Department of Electrical & Computer Engineering

Deciphering the Face

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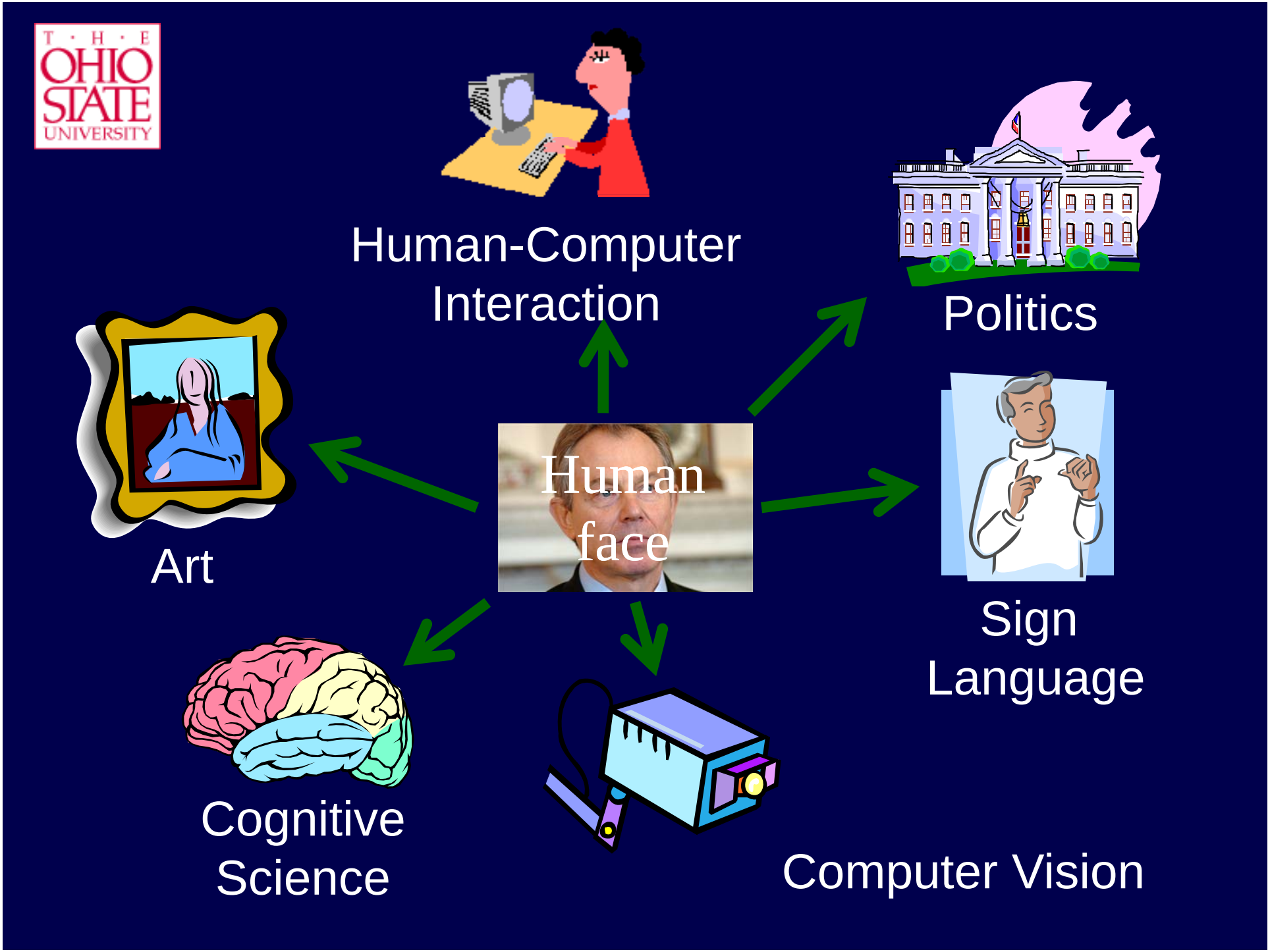
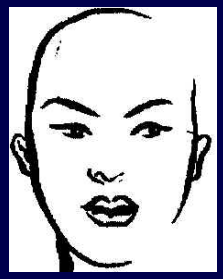
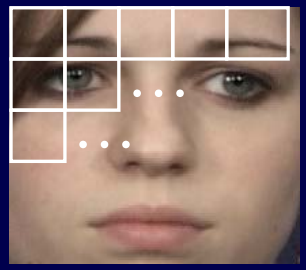

Human-Computer Interaction
Politics
Art
Human face
Sign Language
Cognitive Science
Computer Vision

Models of Face Perception

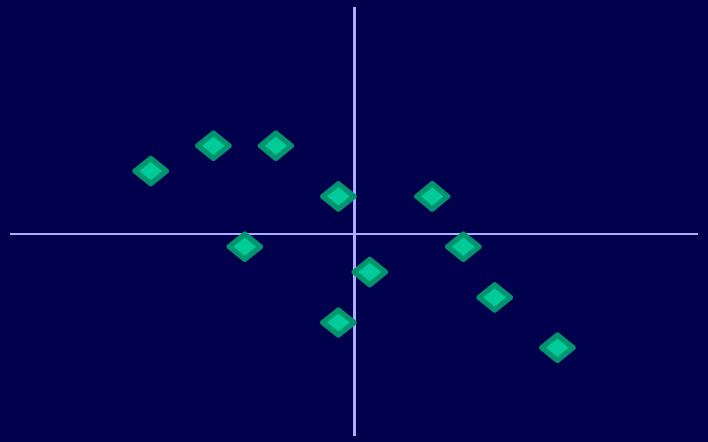
- Features: Shape vs. texture.

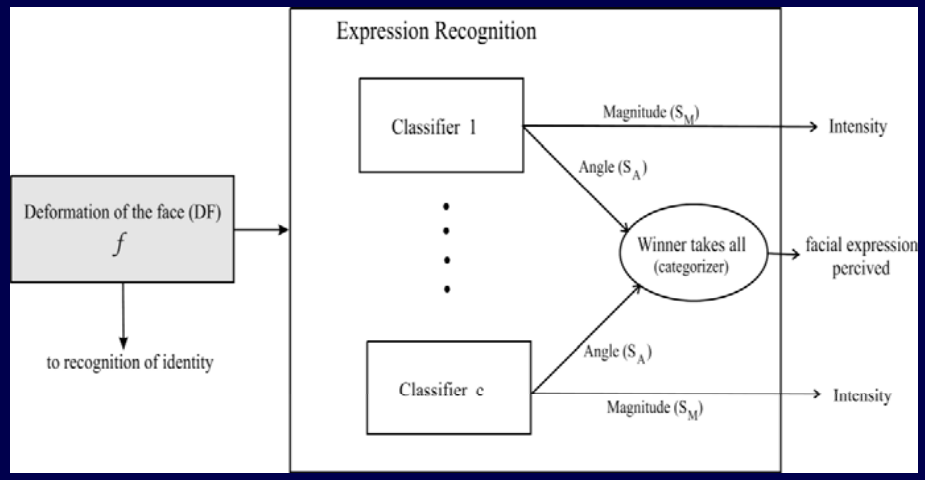




- 2D  vs. 3D 

- Form of the computational space:

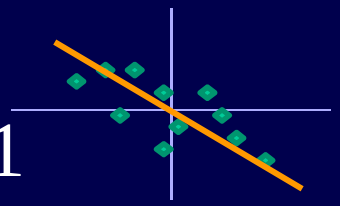
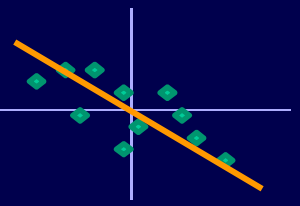
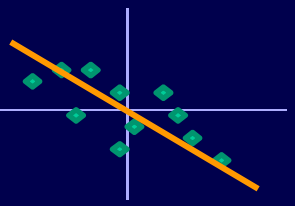




Continuous vs. Categorical

What we are going to show

- What is the form of the computational space in human face perception? **Hybrid approach**: Linear combination of continuous representations of categories.

c_1  + c_2  + … + c_n 

- What are the dimensions? Mostly **configural**.
- In computer vision we need precise detailed detection of faces and facial features.

Identity

Same or different?

Identity

Same or different?

Identity

Same or different?

Identity, expression, gender, etc.

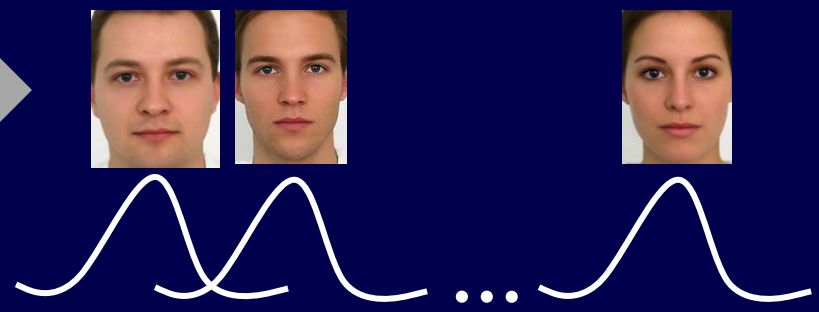
Dimensions of the Face Space

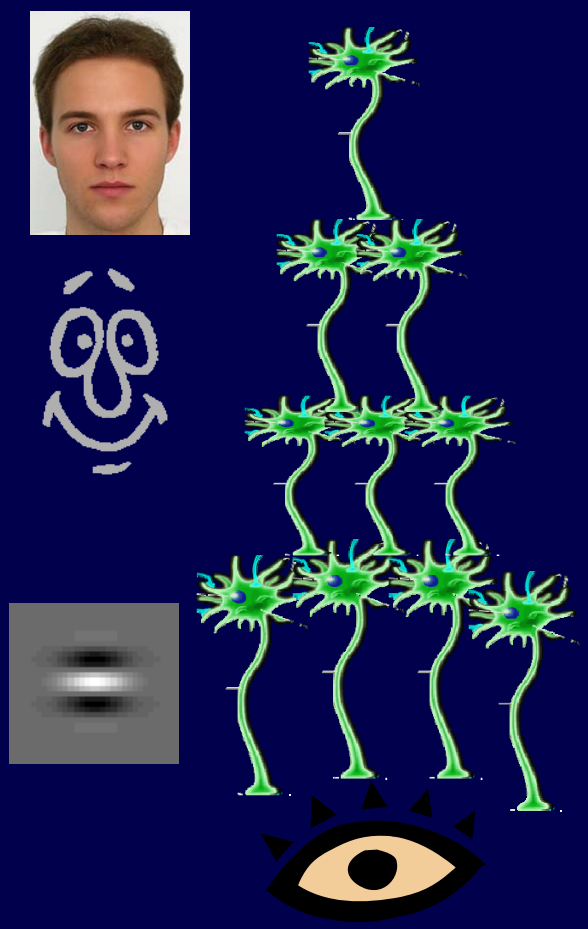
Same or different?

