Resting Gamma Power Associates with Expressive Language Skills in Autistic Youth

McPartland Lab
Yale Child Study Center

Kannan, S., Naples, A., Cairney, B., & McPartland, J.

YALE CHILD STUDY CENTER
Where discovery inspires care

Background

- High-frequency oscillations between 30–45 Hz (i.e., gamma) are associated with language ability and higher-order cognition.[1]
- Gamma oscillations display a pattern of developmental maturation, increasing rapidly during early life to promote cognitive development, slowing in adolescence, and decreasing in advanced age in neurotypical individuals.[2]
- Reduced frontal gamma power has been observed to correlate with expressive language skills and language learning in autistic children.[3, 4]
- However, whether gamma is elevated or reduced in autism is debated, and its development in autistic children is unclear.[5]

Objective

- Examine the relationship between development, expressive language abilities, and gamma power during resting-state EEG in autistic and neurotypical children.

Methods

Participants

- Resting EEG data was collected from 25 autistic (6–18 years; *M*=11.3, *SD*=3.7) and 16 neurotypical (6-18 years; *M*=11.2 *SD*=3.3) children.
- Participants in both groups had an IQ≥70 and did not differ on IQ or age.

Clinical Measures

- Expressive language skills were determined via parent-report on the Vineland Adaptive Behavior Scales-3.[6]
- Autism symptoms were quantified using the Autistic Diagnostic Observation Schedule, Second Edition (ADOS-2) Comparison Score.[7]
- IQ was measured using Differential Abilities Scale-II (DAS-II) and the Wechsler Abbreviated Scale of Intelligence-II (WASI-II).[8, 9]

EEG Acquisition and Pre-Processing

- Data were recorded at 1000 Hz using 128-channel HydroCel Geodesic Sensor Nets.
- Raw data was pre-processed using the Harvard Automated Processing Pipeline for Electroencephalography.[10] Power in the lower gamma frequency band (30-45 Hz) was averaged across all electrodes.

Analysis

- A Welch's Two Sample *t*-test was conducted to examine whether average gamma power across electrodes differed significantly between the two diagnostic groups. For autistic participants, Pearson product-moment correlations were applied to examine the relationship between gamma power and expressive language skills.

Results

Autistic participant demographics

n = 25	M	SD
Age	11.3 years	3.7
Full Scale IQ	111.8	17.3
Sex	**n (%)**	
Male	22 (88%)	
Female	3 (12%)	

Neurotypical participant demographics

n = 16	M	SD
Age	11.2 years	3.3
Full Scale IQ	117.1	10.1
Sex	**n (%)**	
Male	14 (87%)	
Female	2 (13%)	

