Developmental Model of Face and Object Recognition Using Modular Neural Network

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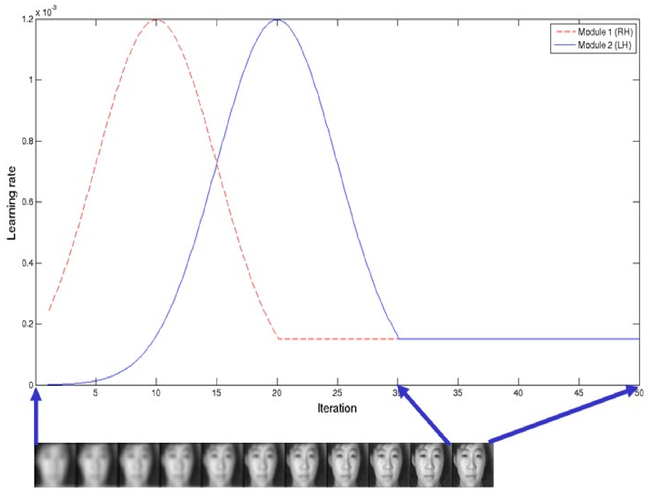
Temporal Dynamics of Learning Center

Introduction

We propose a neurocomputational model account for the development of hemispheric asymmetry of face processing. This is the first object recognition model that combines both structural and temporal constraints based on brain development. The two developmental constraints we consider are:

- **The right hemisphere (RH) develops earlier and faster than the left hemisphere.**
- **The visual acuity of human children develops slowly over years of age.**

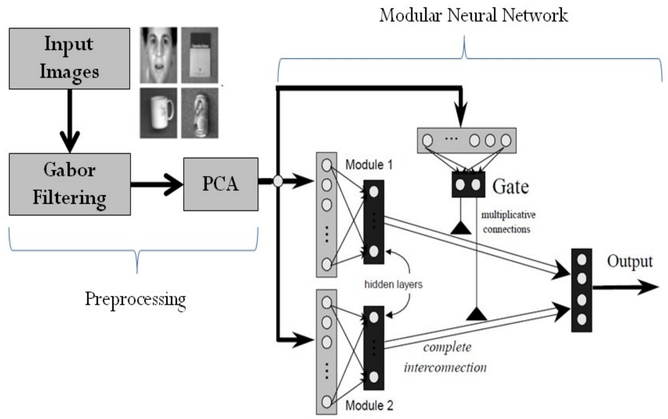
We combine these with the constraint that the infant is driven to differentiate its parents and other family members.



Based on a mixture of experts neural network model, we successfully show that the strong RH and low spatial frequency bias for face recognition emerges naturally from these three constraints.

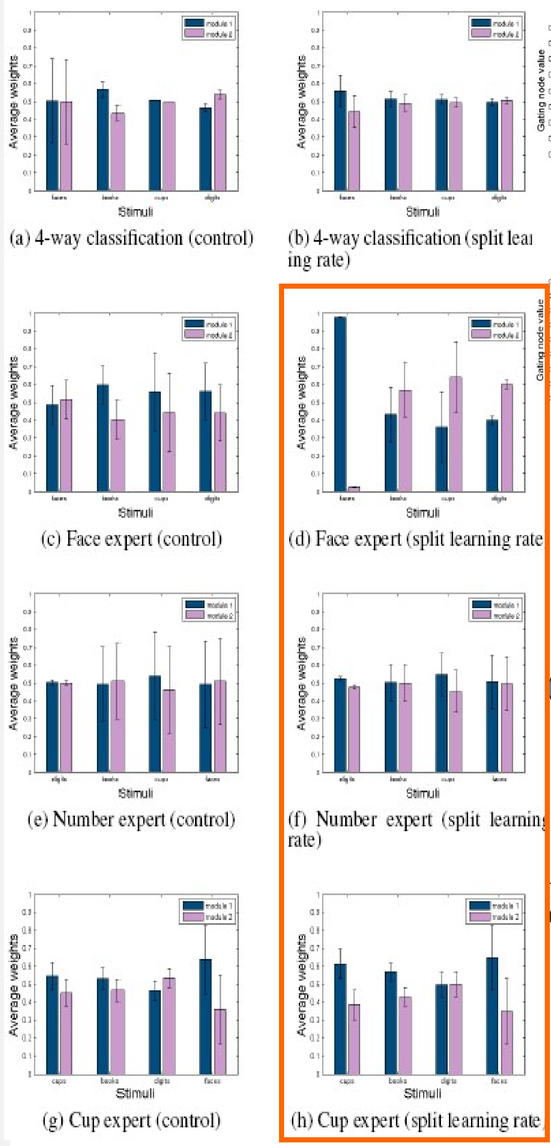
Methods

The Model:



- **Stimuli are preprocessed through Gabor filter banks with 5 scales and 8 orientations, followed by PCA on each orientation, resulting in 40-dimensional vector for each image.**
- **Each module represents one hemisphere, the gating nodes modulate the output based on the contribution of each module.**
- **Using online backpropagation in network training, we record the softmax output of the gating nodes, which represent the contributin of each module**
- **We perform three experiments: 4-way classification, subordinate classification on faces and non-faces (books, cups, digits).**

Results



(a) 4-way classification (control)

(b) 4-way classification (split learning rate)

(a) Face expert

(b) Book expert

(c) Face expert (control)

(d) Face expert (split learning rate)

(c) Cup expert

(d) Number expert

(e) Number expert (control)

(f) Number expert (split learning rate)

(g) Cup expert (control)

(h) Cup expert (split learning rate)

Top: Gating node value vs. Training iterations
Left: Gating node value in different experiments
Bottom: Relationship between age of CSF maturity and RH bias

Table 1: Relationship between age of contrast sensitivity matures and the RH bias for face recognition

"Age"	RH Value	std(RH)	LH Value	std(LH)
6	0.7908	0.0908	0.2654	0.0968
8	0.8088	0.0269	0.1912	0.0269
10	0.8989	0.0241	0.1011	0.0333
12	0.8467	0.1042	0.1533	0.0709
14	0.8352	0.0533	0.1648	0.0525

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Conclusion

We built a face and object recognition model using a developmentally inspired implementation. We showed that the strong RH and low spatial frequency lateralization for face recognition is driven by the two developmental constraints, as well as the task of individuate different faces.