Configural processing

Form of the Computational Face Space

Exemplar-based model



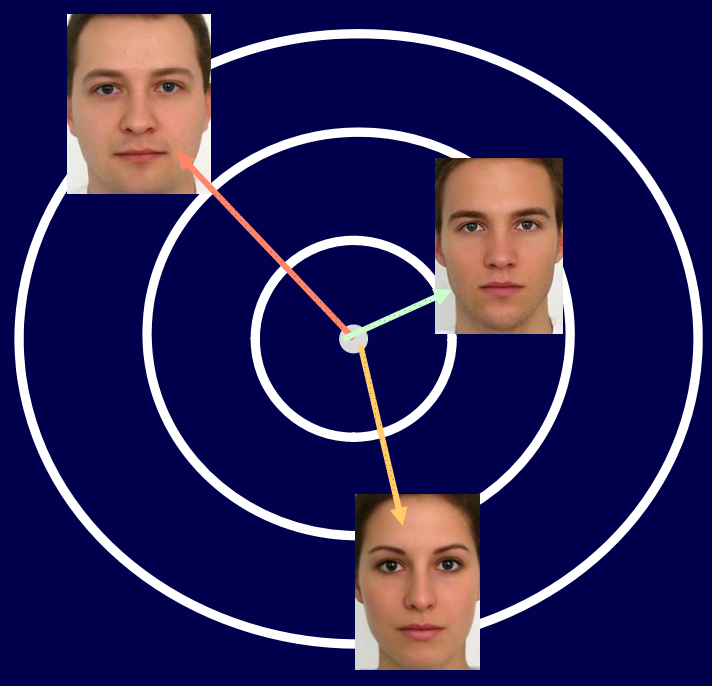


Exemplar cells

Mid-level vision

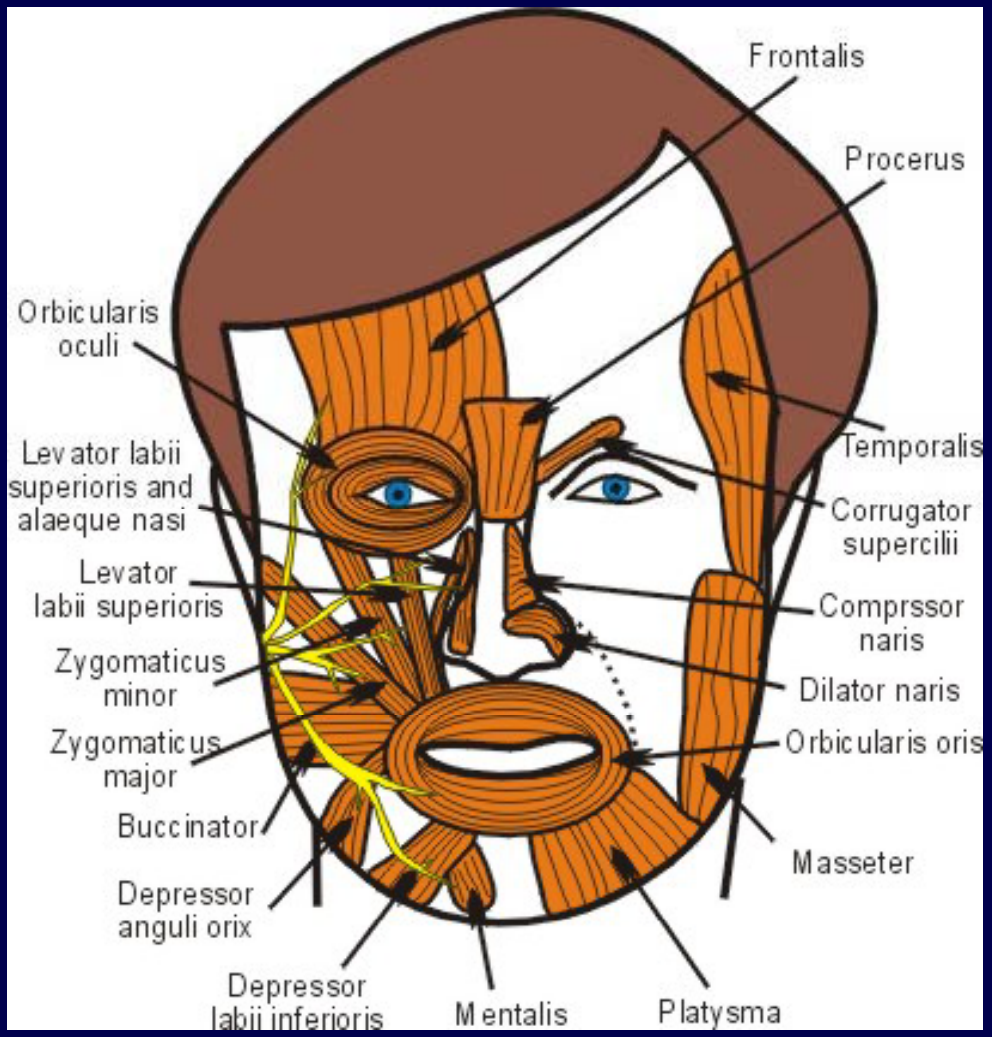
Low-level vision

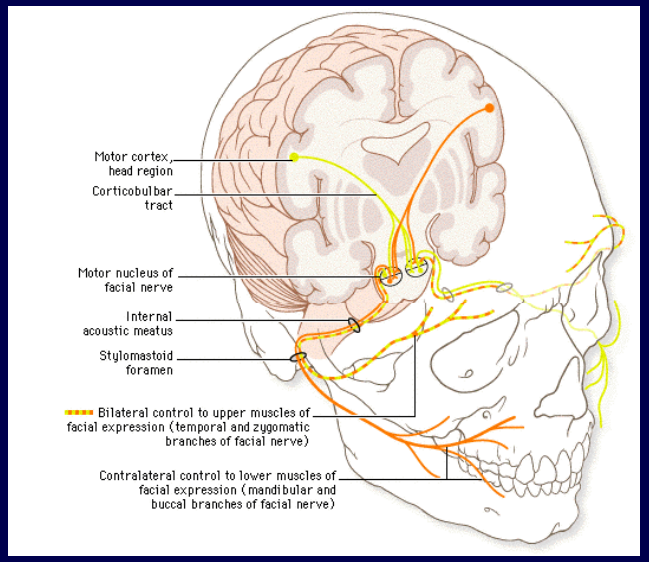
Norm-based model

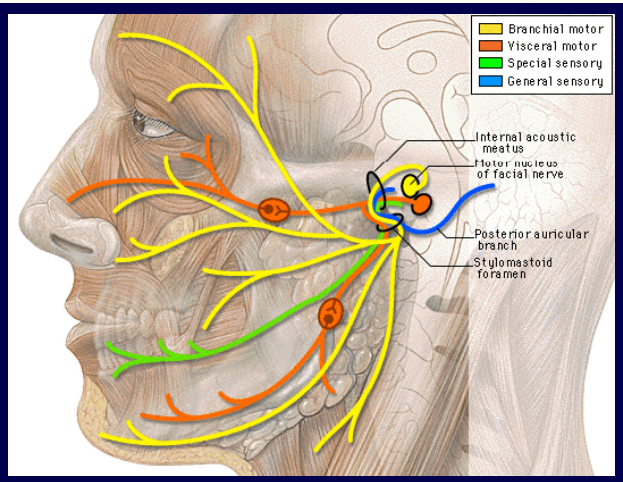


Facial Expressions of Emotion

Muscle Positions Model

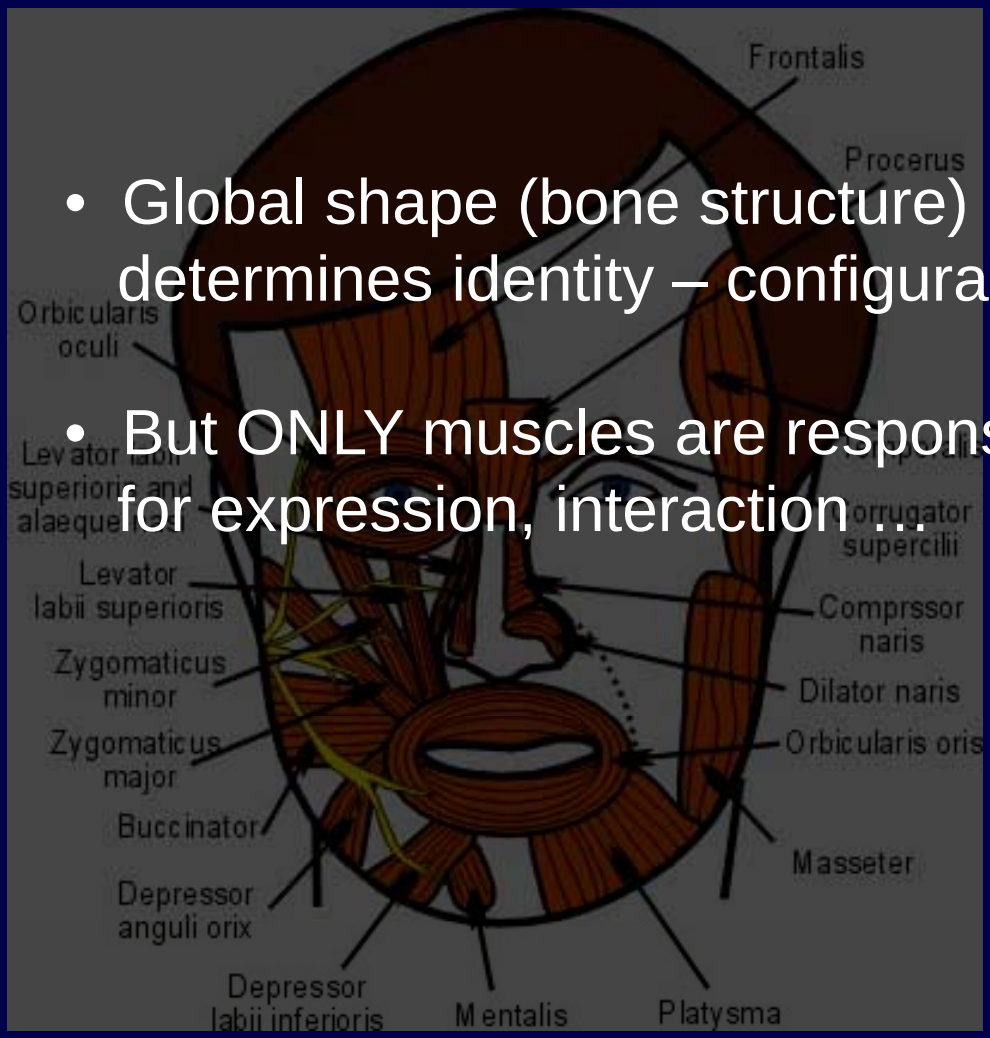


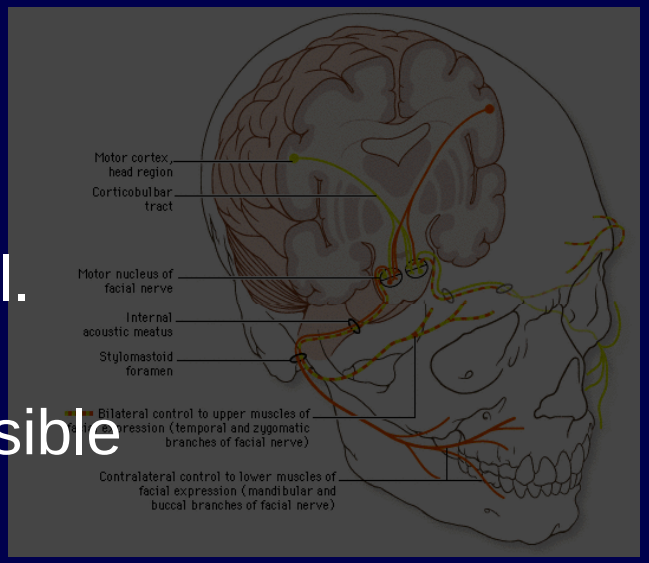