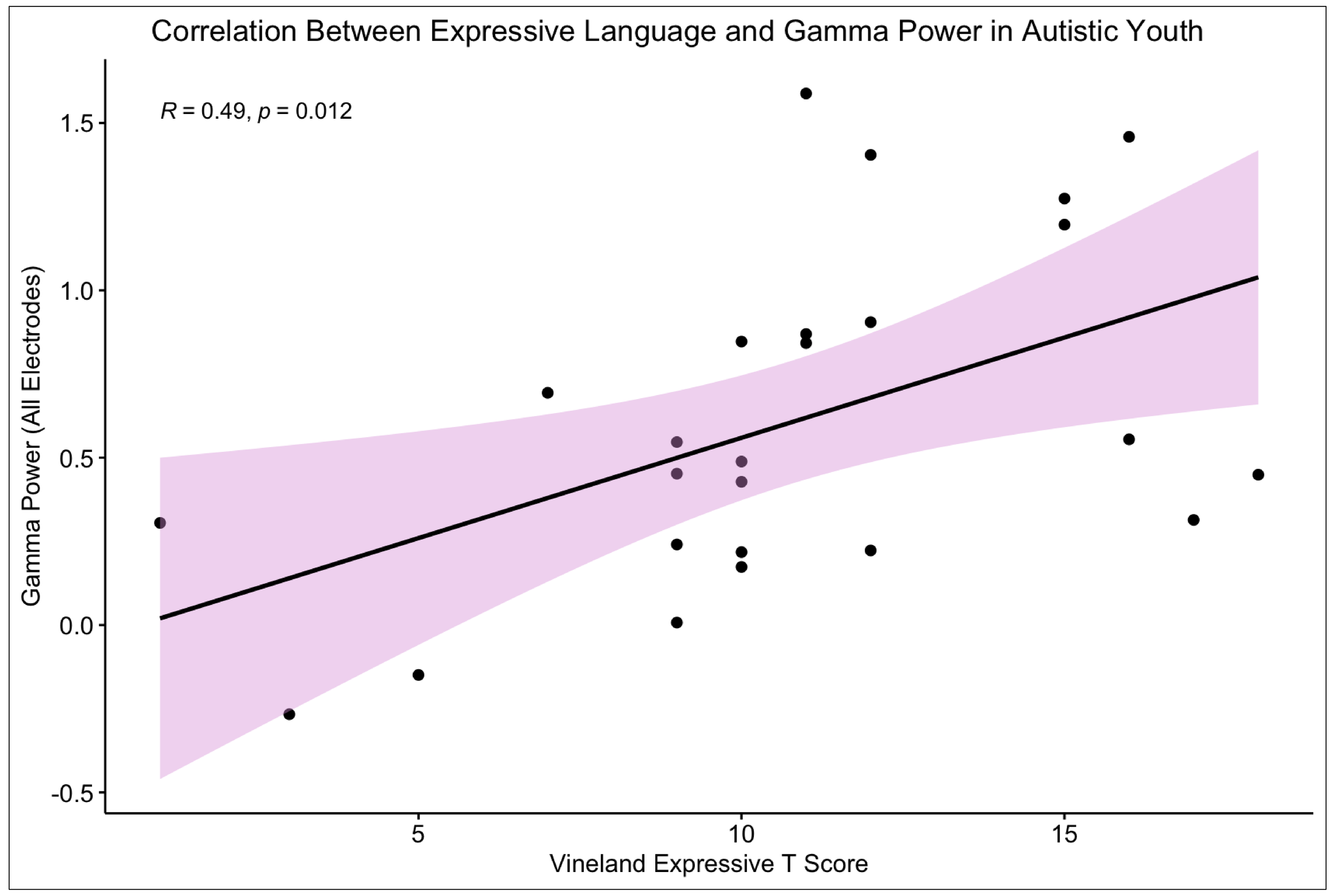

Figure 1. Vineland Expressive T Scores positively correlated with gamma power over all electrodes during resting state EEG among autistic participants such that stronger expressive language skills were associated with greater gamma power.

