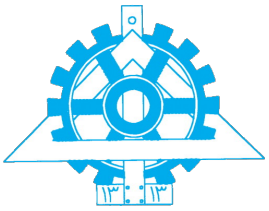
University of Tehran

College of Engineering

School of Electrical & Computer Eng



Principles of Cognitive Science

Homework 1

Name

Reza Chehreghani

Student ID

810101401

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Abstract

This study investigated perceptual sensitivity to facial identity changes by comparing texture-based (appearance) and geometry-based (shape) features. Participants completed a psychophysical task using morphed facial images sampled along two distinct feature dimensions. Responses were analyzed by fitting psychometric functions and calculating Just Noticeable Differences (JNDs). Results indicated generally lower JNDs for appearance features compared to shape features, suggesting finer sensitivity to texture-based variations. Although a Wilcoxon signed-rank test did not reach significance ($p = 0.0547$), the trend supports the notion that texture information plays a dominant role in facial identity discrimination. Individual differences in sensitivity patterns were also observed.

Methods

Participants viewed morphed facial images from four feature sets (`app/f1`, `app/f11`, `sha/f1`, `sha/f11`). Ten images per folder were selected at equal intervals along the morph continuum (specifically at indices 0, 11, 22, 33, 44, 55, 66, 77, 88, and 99).

Each selected image was presented 10 times in random order.

During each trial, participants were instructed to indicate which of the two original faces the morphed image more closely resembled, using the right and left arrow keys. Responses and reaction times were recorded using PsychoPy.

Results

Psychometric functions (sigmoid curves) were fitted to the response data separately for each feature and subject. The Just Noticeable Difference (JND) was calculated for each fitted curve as the inverse of the sigmoid's slope.

Plots of the fitted psychometric curves are provided below:

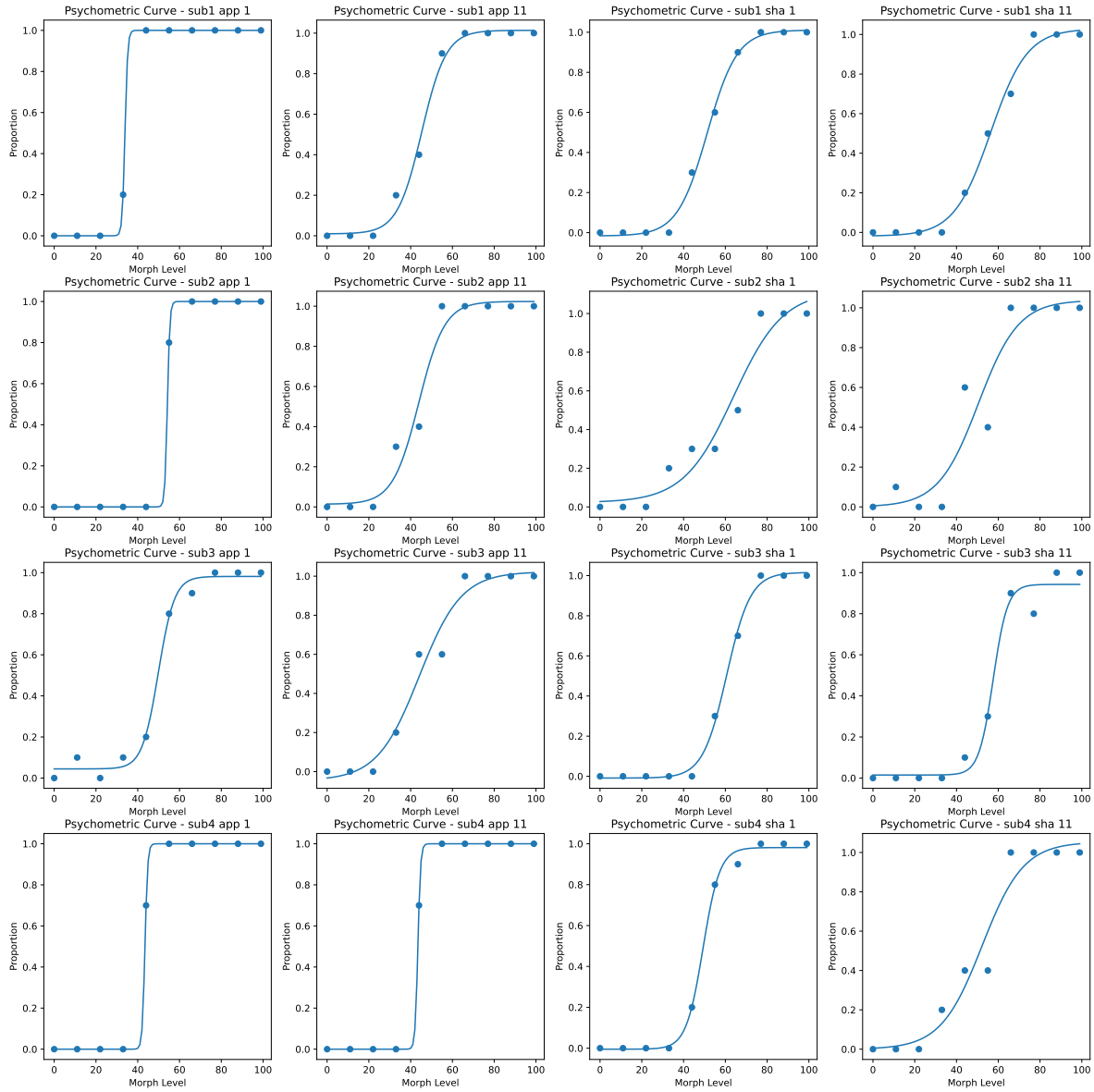

Figure 1: Sigmoid curves fitted to individual subject data across features.