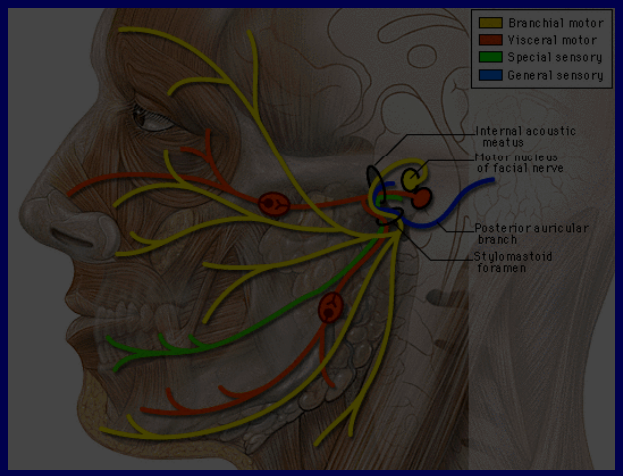


Muscle Positions Model

- Global shape (bone structure) determines identity – configural.
- But ONLY muscles are responsible for expression, interaction …

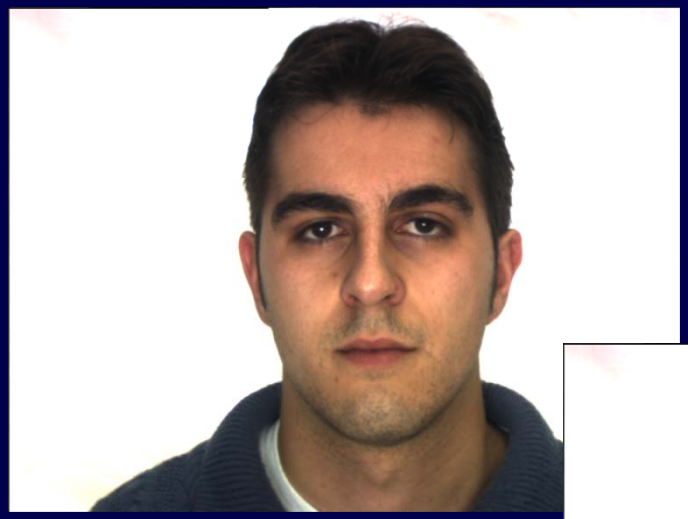






Configural Processing

Emotion perception in *emotionless* faces



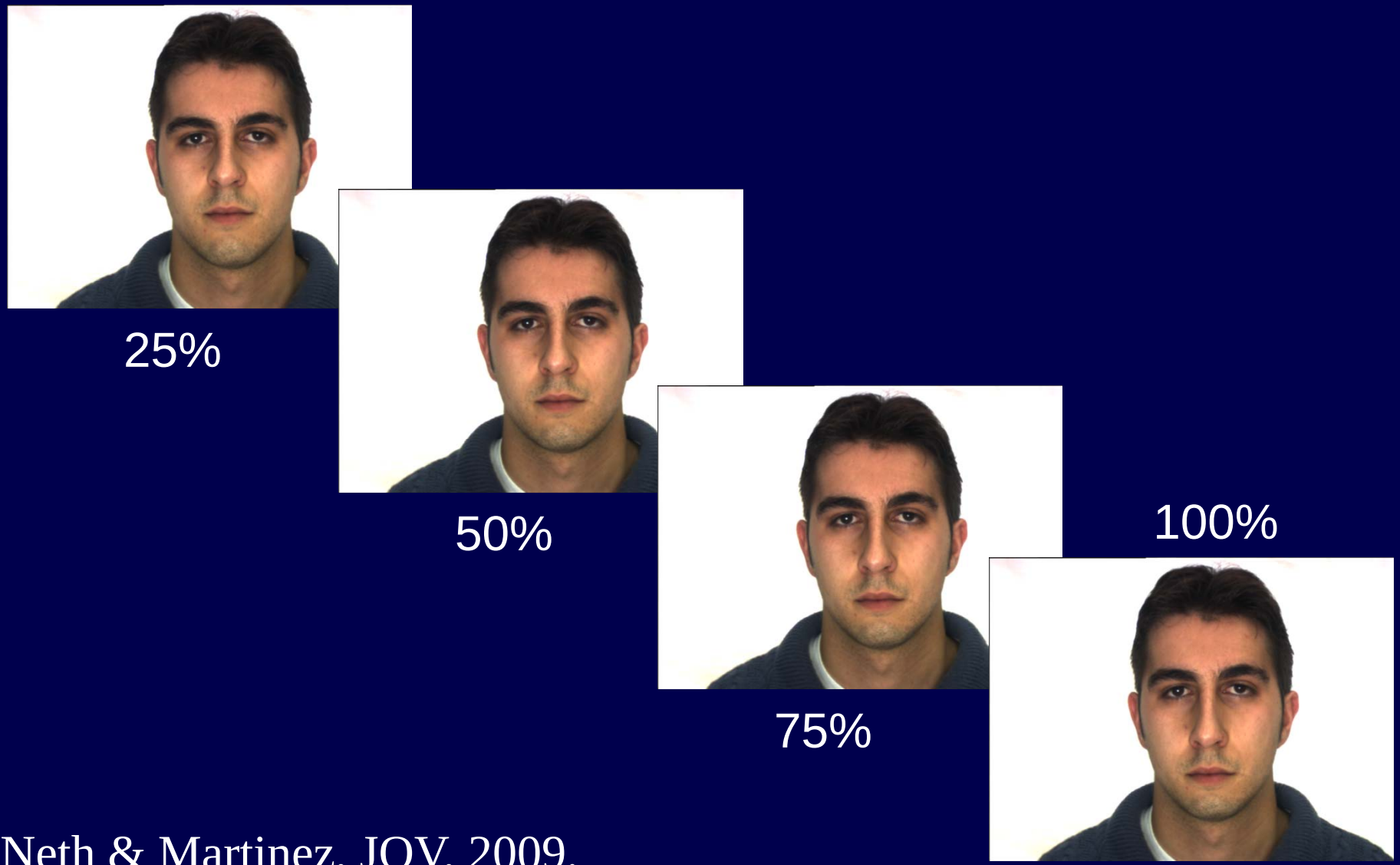
Neutral

Sad

Angry

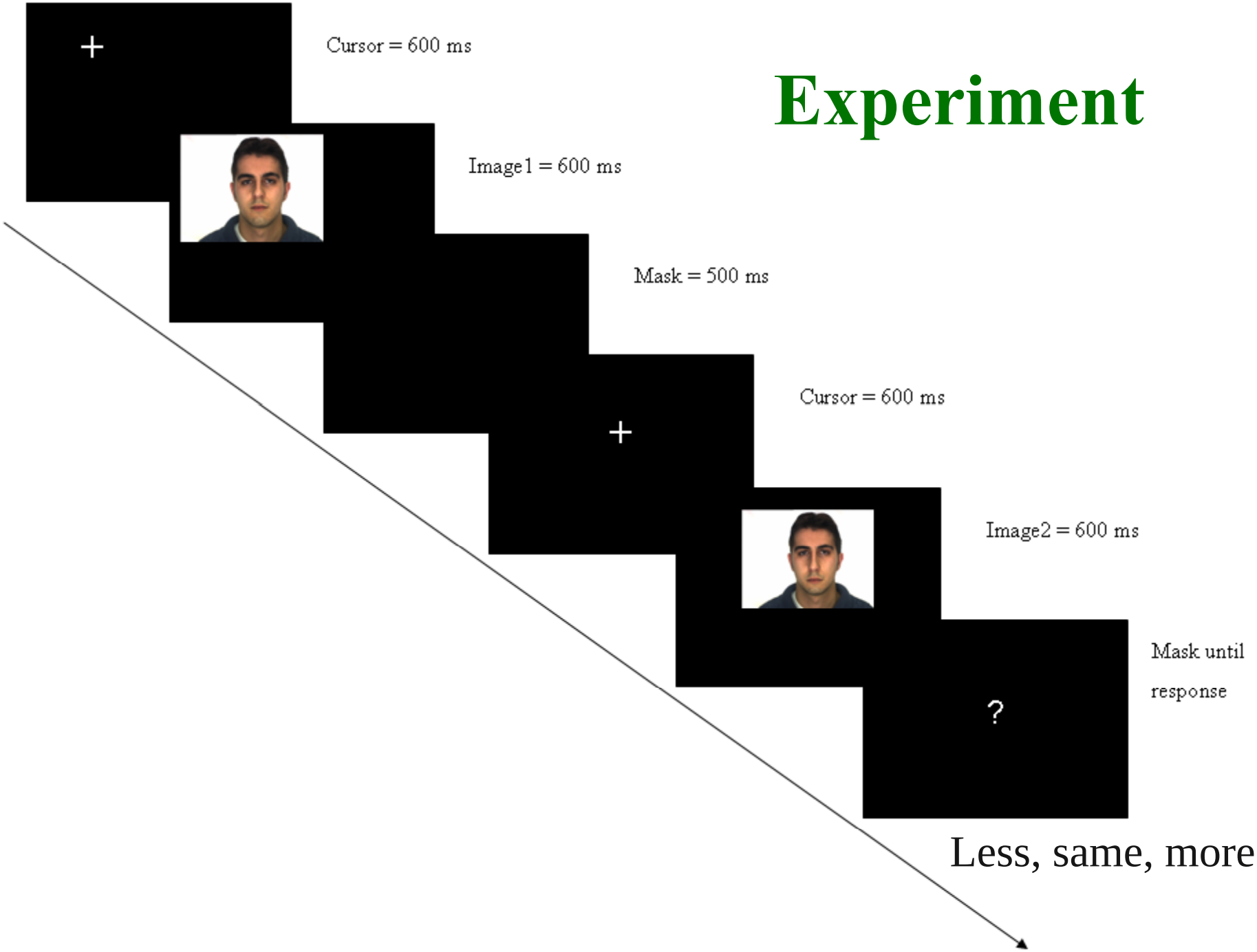
Neth & Martinez, JOV, 2009.

