Distinct Neural Network Dynamics Underlie the Visual Processing of Faces in Autistic Individuals

William E Carson IV[1]* (william.carson@yale.edu), J Wolf[1]*, AJ Naples[1]*, JC McPartland[1,2]*

[1]Yale Child Study Center, Yale School of Medicine, [2]Center for Brain and Mind Health, Yale School of Medicine, *Yale University

Background

The visual processing of faces is critical to the development of social relationships and recognition of emotional states, intentions, and identities [1]. Characterizing the neural response to faces could provide key insights into the neural dynamics underlying social communication differences in autistic individuals [2].

Goal: Model-driven and data-driven characterization of brain dynamics underlying the visual processing of faces.

- **Model-driven:** Use a custom machine learning approach to characterize neural activity in terms of brain *networks* that change in expression in response to visual stimuli.
- **Data-driven:** Evaluate the relevance of all learned brain networks to autism diagnosis.

Methods

Cohort: 90 participants, 51 autistic (23.1 ± 9.1 years), 39 non-autistic (21.1 ± 9.3 years)

Data: 19-channel electroencephalographic (EEG) data collected while participants are shown images of faces or houses (control).

Approach:

1) Use a machine learning approach to identify networks of brain activity strongly represented in the EEG signal, defined in terms of spatial and spectral (i.e., frequency-based) properties.
2) Reference existing literature to interpret brain network dynamics.
3) Perform statistical analyses to determine differences in peak brain network expression in autistic individuals.

