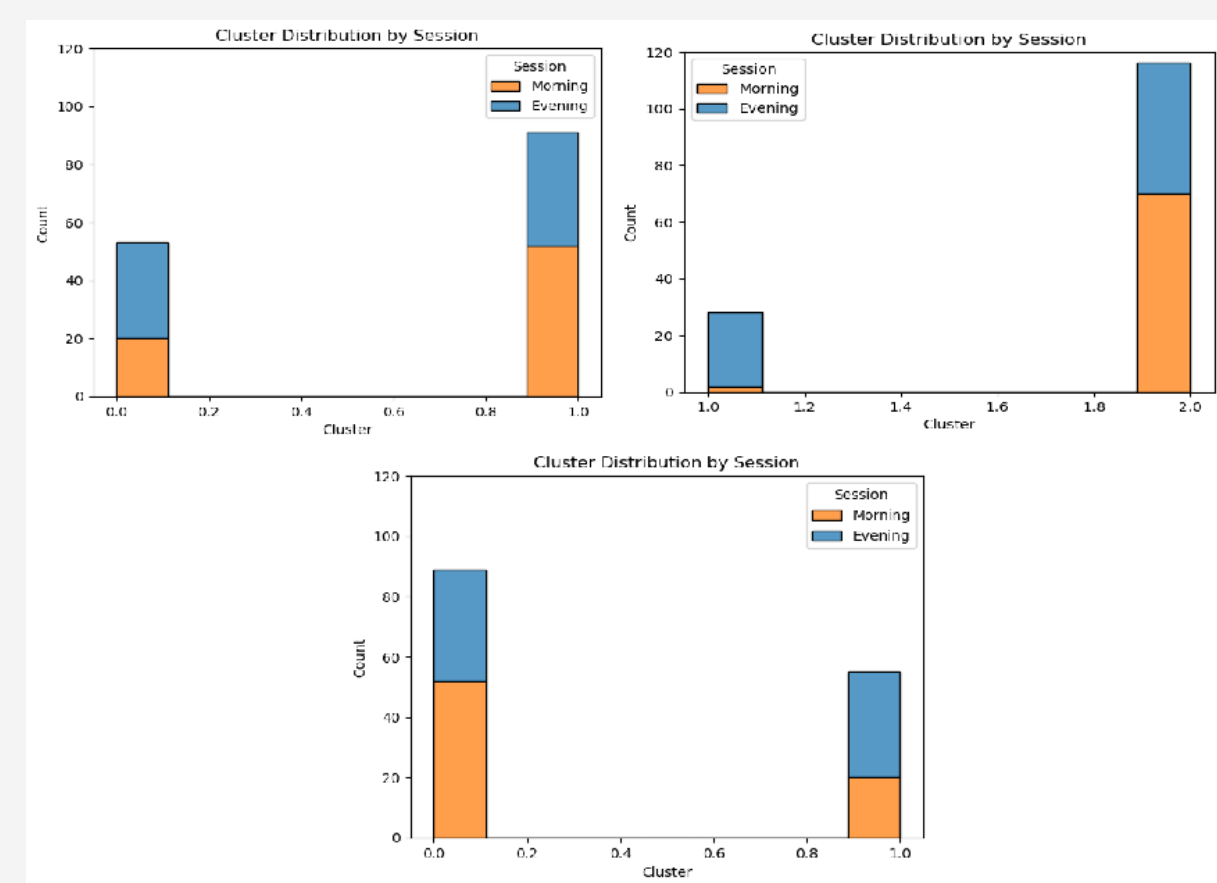


Figure 2: Clustering results: K-Means, Hierarchical and GMM, respectively

KMeans, Hierarchical, and GMM analyses reveal that Cluster 0 displays a lower average heart rate than Cluster 1, suggesting less physiological arousal. Cluster 0's higher temperature and electrodermal activity—contrasting with Cluster 1's lower indicate enhanced sensitivity or more intense reactions to environmental stimuli, compared to the relatively calmer responses observed in Cluster 1.

Participant roles We analyzed how participant roles and activity phases affect their emotions using clustering:

Distribution	Significant Emotions
Phase 1	
C1: 8 Puz., 4 Inst.	Frustrated: p=0.0165
C2: 44 Puz., 48 Inst.	Active: p=0.0232
Phase 2	
C1: 5 Puz., 1 Inst.	Emotions similar
C2: 47 Puz., 51 Inst.	
Phase 3	
C1: 12 Puz., 10 Inst.	Frustrated: p=0.0165
C2: 35 Puz., 39 Inst.	Active: p=0.0232
C3: 5 Puz., 3 Inst.	

Table 2: Emotional Clustering Summary

Table 2 is divided into three sections, each representing a different phase of the activity. For each phase, the distribution of participants across clusters is shown along with significant emotional responses. The p-values denote the statistical significance of these emotions.

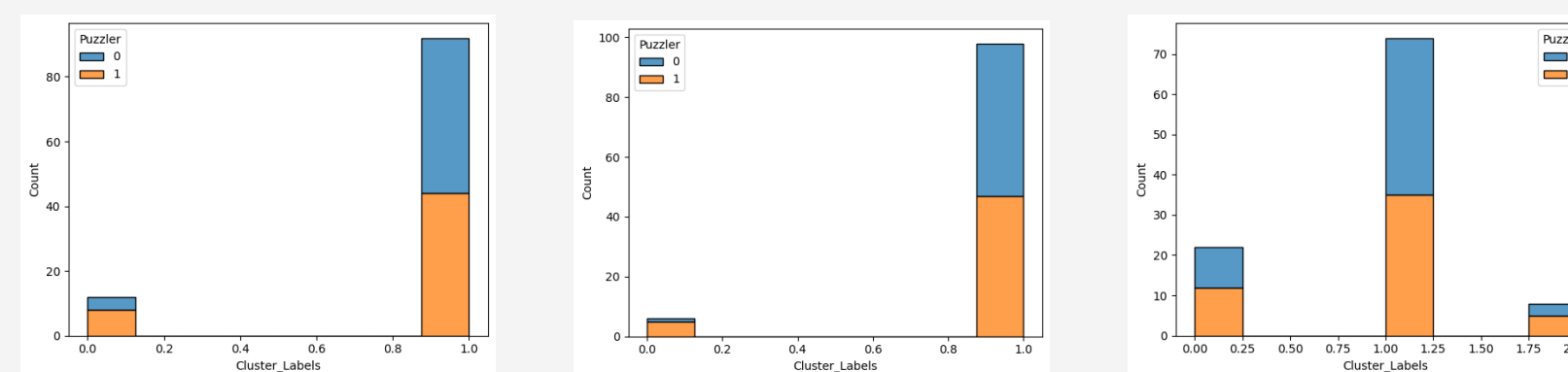


Figure 3: Clustering results