Stimuli



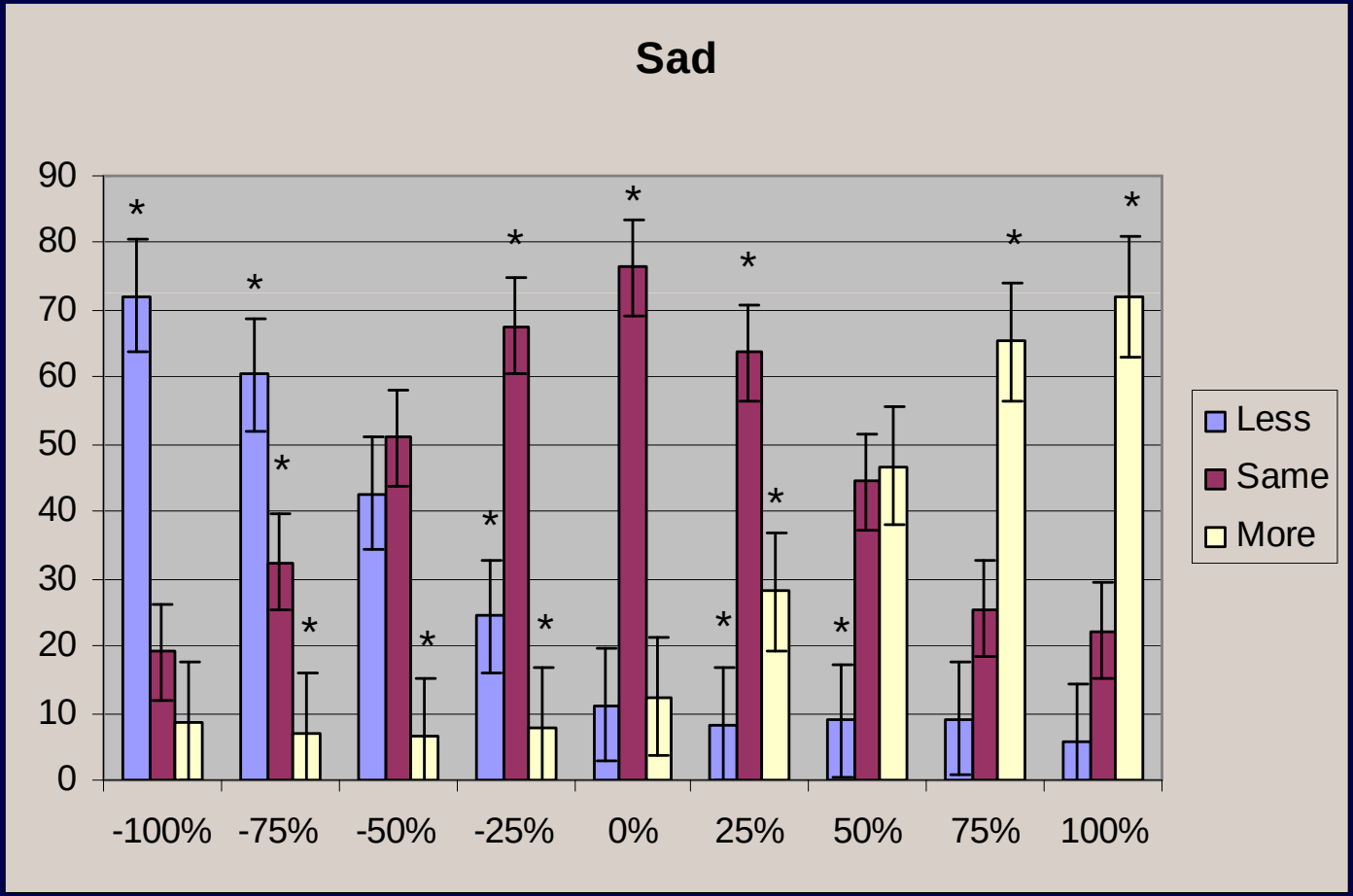
Neth & Martinez, JOV, 2009.

Experiment



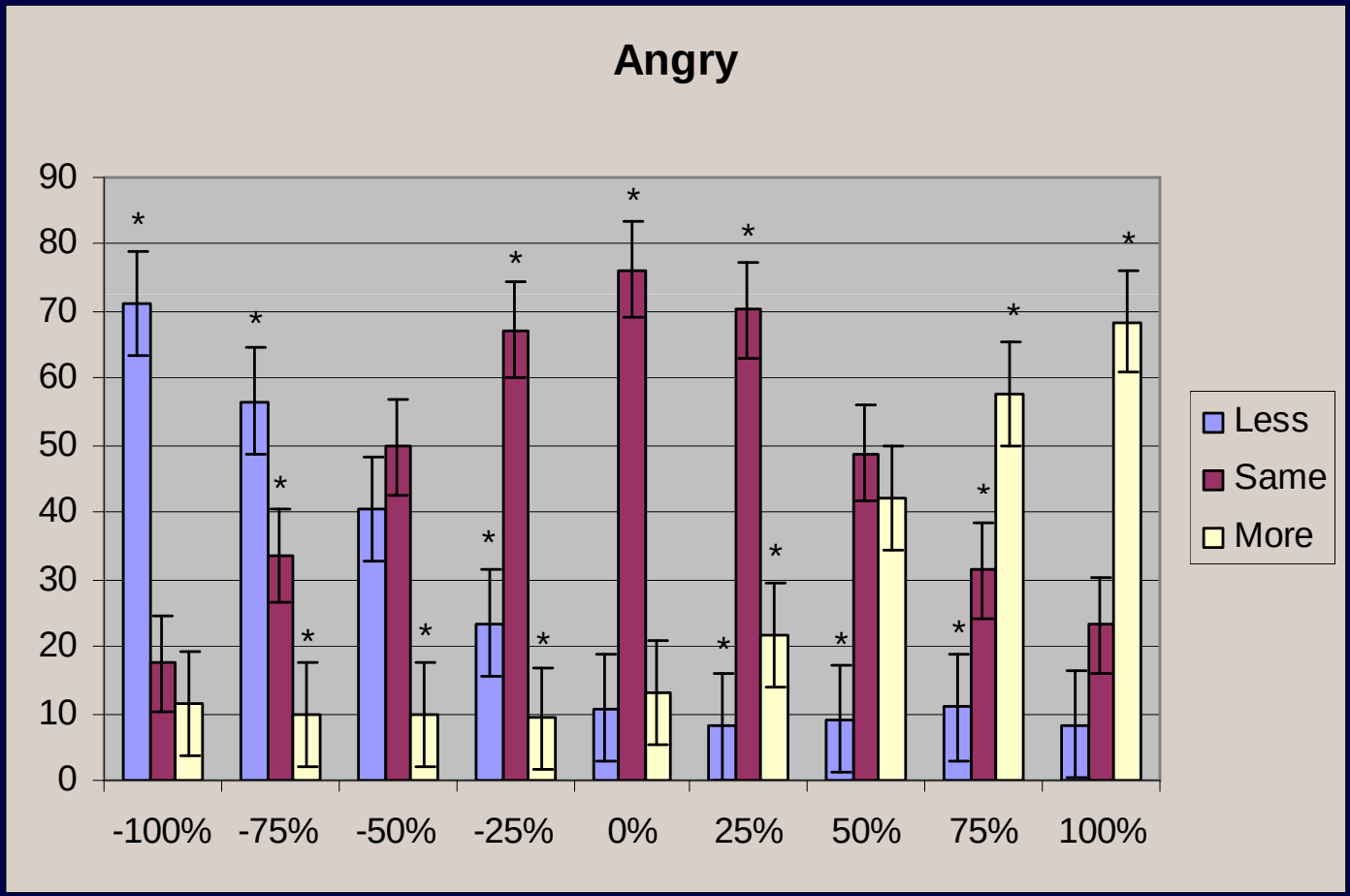
Less, same, more.

