Lempel-Ziv complexity shows inverted U-shaped pattern across the adult lifespan

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Background

- Increasing evidence suggests that temporal complexity reflects functional integration of the brain (Garrett et al., 2018).
- EEG Complexity has been found to be reduced in ageing comparing young and old adults (Ma et al., 2021).
- The trajectory of brain complexity across the lifespan remains to be investigated.

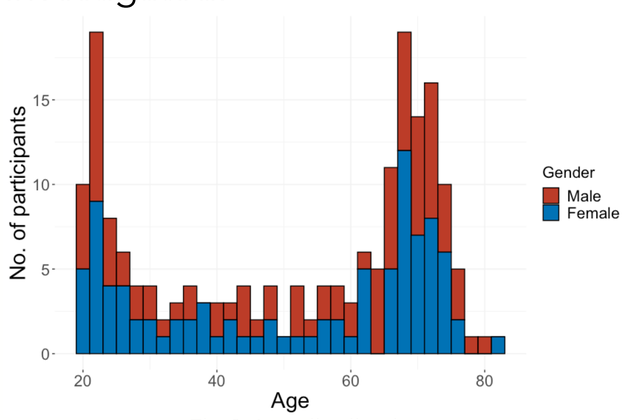
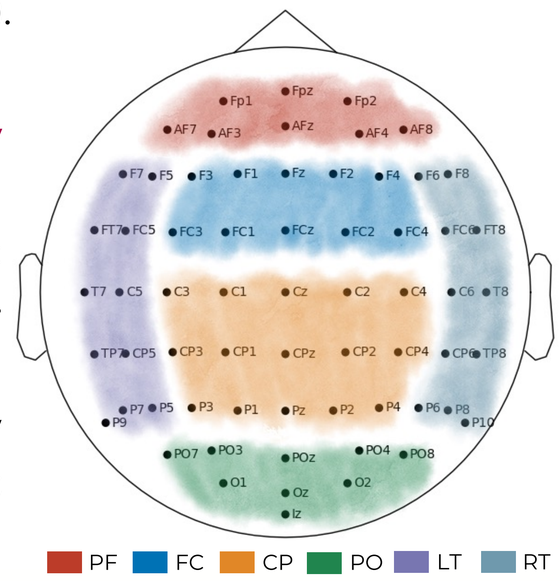


Fig. 1. Age distribution.

Methods

- 186 participants (95F, aged 19.1 – 81.2, mean 51.3).
- Eyes-closed resting-state.
- EEG complexity quantified by (1) Lempel-Ziv complexity (LZC) and (2) spectral exponent.
- Features averaged over 6 ROIs (PF: prefrontal, FC: frontocentral, CP: centroparietal, PO: parieto-occipital, LT: left temporal and RT: right temporal).
- Linear-mixed effect model with complexity measures as DV, age and its quadratic term as IVs; and Gender as covariate.
- Correlation analysis with cognitive variables such as Stroop.



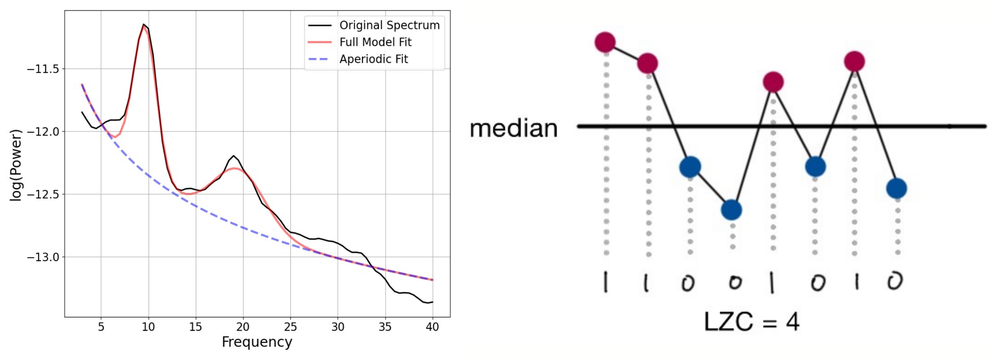


Fig. 2. Left: power spectrum, exponent is extracted from the dotted fit. Right: Lempel-Ziv complexity.

