Neural Responses to familiar and unfamiliar stimuli:

Building a Binary Classifier

A Project by Eva Mazur (1008795)

Exploring how neural responses differ when the brain processes familiar vs. Unfamiliar stimuli

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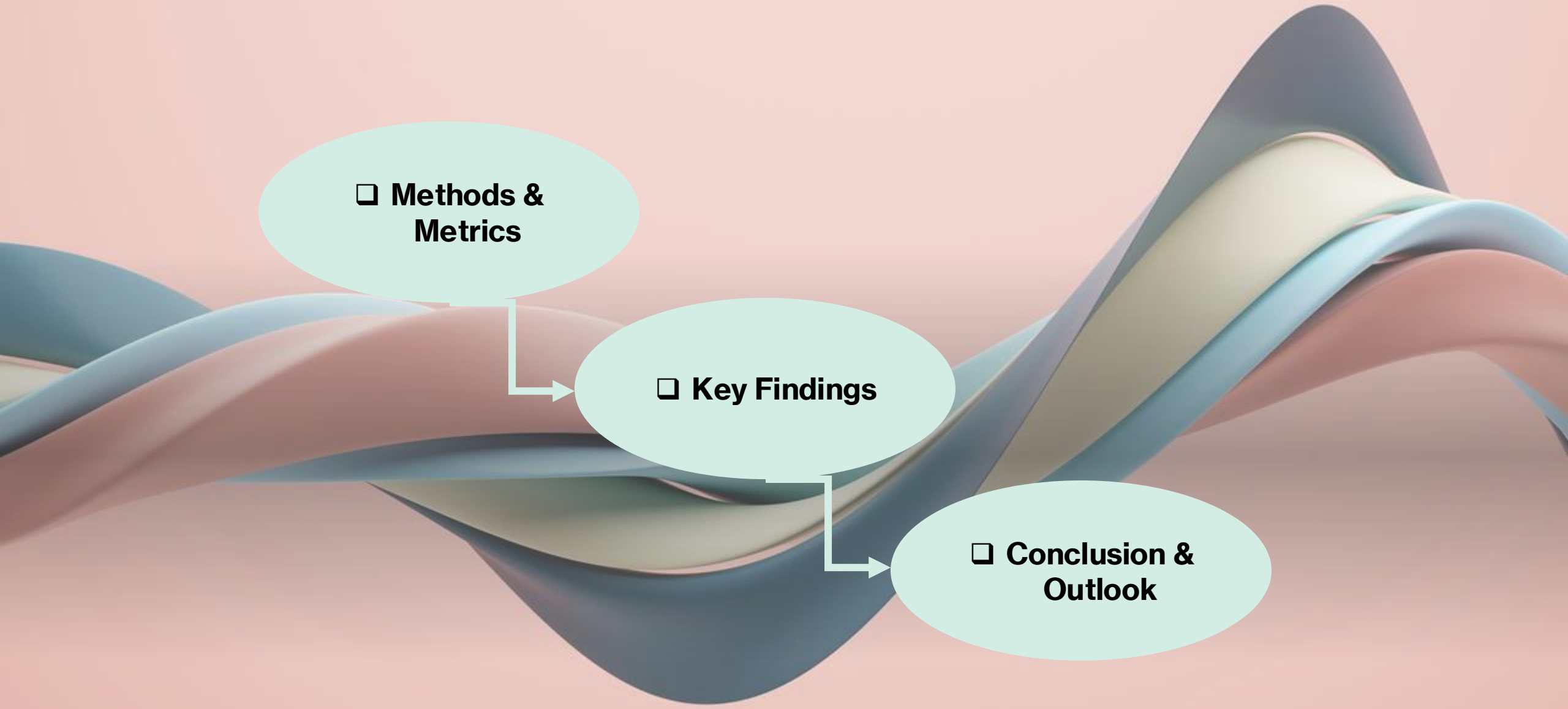

❑ Methods & Metrics
❑ Key Findings
❑ Conclusion & Outlook

Feature Extraction (Step 3)

➔ turning raw spike trains into simple, useful features to train classifiers

1. FIRING RATE	2. SYNCHRONY	3. FREQUENCY DOMAIN
• Calculated **average FR** per neuron • **FR Comparison** • Neuron Relevance Filtering (**highly correlated neurons**)	• Measured as the **standard deviation of total neuron activity** per sample • **FR vs. Sync.** plotted by Class	• Applied **Fourier Transform** to selected neurons' activity to capture oscillatory patterns • Used average power of **first 10 frequency bins** as **FFT-band feature**

Model Comparison (Step 4)

➔ **Histogram** of **average firing rates** shows **different distributions** for familiar vs. unfamiliar stimuli.