Configural Processing



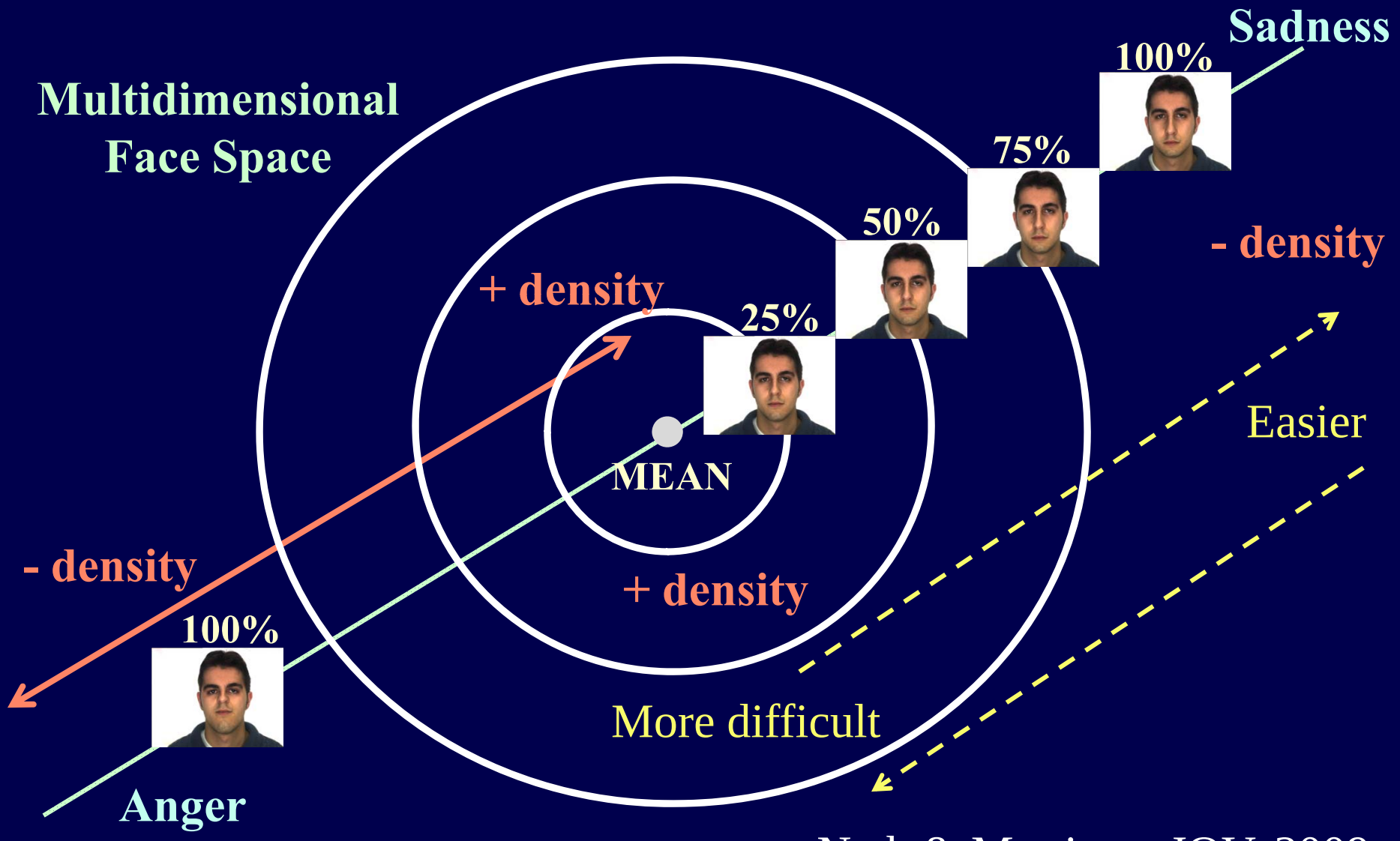
Neth & Martinez, JOV, 2009.

Configural Processing



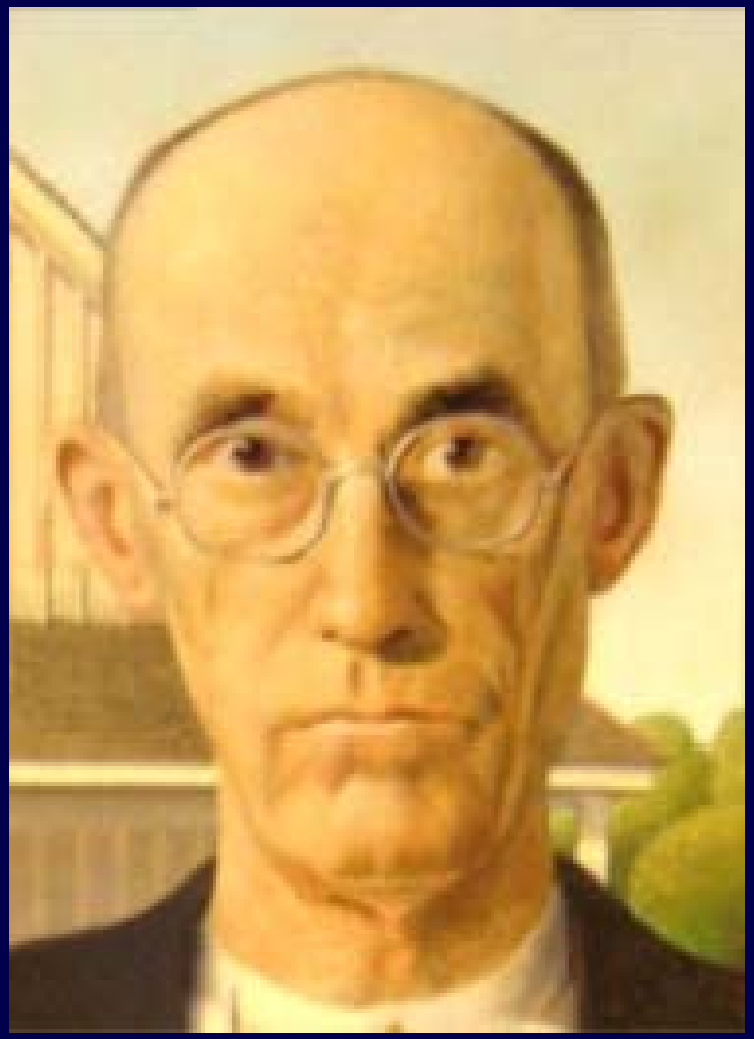
Neth & Martinez, JOV, 2009.

Norm-based Face Space



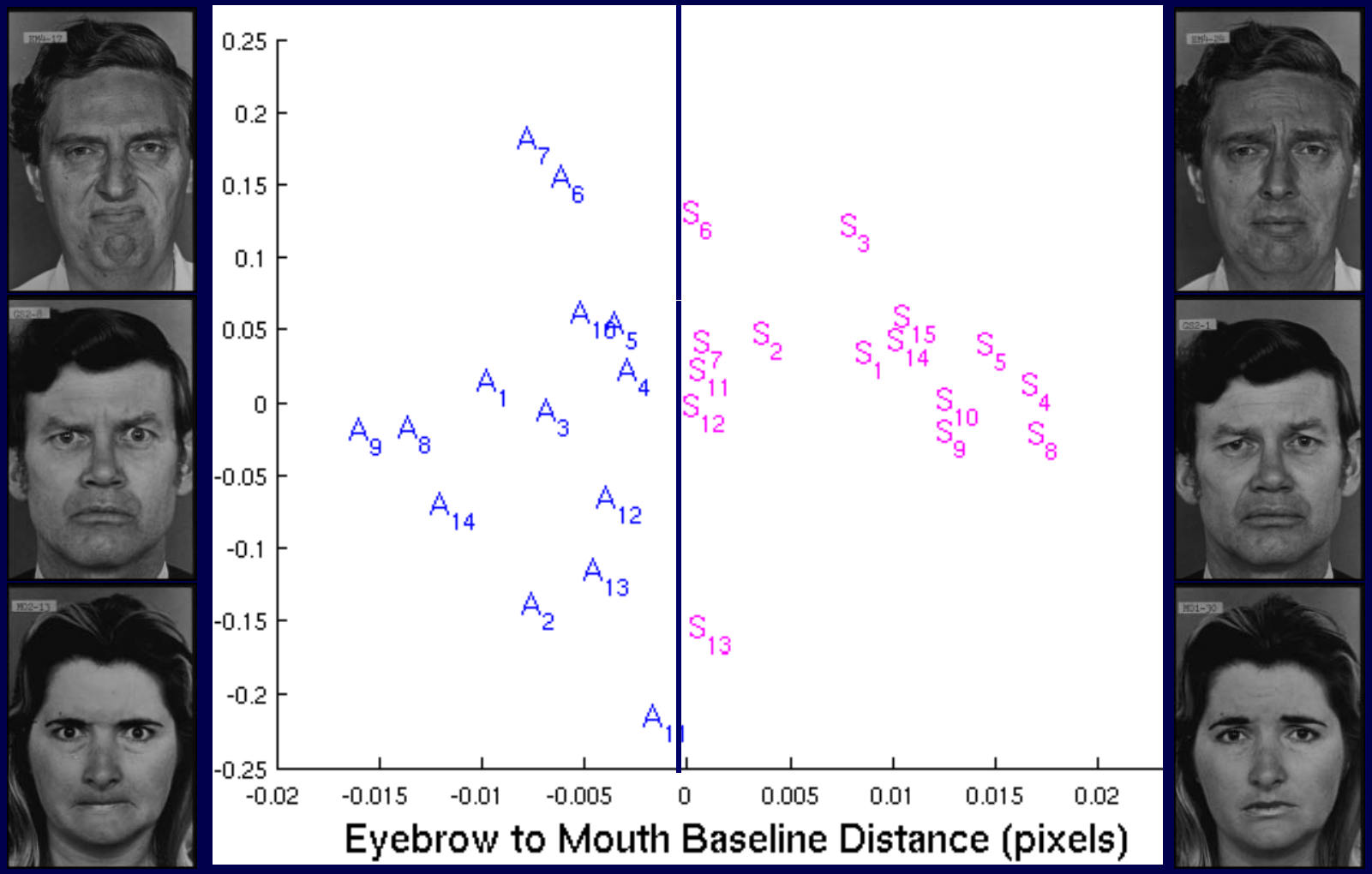
Neth & Martinez, JOV, 2009.

