Talk 307

A model-based investigation of face processing in autism

(NIMH R01-MH076281 FY 05)

Maximilian Riesenhuber
Georgetown University Medical Center

Tom Zeffiro
Georgetown University Medical Center

Recognizing objects is a fundamental cognitive ability, e.g., for reading or social communication, and its loss or impairment is associated with a number of neural disorders. For example, many studies have shown that individuals with Autism Spectrum Disorder (ASD) are impaired in face recognition, possibly contributing to their difficulty in social interaction. Differences in social cognition are one of the defining features of autism. However, the precise nature of the differences in the neural mechanisms of face processing seen in autism has been difficult to study and its relationship to social behavior is unknown. While our understanding of the network of brain areas underlying human face perception has advanced considerably, current models are still qualitative and treat processing within specific brain areas as "black boxes". To understand the graded (rather than all-or-none) recognition deficits and to identify targets for therapeutic intervention, a quantitative and mechanistic model of the neural computations underlying face perception is required that rigorously links visual stimuli to neural activation and behavior. The purpose of the proposed project is to explore the neural mechanisms of face processing in typically developing and autistic individuals using an integrated approach based on a tight interaction of computational modeling of neural processing in the brain areas underlying human face recognition and of model-driven behavioral and fMRI experiments. In particular, the model motivates experiments to probe the face representation in typically developing and ASD subjects, and to mechanistically link differences in behavior and fMRI to differences at the level of neural processing – providing insight into the neural causes of the observed face recognition deficits along with an opportunity to evaluate current theories of neural processing differences in ASD. In a second part of the study, the model will drive experiments to study high-level plasticity and perceptual learning in typically developing and autistic individuals. This will not only leverage the insights from face perception to explore more general differences between the two subject groups, but is also expected to provide a foundation for remediation efforts. The relevance of this research to public health lies in its direct application of the results of this research program to achieve a better understanding of impairments found within and outside the autism spectrum.

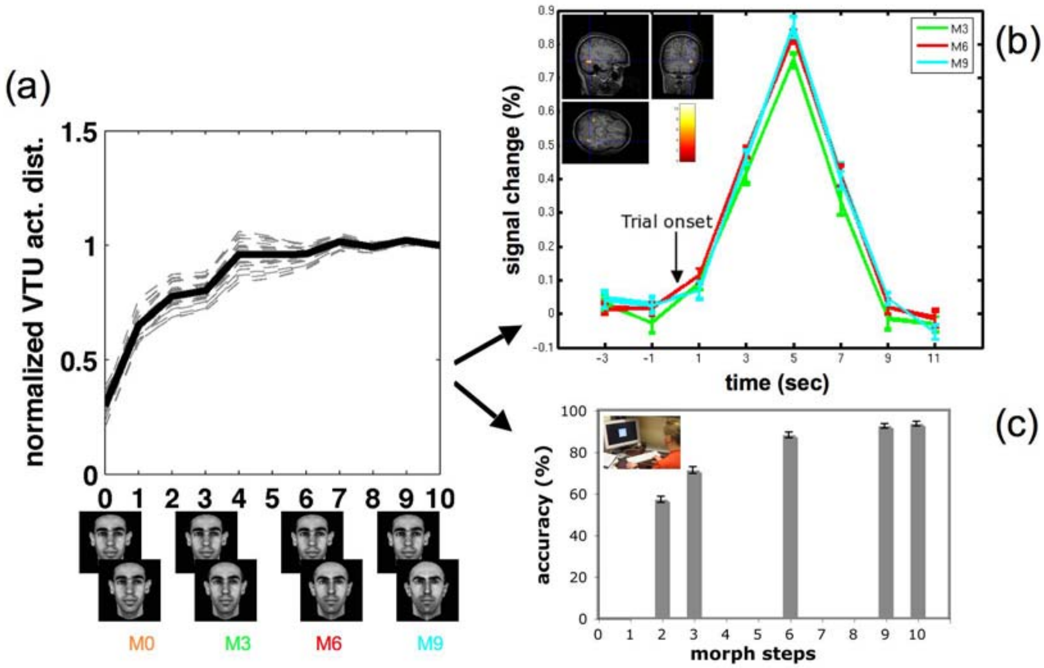

Figure 1: Illustration of the project's integrative approach. Existing experimental data on face perception in monkeys and humans from physiology, fMRI, and behavior serve to constrain parameters for "face neurons" in the computational model of object recognition. The model then is used to generate quantitative predictions at different levels of description. For instance, by calculating differences in activation patterns over model face neurons for pairs of faces of varying similarity ***(a)****, predictions can be derived for fMRI and behavior (face images were created using a photo-quality computer graphics morphing system (Vetter & Blanz 1999), which allowed us to create intermediate morphs from pairs of original faces; in the experiments here, there were nine intermediate morphs, creating 10 "morph steps" from the first to the second original face). In the example, the model was used to predict how well subjects would be able to discriminate pairs of faces of varying similarity, and how activation in the "Fusiform Face Area", FFA, a region in the human brain thought to be crucial for face perception, depends on the similarity of the faces in a pair. In particular, the model predicts a rapid rise in BOLD response and discrimination performance for small shape differences and asymptotes in BOLD and behavior for pairs differing by six morph steps for fMRI and behavior. These highly nontrivial predictions were tested using fMRI (****b** *– inset shows FFA) and behavioral* ***(c)*** *paradigms (Jiang* et al., Neuron, 2006). *The experimental data agree well with the model predictions, indicating that the computational model can be used to mechanistically link neural activation, BOLD contrast in fMRI, and behavior. In a next step, we plan to apply the model-based approach "in reverse" to link behavioral deficits in face perception, as found autism, to hypotheses about processing differences at the neural level.*

Project (or PI) Website

http://maxlab.neuro.georgetown.edu

Publications

1. Jiang X, Rosen E, Zeffiro T, Van Meter J, Blanz V, Riesenhuber M. Evaluation of a shape-based model of human face discrimination using FMRI and behavioral techniques. Neuron **50,** 159-72 (2006). >