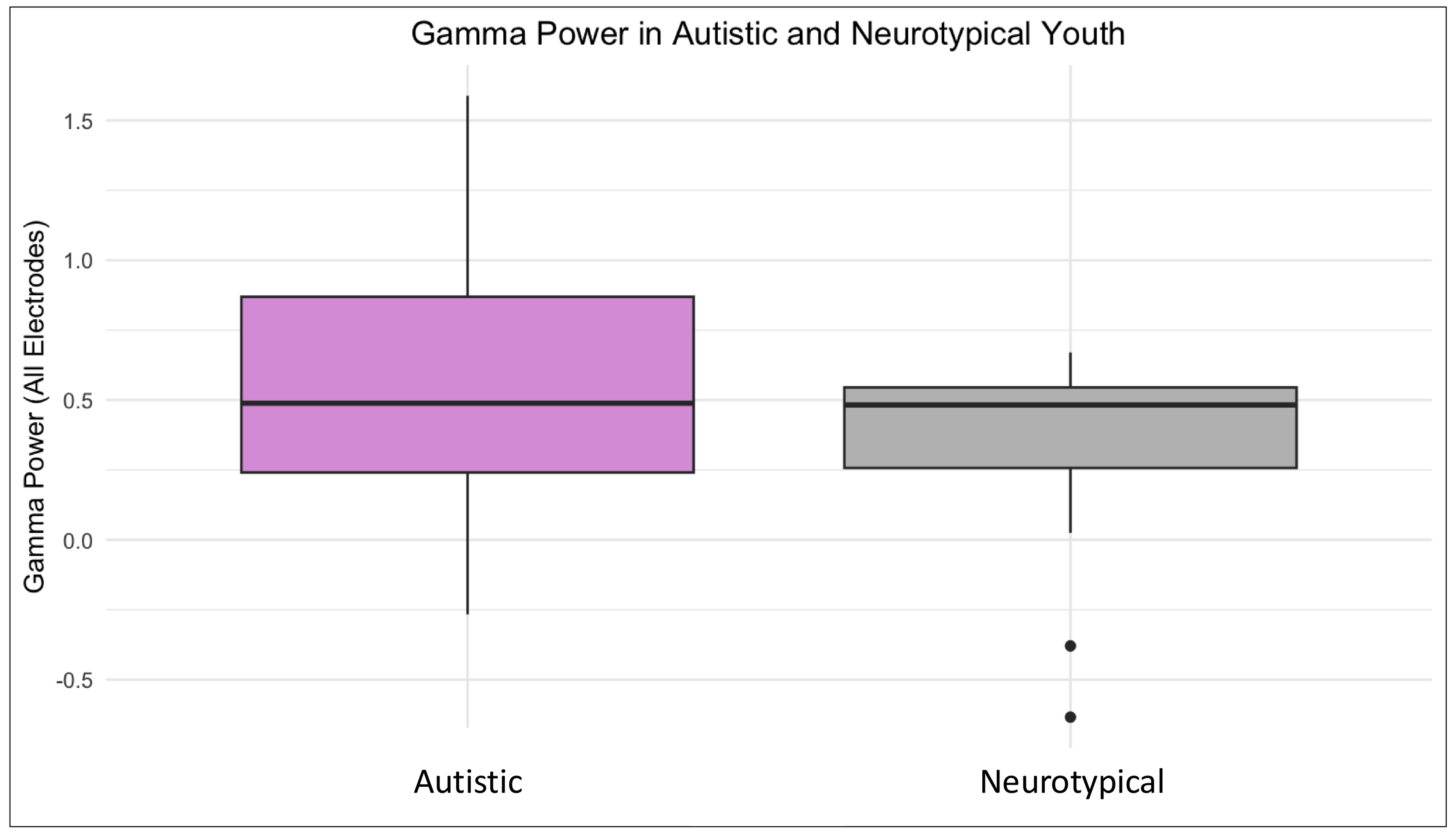

Figure 2. Autistic youth had elevated gamma power over all electrodes compared to the neurotypical group.

Results

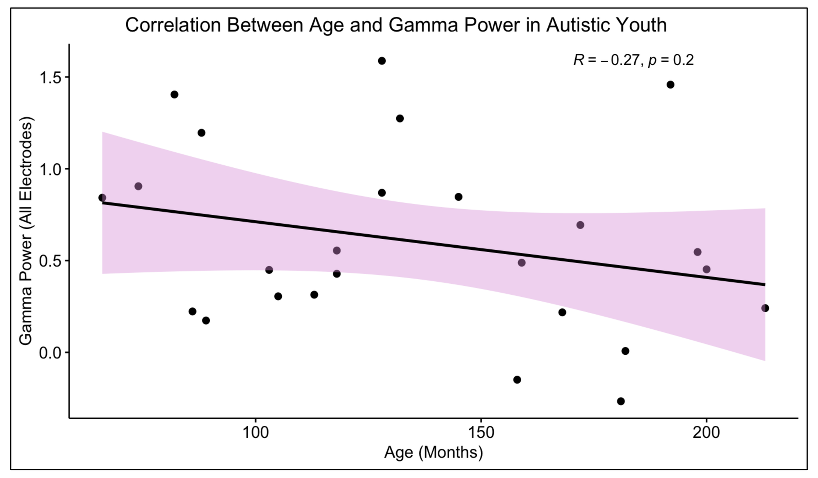

Figure 3. Gamma power over all electrodes decreased with age in autistic youth.