Configural Processing



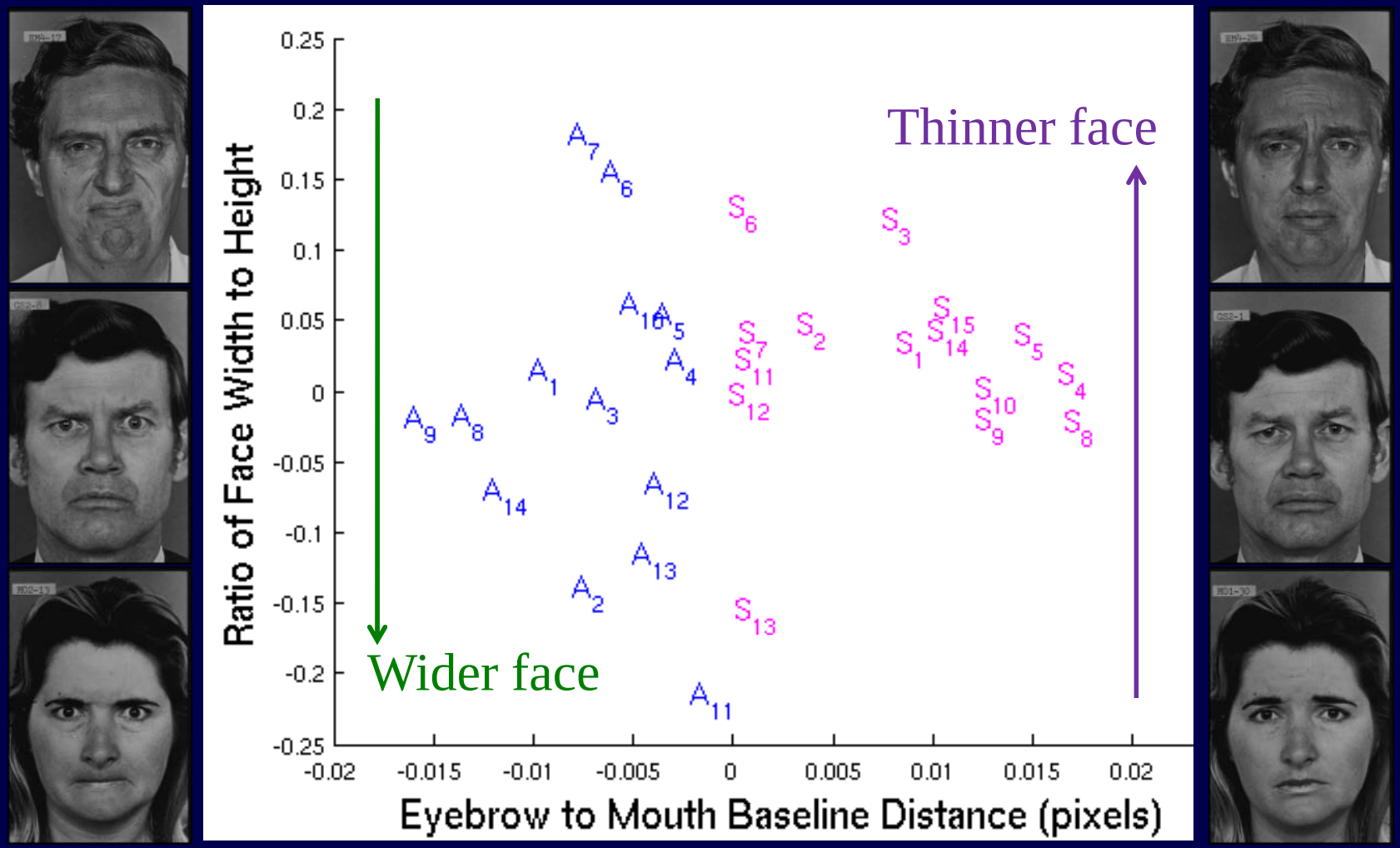
Neth & Martinez, JOV, 2009.

Computational Space



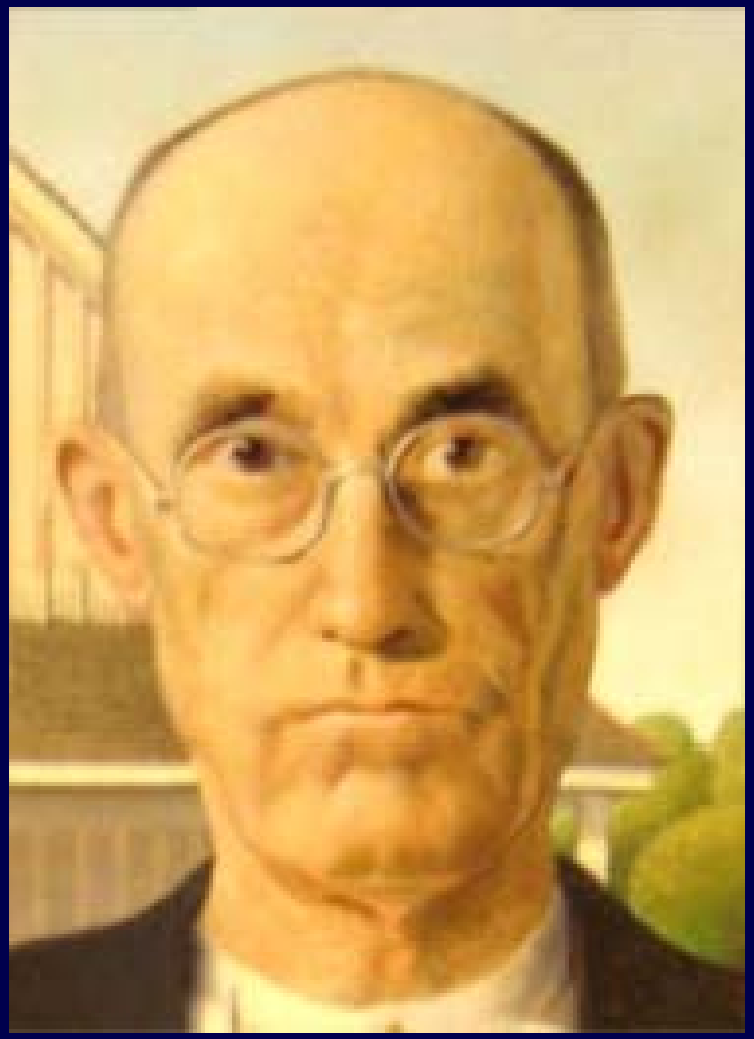
Neth & Martinez, Vision Research, 2010

Computational Space



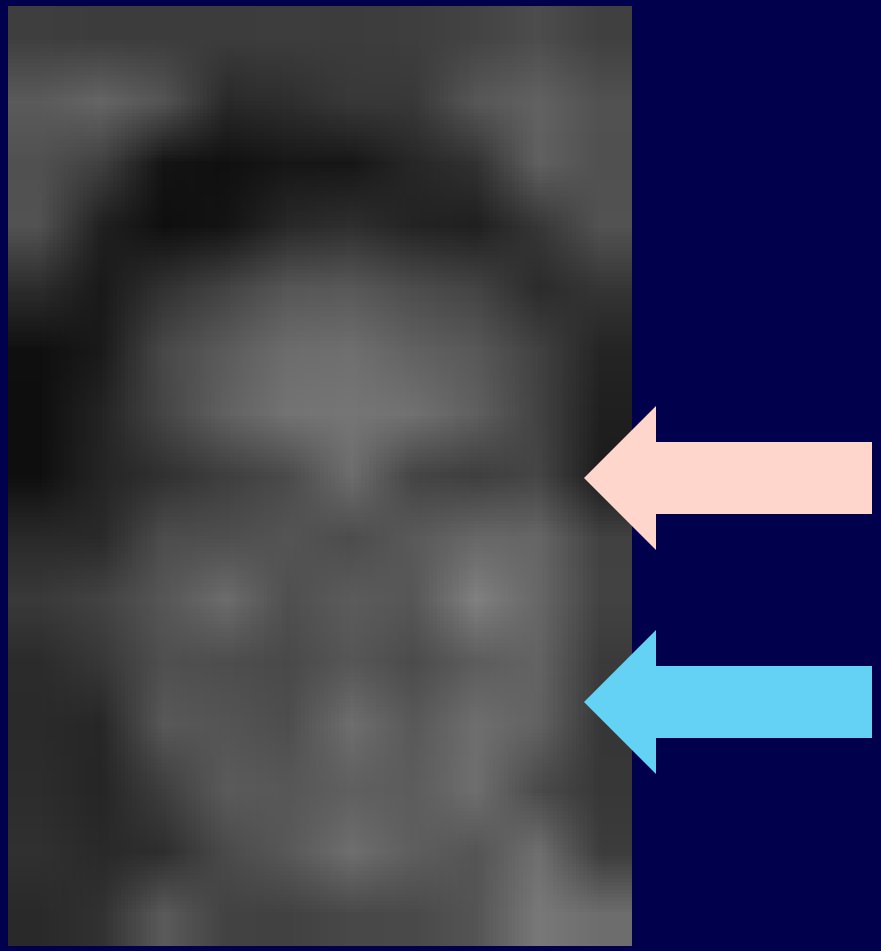
Neth & Martinez, Vision Research, 2010

American Gothic Illusion



Neth & Martinez, Vision Research, 2010

Why Configural Features?



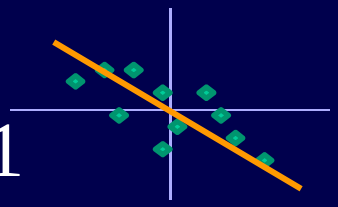
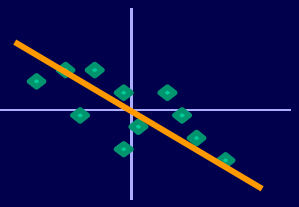
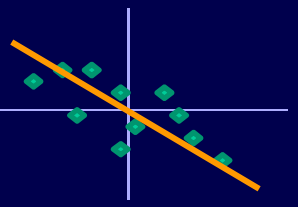
15 x 10 pixels

Why Configural cues?