The calculated JND values for each subject and feature are summarized in Table 1.

	Appearance (app)		Shape (sha)	
Subject	**f1**	**f11**	**f1**	**f11**
sub1	0.637	5.833	7.155	8.756
sub2	0.591	6.202	11.869	9.591
sub3	3.868	10.050	5.702	3.423
sub4	0.641	0.641	4.024	9.891

Table 1: Just Noticeable Difference (JND) values for each subject and feature.

Interpretation

A lower JND reflects greater perceptual sensitivity, indicating better discrimination ability between facial identities.

Comparison of JNDs across appearance (`app/`) and shape (`sha/`) features revealed notable differences in the perceptual encoding of these two facial dimensions:

- Across most subjects, appearance features (`app/f1`, `app/f11`) were associated with consistently lower JNDs than shape features (`sha/f1`, `sha/f11`).
- This pattern suggests that participants were generally more sensitive to texture-based variations (appearance) than to geometric variations (shape) when discriminating between faces.

In particular, for feature `f1`, appearance JNDs (approximately 0.6) were markedly smaller than the corresponding shape JNDs (ranging from 4 to 12), indicating a clear advantage in detecting texture-based identity changes.

However, for feature `f11`, the pattern was less consistent: while most subjects still demonstrated greater sensitivity to appearance features, some (notably Subject 3) exhibited better sensitivity to shape features.

Overall, these findings suggest that texture cues are often more salient than shape cues in facial identity perception, although considerable individual variability exists in the reliance on different facial information sources.

4.1 Statistical Analysis

To formally test whether JNDs for appearance features were significantly smaller than those for shape features, a Wilcoxon signed-rank test was conducted across all conditions (i.e., aggregating across features and subjects).

Formal Hypotheses:

- Null Hypothesis (H_0): There is no difference between JNDs for appearance and shape features.
- Alternative Hypothesis (H_1): JNDs for appearance features are lower than those for shape features.

Given the small sample size ($n = 8$ paired observations), the non-parametric Wilcoxon signed-rank test was chosen over a paired t-test.

The test yielded a statistic of $W = 6.0$ and a p-value of 0.0547.

Although the result approached significance, it did not reach the conventional threshold of $\alpha = 0.05$. Thus, we cannot formally reject the null hypothesis; however, the trend suggests a potential tendency toward finer sensitivity to appearance-based variations.

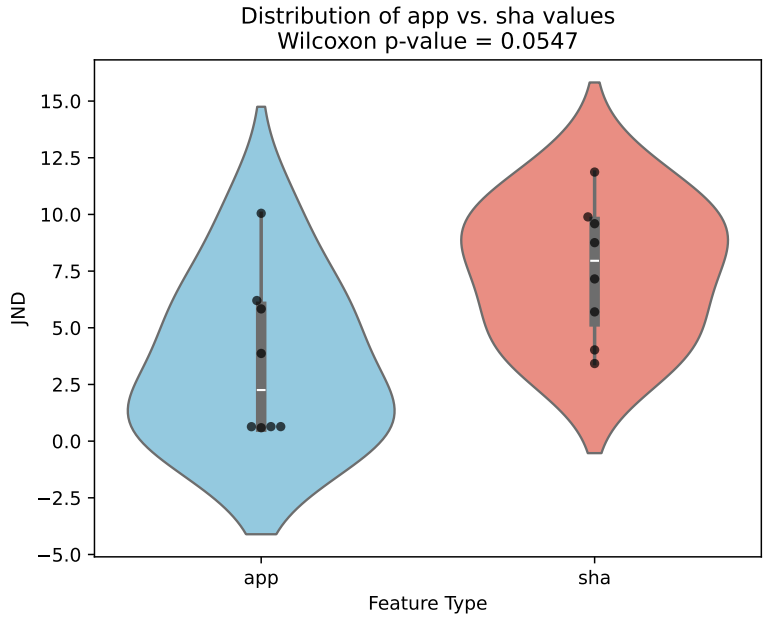

Figure 2: Violin plot comparing JND distributions for appearance (app) and shape (sha) features.

Conclusion

Overall, the results of this study suggest that participants demonstrate greater sensitivity to texture-based (appearance) variations compared to geometric (shape) variations in facial identity discrimination tasks. Although statistical significance was not achieved, the observed trend highlights the important role of appearance cues in facial recognition processes.