➔ Scatter plot of Firing Rate vs Synchrony shows **two distinct clusters**:

- ❖ **Unfamiliar: low FR + low synchrony**
- ❖ **Familiar: high FR + high synchrony**

Metrics used:

➔ **KL-Divergence –** measures how distributions of two classes differ

➔ **Log-Likelihood & Deviance –** checks how well Gaussian model fits each class

➔ **AIC –** value indicates model fit (combines fit and complexity)

Binary Classification (Step 5)

- Trained **Logistic Regression** on:
  - Mean Firing Rate only ➔ Accuracy: 71,7%, F1: 0.70
  - FR + Synchrony ➔ Accuracy: 85.0%, F1: 0.84 (fewer misclassifications)

To understand familiarity in neural signals, it is not just about **how much** the brain fires, but **how well** it fires in sync!

➔ Cognitive processes like memory often involve coordinated activity across neurons.

Comparing Multiple Models (Step 6)

[6.1]

➔ Added **FFT-band power** as a **third feature** to FR + synch.

➔ Captures both time and frequency patterns

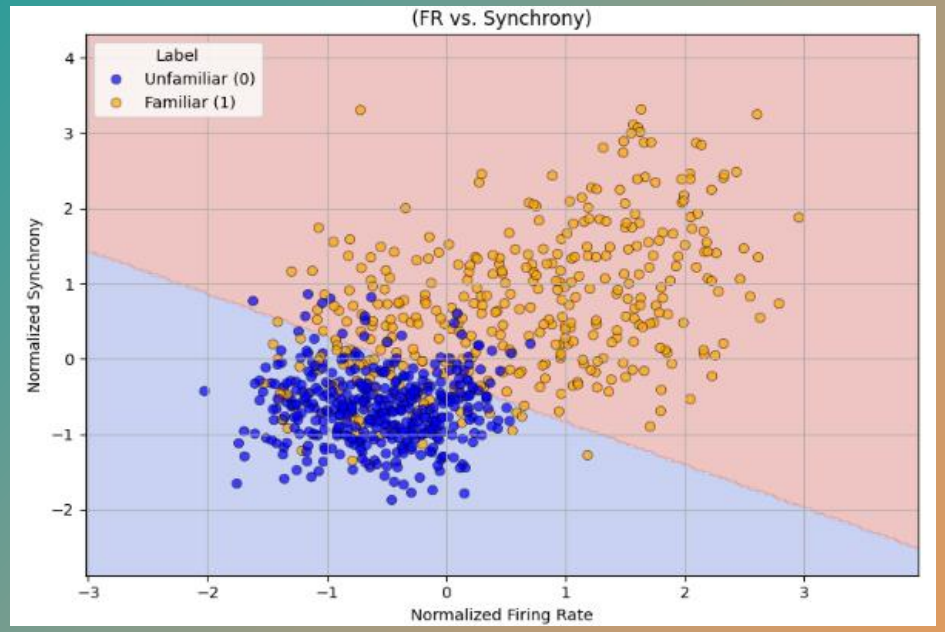
[6.2]