sad neutral angry

Neth & Martinez, Vision Research, 2010; Du & Martinez, 2011

Proposed Hybrid Model: Recognizing other emotion labels

c_1  + c_2  + … + c_n 

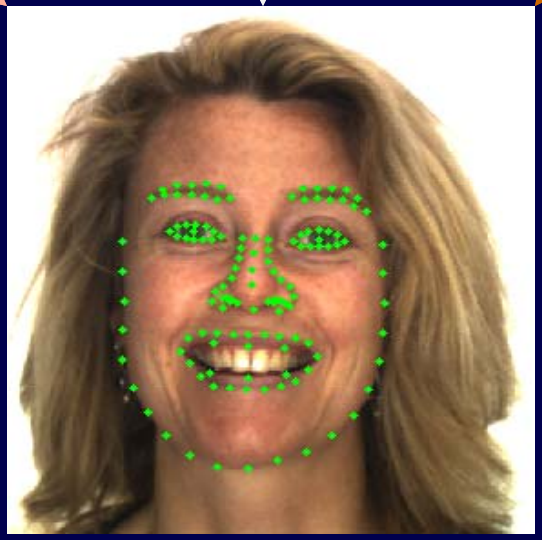
Happily surprised

Angrily surprised

Martinez, CVPR, 2011

Configural Processing = Precise detection of facial features

3,930 images



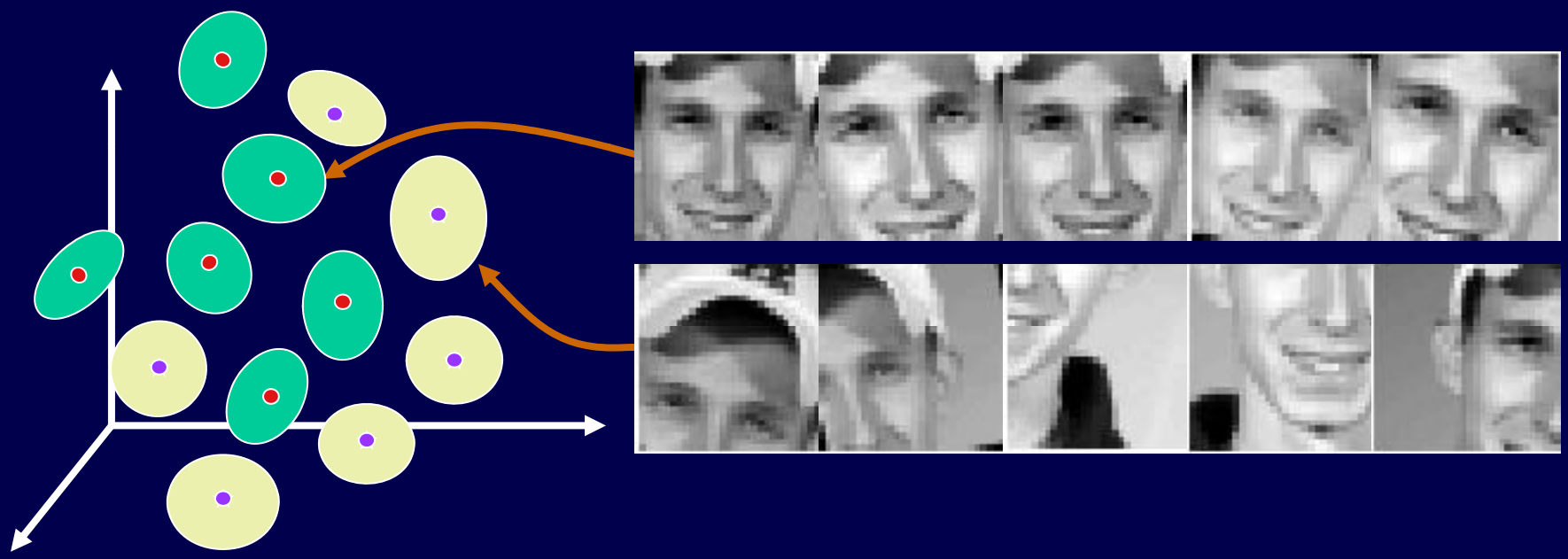
4.2 pixels error (1.5%)

Ding & Martinez, PAMI, 2010

Face Detection

Features VS context

Observation: Most detections are near the correct location – they are not incorrect, they are *imprecise*.



Key idea: Use context information to train where **not** to detect faces and facial features.

Ding & Martinez, CVPR, 2008; PAMI, 2010

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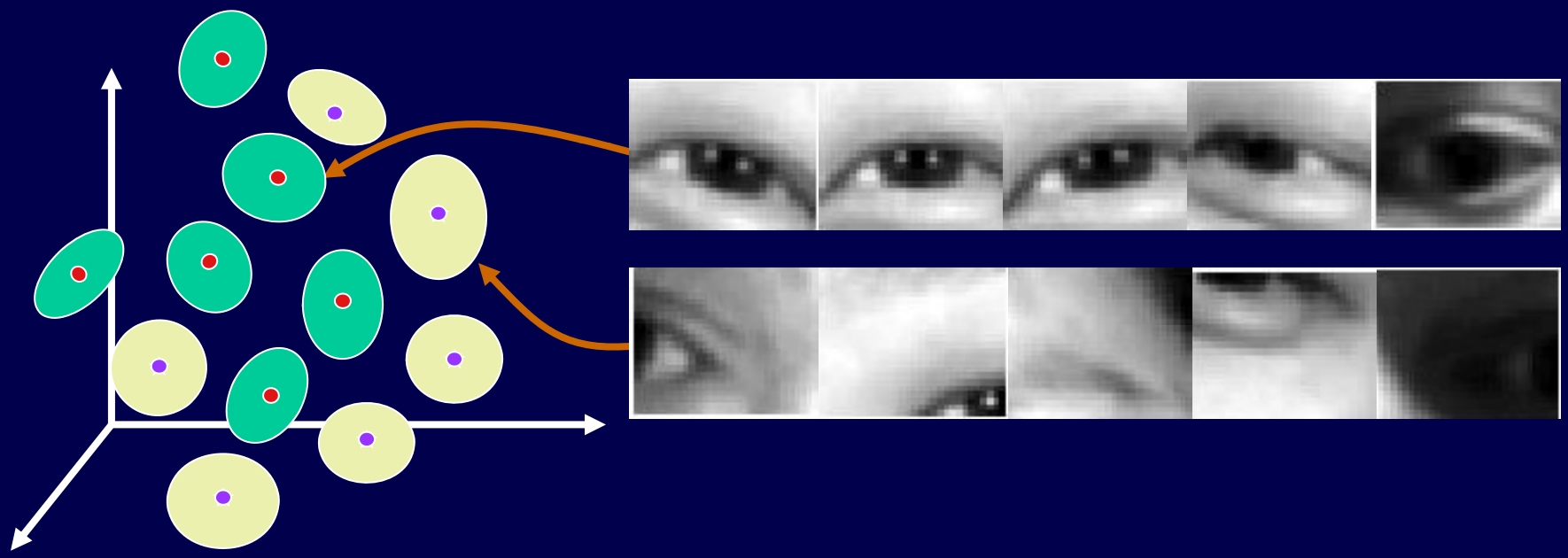

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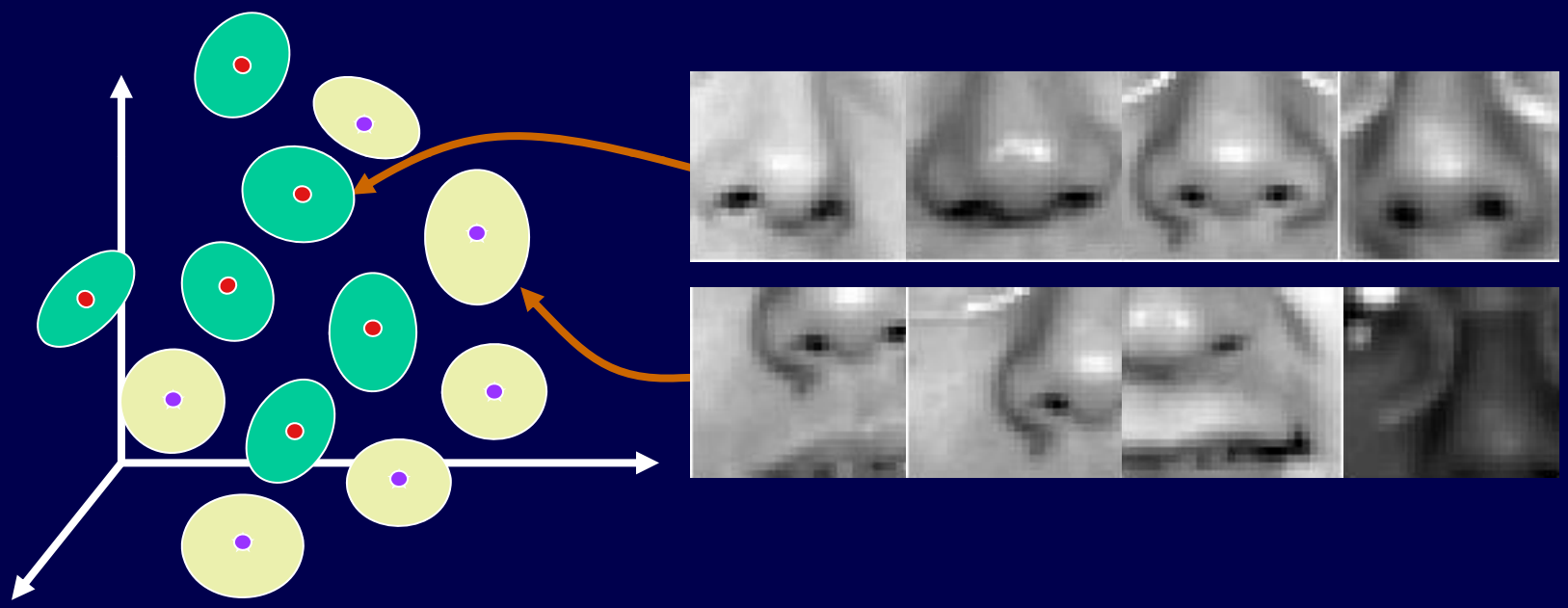


Key idea: Use context information to train where **not** to detect faces and facial features.