Results

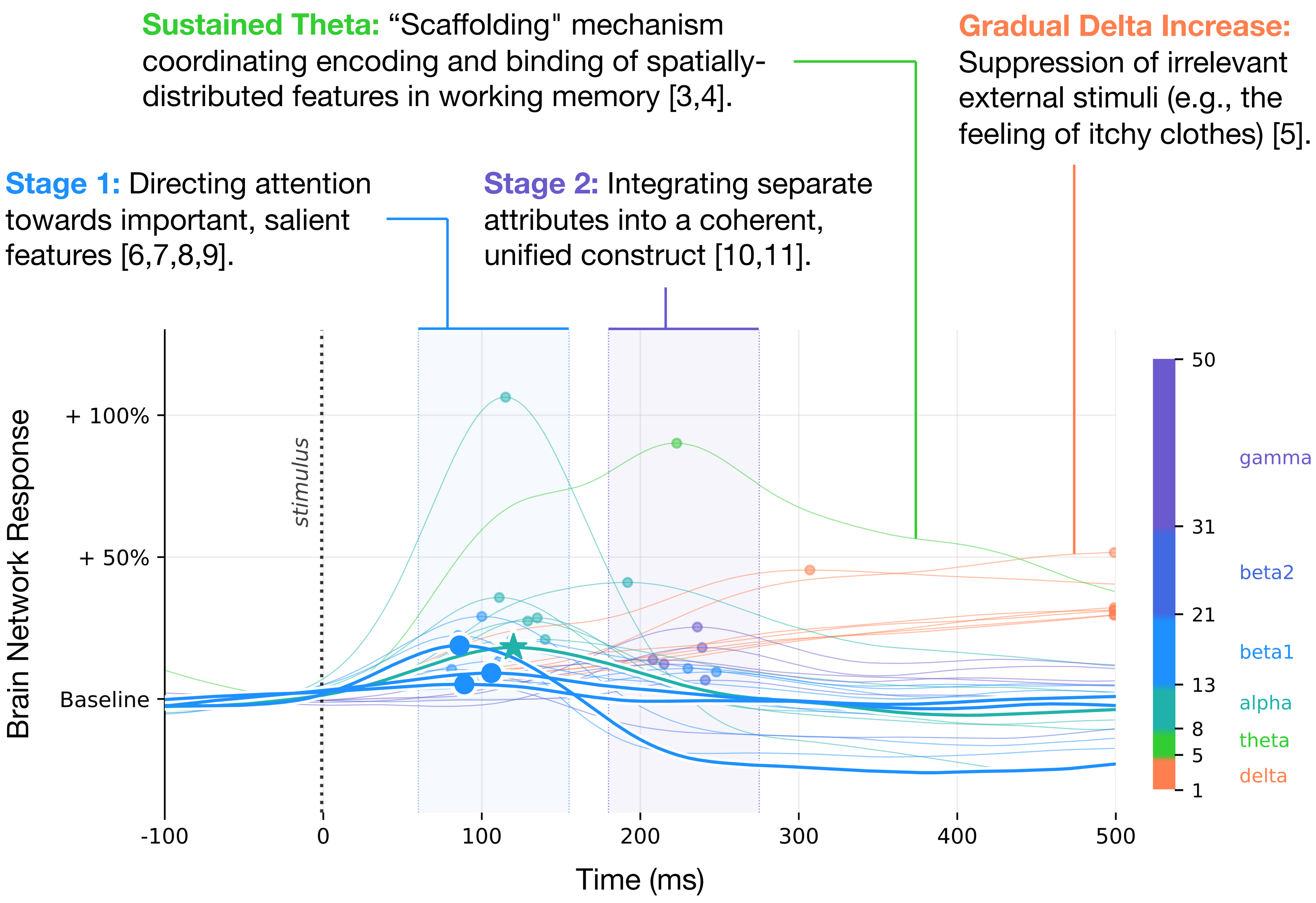

Figure 1: Autistic neural responses to faces. Grand-average of brain network responses to faces of autistic individuals (*n* = 51*).* Trajectories are colored according to the dominant frequency of the network (color bar to the right of plot). Circles indicate peak post-stimulus network expression. Network trajectory peaks group together in two separate stages, indicating a temporal organization of the visual encoding process. Trajectories with thicker lines indicate networks that were significantly lower in expression in autistic individuals.

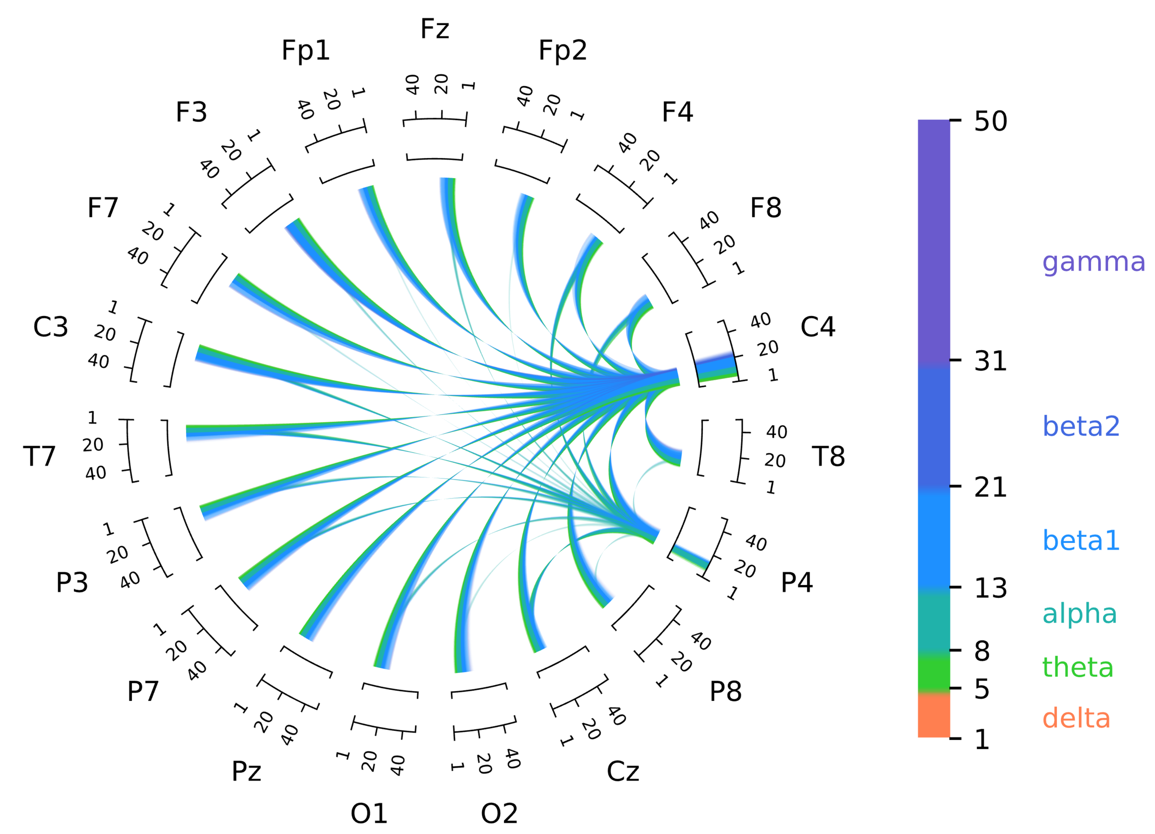

Figure 2: Parietal alpha network. Brain network with a 10 Hz dominant frequency, activity in right parietal regions. Autistic individuals exhibited significantly lower peak activity (indicated by a star in Figure 1) in response to faces than non-autistic individuals.