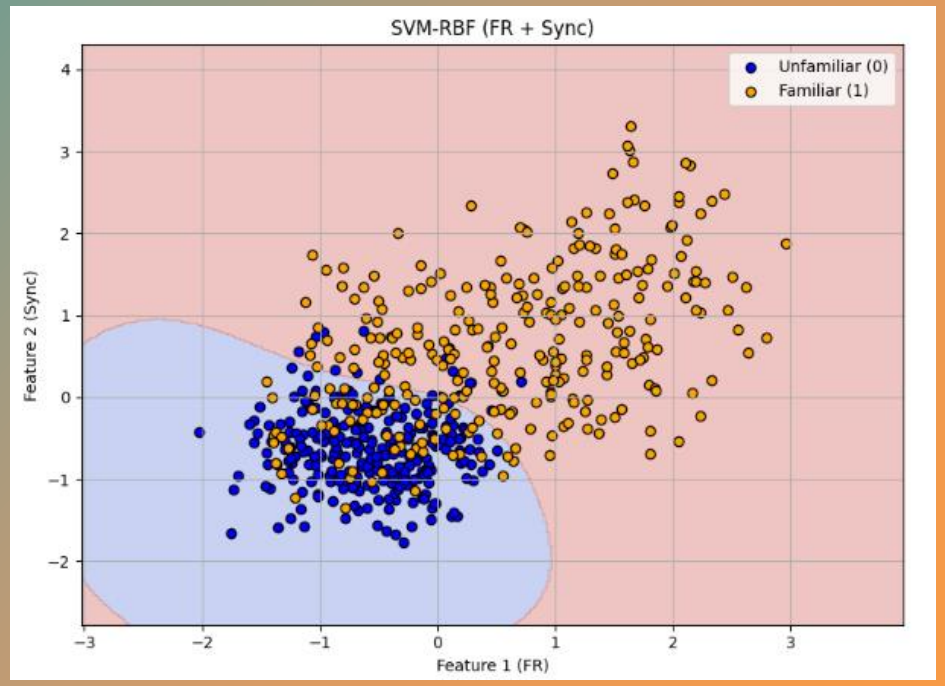
➔ **Logistic Regression**

- Accuracy: **85.0%**, F1-score: **0.84**
- Balanced performance across both classes, **linear**

➔ **SVM-RBF**

- Accuracy: **84.2%**, F1-score: **0.82**
- Better at detecting *unfamiliar* stimuli
- Captures **non-linear** patterns

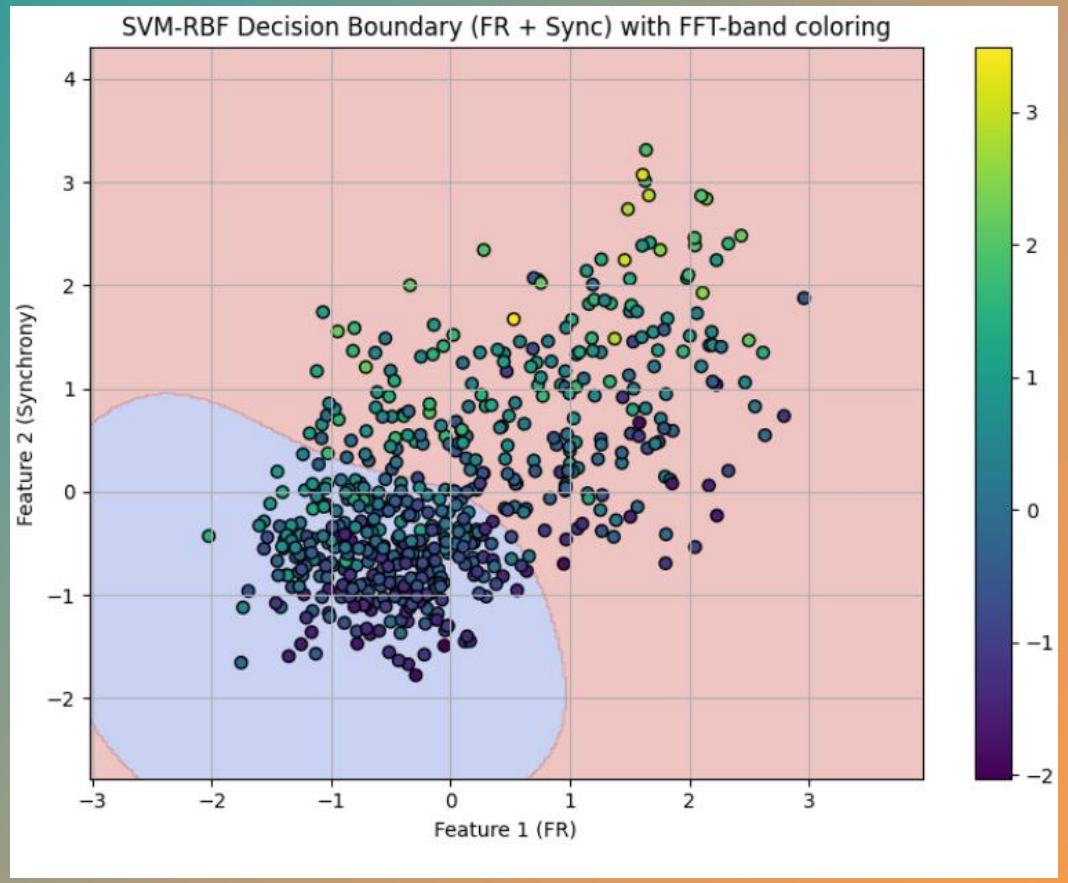




Visualizing the Decision Boundaries

[6.3]