Ding & Martinez, CVPR, 2008; PAMI, 2010

Subclass Discriminant Analysis

Between-subclass scatter matrix:

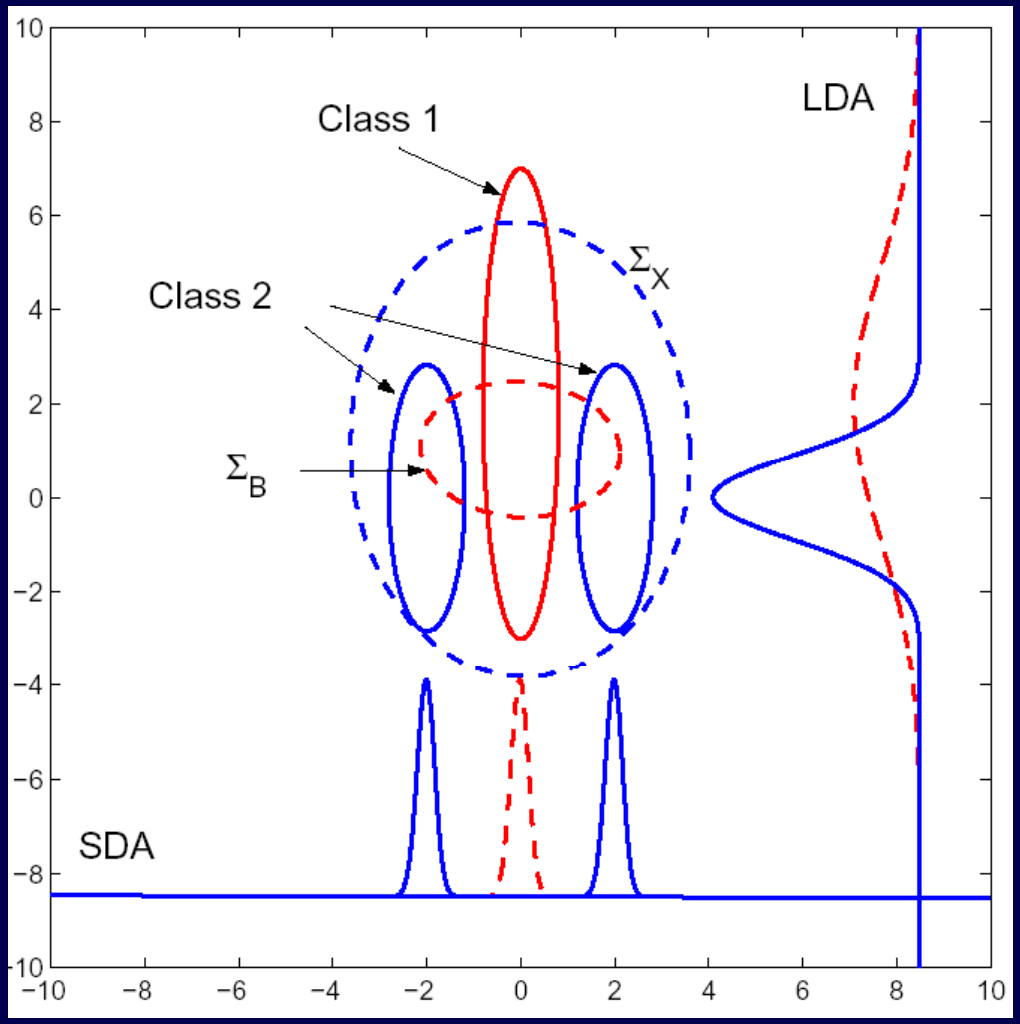
$$\mathbf{\Sigma}_B = \sum_{i=1}^{C}\sum_{j=1}^{H_i} p_{ij}\left(\mu_{ij}-\mu\right)^T\left(\mu_{ij}-\mu\right).$$

Basis vectors:

$$\mathbf{\Sigma}_B\mathbf{V} = \mathbf{\Sigma}_X\mathbf{V}\mathbf{\Lambda}.$$

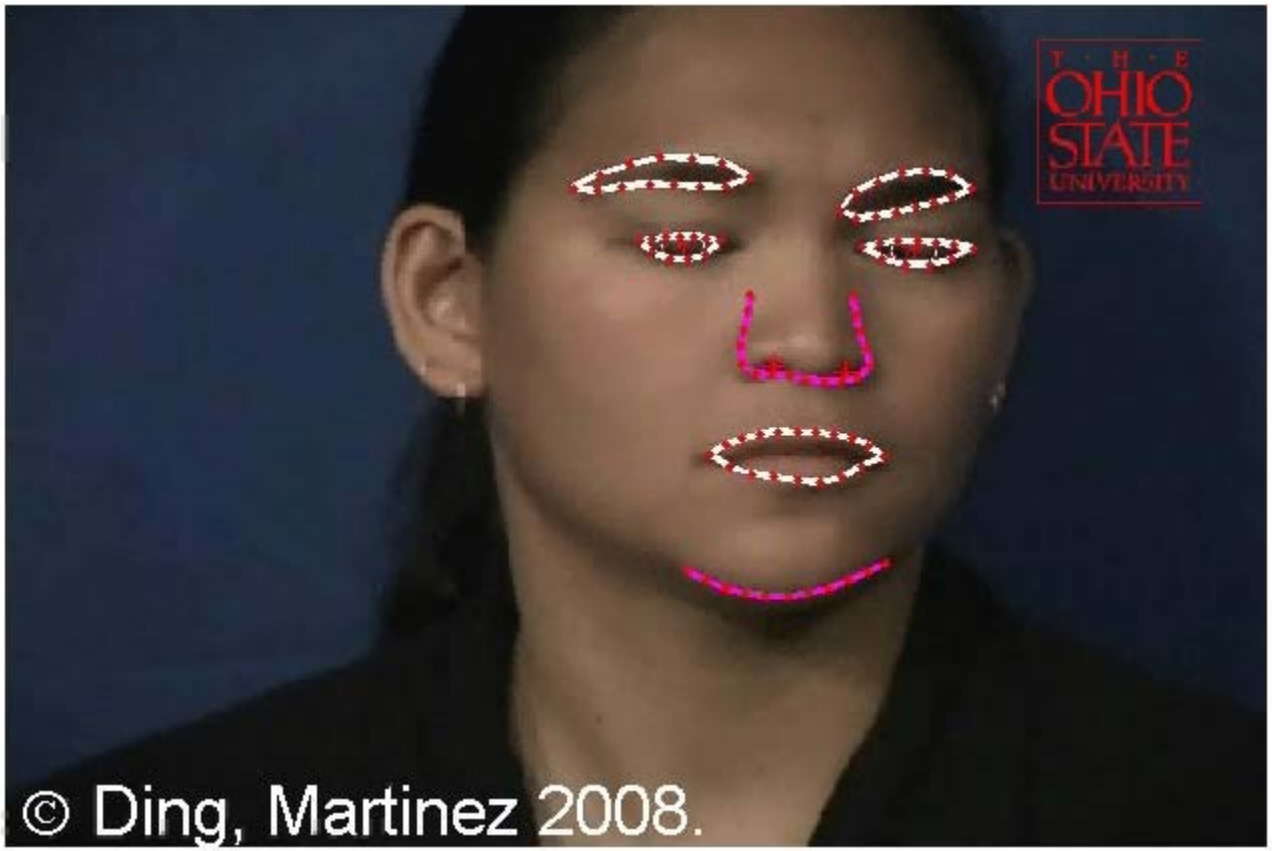
How many subclasses (H):

Minimize the conflict, *K*.



Zhu & Martinez, PAMI, 2006

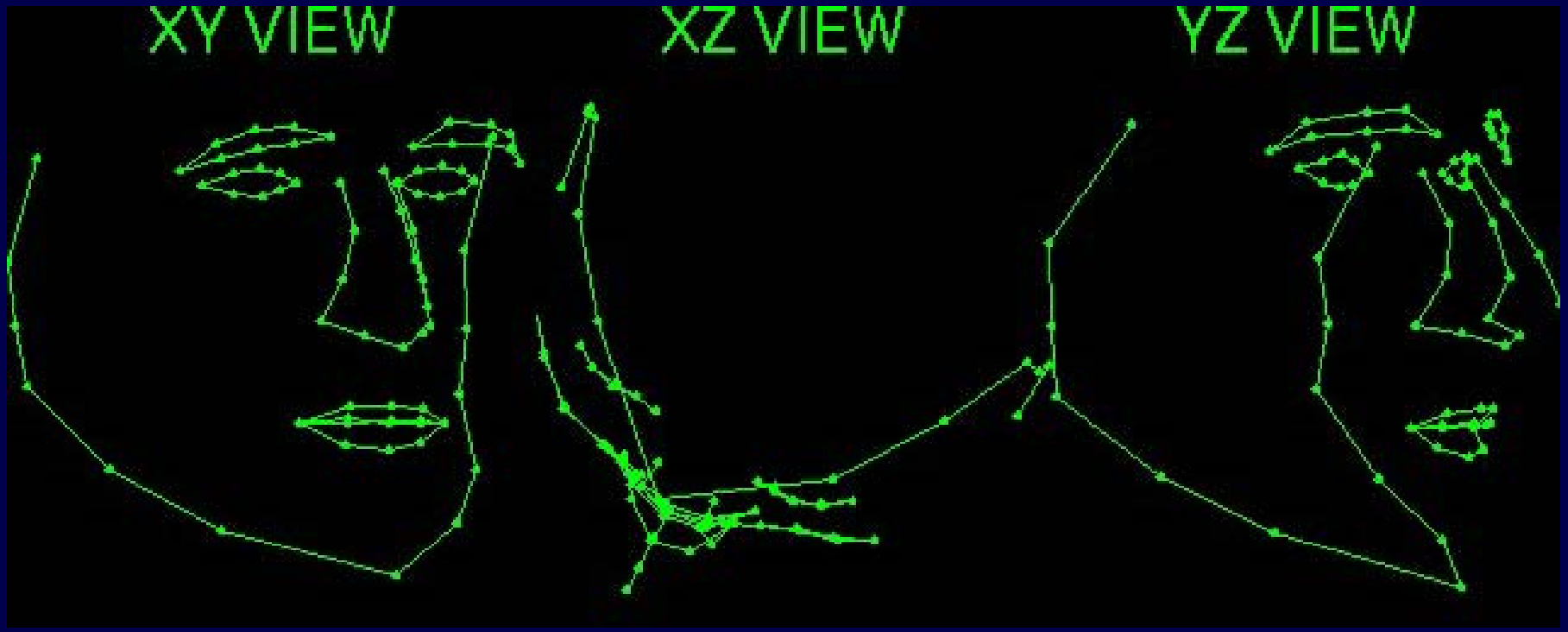
Precise Detailed Detection



Error: 6.2 pixels (2%) **vs** Manual: 4.2 (1.5%)

Ding & Martinez, CVPR, 2008; PAMI, 2010

Detection + non-rigid SfM



Gotardo & Martinez, PAMI, 2011; Gotardo & Martinez, CVPR, 2011.

Take Home Messages

- What is the form of the computational space in human face perception? Linear combination of known categories.

c_1  + c_2  + … + c_n 

- What are the dimensions? Mostly **configural**.
- **Precise detection of facial features**.

CBCSL

Paulo Gotardo, Shichuan Du, Don Neth, Liya Ding, Onur Hamsici, Samuel Rivera, Fabian Benitez, Hongjun Jia, Di You.

National Institutes of Health
National Science Foundation