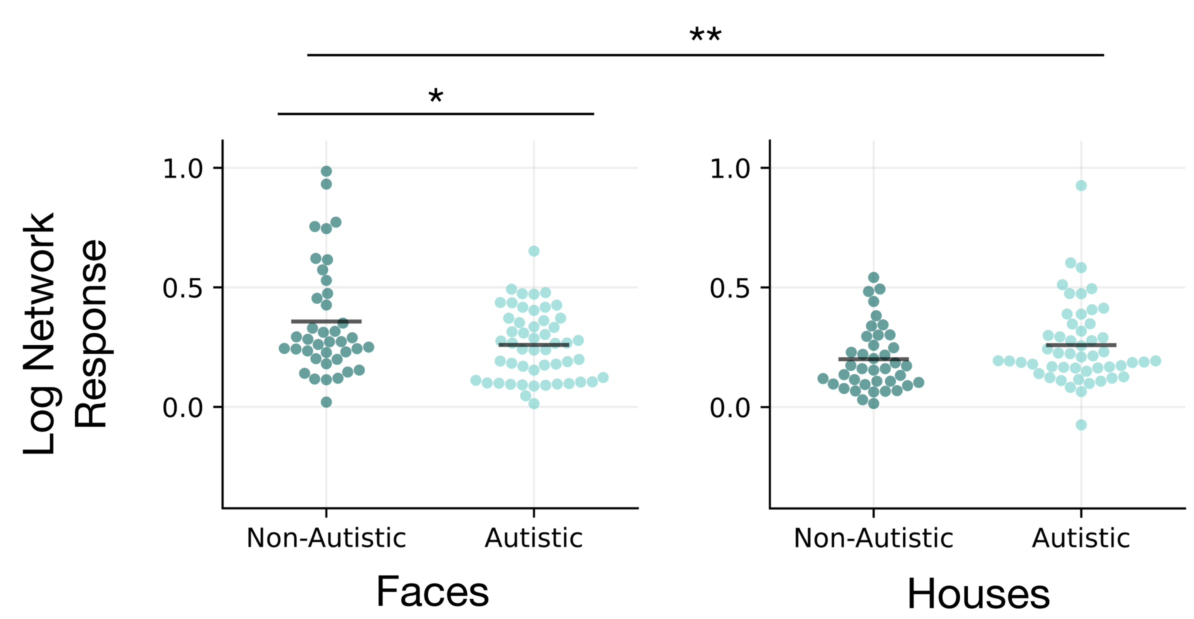

Figure 3: Network response to visual stimuli. Autistic individuals exhibit a significantly lower responses of a parietal alpha network (Figure 2) to faces (left) and an increased response to houses (right). Each point represents the average response of this network for a single participant.

Conclusions

Conclusion: Autistic individuals exhibit *distinct neural dynamics* during the visual processing of faces, specifically, lower expression of brain networks with:

- **Spatial properties:** Activity in central/parietal regions.
- **Spectral properties:** Frequencies in alpha (8-12 Hz) and beta (13-30 Hz) ranges.
- **Temporal properties:** Peak expression in earlier stages of visual processing related to directing attention towards salient features [6,7,8,9].

Implications: This work could provide data-driven tools for navigating autism heterogeneity, e.g., using brain networks as neurobiologically-grounded strata.

References: **[1]** Todorov et al. (2015). Social attributions from faces. *Annual Review of Psychology*. **[2]** Dawson et al. (2005). Understanding the nature of face processing impairment in autism. *Developmental Neuropsychology*. **[3]** Klimesch (1999). EEG alpha and theta oscillations reflect cognitive and memory performance. *Brain Research Reviews*. **[4]** Bastiaansen et al. (2002). Event-related alpha and theta responses. *Clinical Neurophysiology*. **[5]** Harmony (2013). The functional significance of delta oscillations. *Frontiers in Integrative Neuroscience*. **[6]** Klimesch (2012). Alpha-band oscillations, attention, and controlled access to stored information. *Trends in Cognitive Sciences*. **[7]** Klimesch et al. (2007). The inhibition–timing hypothesis. *Brain Research Reviews*. **[8]** Schmidt et al. (2019). Beta oscillations in working memory. *The Journal of Neuroscience*. **[9]** Lundqvist et al. (2024). Beta: bursts of cognition. *Trends in Cognitive Sciences*. **[10]** Herrmann et al. (2010). Human gamma-band activity. *Neuroscience & Biobehavioral Reviews*. **[11]** Meador et al. (2002). Gamma coherence and conscious perception. *Neurology*.

Funding: Hilibrand Foundation, Autism Speaks Translational Postdoctoral Fellowship (Naples), CTSA UL1 RR024139 (McPartland), NIMH K23 MH086785(McPartland), NIMH R01 MH100173 (McPartland), NIMH R01 MH107426 (McPartland, Srihari), NIMH R21 MH091309 (McPartland), Patterson Trust 13-002909 (McPartland), Waterloo Foundation 1167-1684 (McPartland).

McPartland Lab
Website: mcp-lab.org
Email: mcp.lab@yale.edu