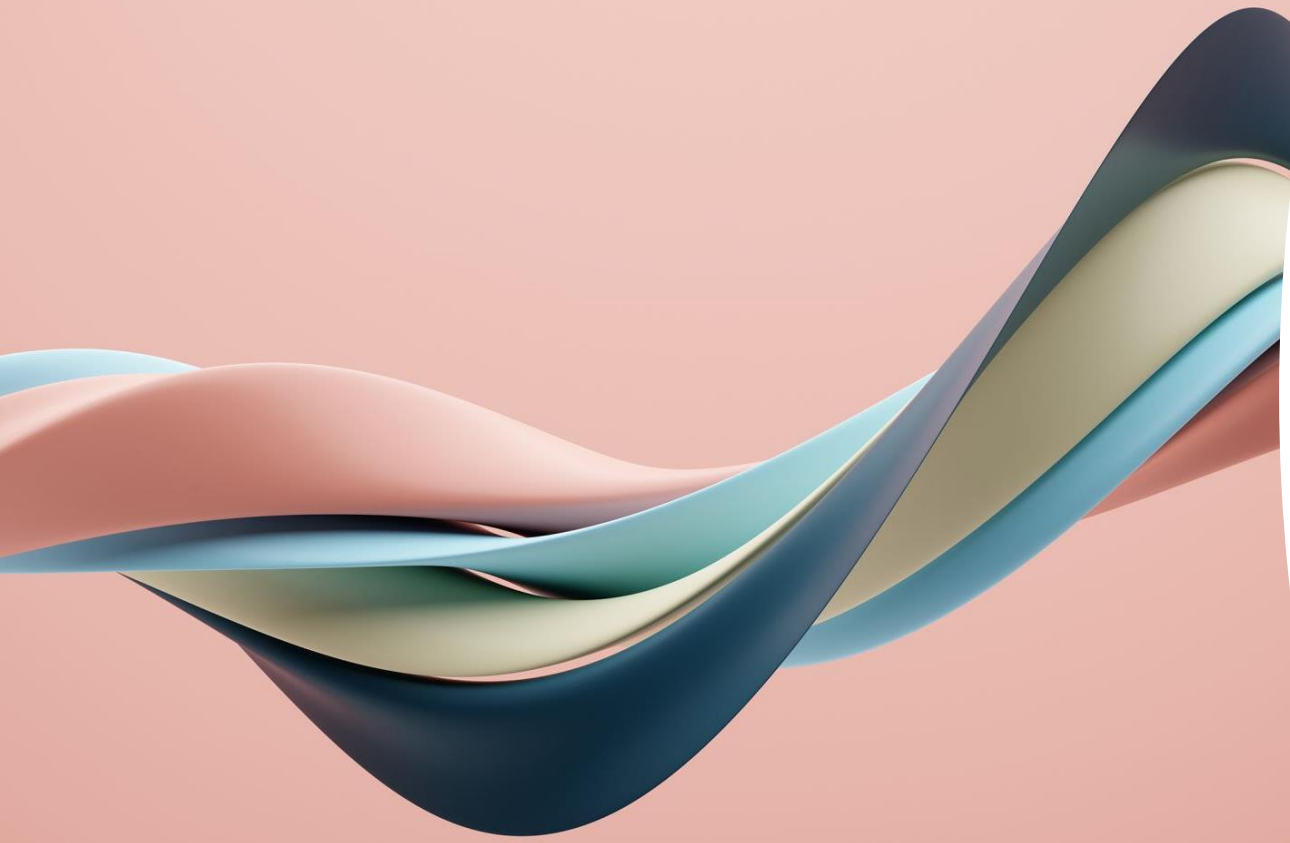
- **SVM** allows for **more flexible class separation** (since it is non-linear)
- **Helpful distinction in overlap** between familiar and unfamiliar samples



FFT-Band Power Visualization

[6.4]

- FFT band power displayed as a color gradient
- Adds a **temporal frequency** component to model
- **Higher oscillation power** is often linked with *familiar* stimuli



Conclusion & Outlook

- **Logistic Regression**: simple, balanced, interpretable
- **SVM-RBF**: better at capturing complex, non-linear patterns
- **FFT-band** improved understanding of neural rhythms (esp. for familiar stimuli)

➔ Explore **more frequency ranges**

➔ Use **PCA** to reduce FFT dimensionality

➔ Try **neural networks** for deeper pattern recognition

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