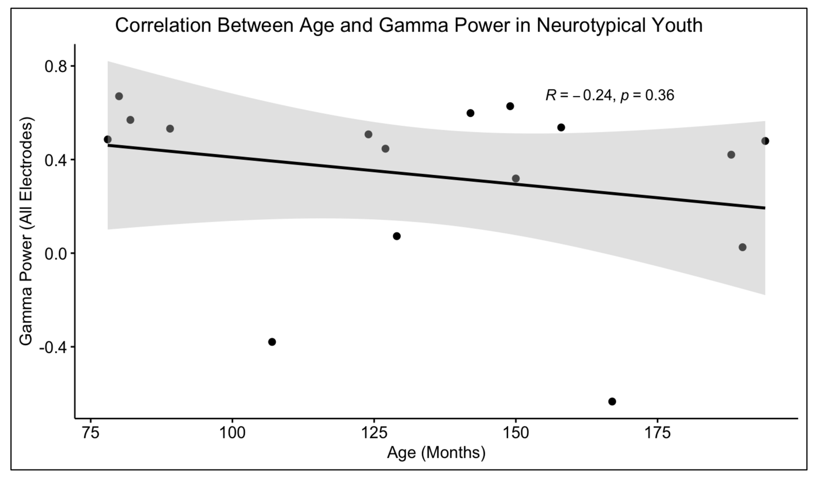

Figure 4. Gamma power over all electrodes decreased with age in neurotypical youth.

- In the autistic group, gamma power positively correlated with expressive language skills on the Vineland, $r = .49$, $p = .01$ (Fig. 1).
- Autistic youth had elevated gamma over all electrodes compared to neurotypical children, $t(37.88) = 1.99$, $p = .05$, Cohen's $d = 0.59$ (Fig. 2).
- Gamma power over all electrodes decreased with age in both groups. Autistic: $r = -.27$, $p = .2$ (Fig.3); neurotypical: $r = -.24$, $p = .36$ (Fig. 4).
- There was no correlation between gamma and expressive language in the neurotypical group.

Conclusion

- As expected based on prior research, gamma power decreased with age in both groups, and was elevated overall in autistic compared to neurotypical children, potentially reflecting differences in attention, perception, and learning.
- Contrary to prior research, gamma power was *positively* associated with expressive language skills in the autistic group.
- This positive correlation might indicate more effective neural communication within language-related networks in the brain. However, this relationship could also be influenced by other factors, such as individual differences in brain development or neural plasticity.
- Future studies with larger samples and constrained developmental ranges may further clarify the relationship between gamma power, development, and language abilities in autism.

References

1 Kaiser J, Lutzenberger W. Human gamma-band activity: a window to cognitive processing. Neuroreport. 2005 Feb 28;16(3):207-11. 2 Cho KK, Hoch R, Lee AT, Patel T, Rubenstein JL, Sohal VS. Gamma rhythms link prefrontal interneuron dysfunction with cognitive inflexibility in Dlx5/6(+/-) mice. Neuron. 2015 Mar 18;85(6):1332-43.3 Mukerji CE, Wilson JS 3rd, Wilkinson CL, Krol MA, Nelson CA, Tager-Flusberg H. Resting Frontal Gamma Power is Associated with Both Expressive Language and Non-verbal Cognitive Abilities in Young Autistic Children. J Autism Dev Disord. 2024 Apr 12. 4 Arutiunian, V., Santhosh, M., Neuhaus, E. *et al.* The relationship between gamma-band neural oscillations and language skills in youth with Autism Spectrum Disorder and their first-degree relatives. *Molecular Autism* **15**, 19 (2024). 5 Rojas DC, Wilson LB. γ-band abnormalities as markers of autism spectrum disorders. Biomark Med. 2014;8(3):353-68. 6 Sparrow, S. S., Cicchetti, D. V., & Saulnier, C. A. (2016). Vineland Adaptive Behavior Scales (3rd ed.). Pearson. 7 Lord, C., Rutter, M., Goode, S., Heemsbergen, J., Jordan, H., Mawhood, L., & Schopler, E. (1989). Autism Diagnostic Observation Schedule (ADOS) [Database record]. PsycTESTS. 8 Elliott, C. D. (2007). Differential Ability Scales – Second Edition (DAS-II). San Antonio, TX: Harcourt Assessment. 9 Wechsler, D. (2011). Wechsler Abbreviated Scale of Intelligence--Second Edition (WASI-II) [Database record]. APA PsycNET. 10 Gabard-Durnam, L. J., Mendez Leal, A. S., Wilkinson, C. L., & Levin, A. R. (2018). The Harvard Automated Processing Pipeline for Electroencephalography (HAPPE): standardized processing software for developmental and high-artifact data. Frontiers in neuroscience, 12, 97.

Funding Source

NIMH R01 MH100173 (McPartland)

McPartland Lab
mcp-lab.org
mcp.lab@yale.edu