Results

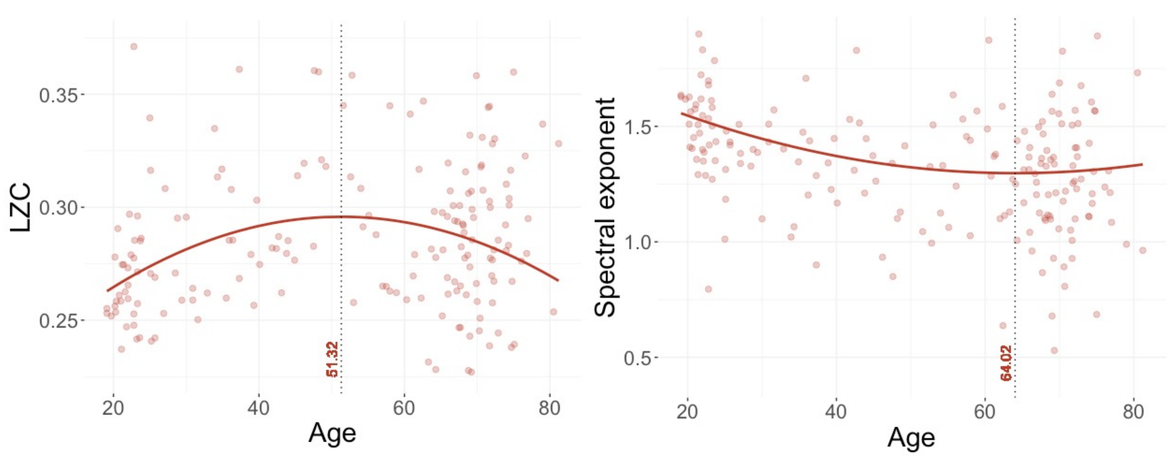


Fig. 3. Complexity trajectories across adult lifespan at the PF site. Left: LZC. Right: spectral exponent. The "turning point" is labeled with a vertical line with the age shown on the figure.

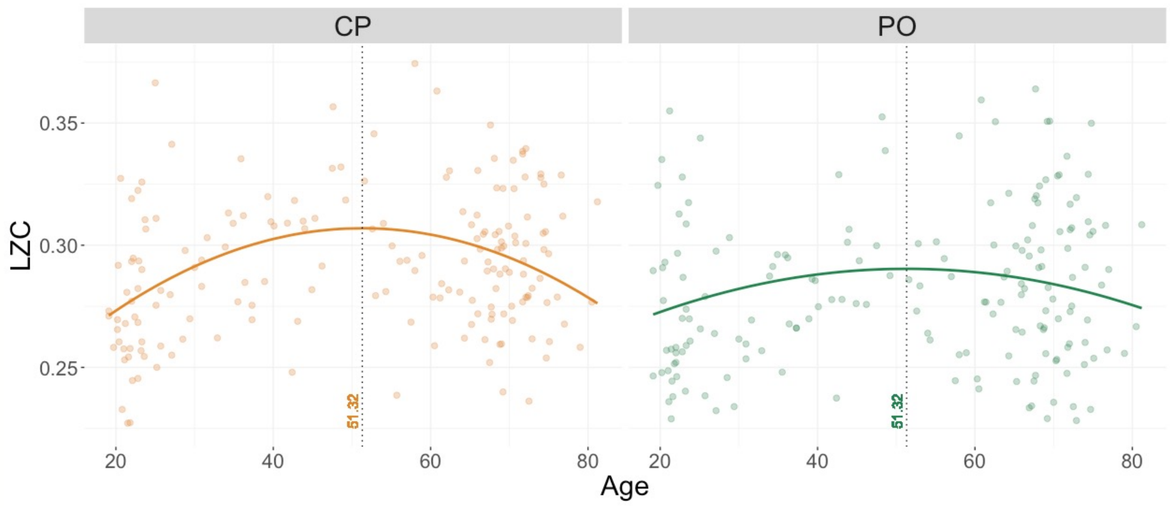


Fig. 4. Complexity trajectories of LZC at CP and PO sites. Notice that the rate of change in CP site is greater than that of PO site (p = 0.08, corrected).

- Both LZC and spectral exponent varies nonlinearly with age (Fig. 3).
- LZC shows an inverted U-shaped pattern, peaking at approximately age 51.
- Spectral exponent declines linearly during early age, slows down after age 40, and reaching the minimum around age 64.
- The "turning point" do not vary across sites.
- Significant site-specific rate of change on LZC but not spectral exponent (Fig. 4).
- Significant gender-specific effect on spectral exponent but not LZC.
- LZC shows opposing correlation with Stroop task performance before/after the "turning point" (Fig. 5).

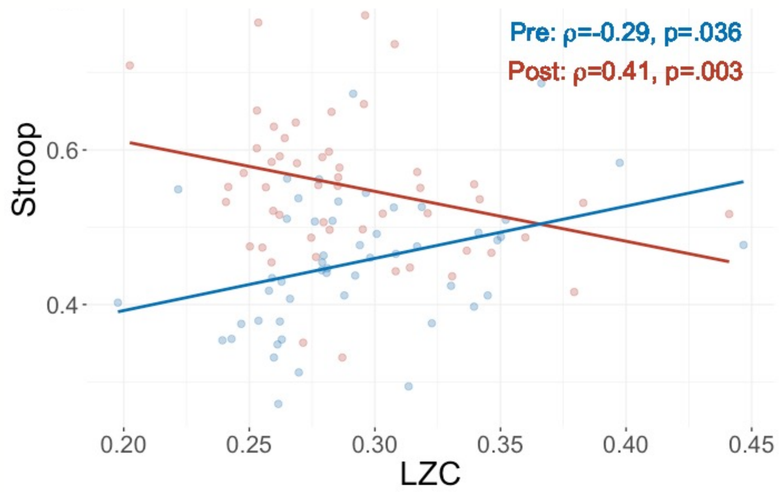


Fig. 5. Correlation between LZC and Stroop task performance. Pre/Post corresponds to participants age before/after the turning point.

Conclusion

- Lempel-Ziv complexity and spectral exponent reflect distinct properties of the ageing brain.
- Higher complexity is beneficial during early life stages but can become detrimental later in life.
- The turning point at around age 51 might reflect a shift in the resting-state functional architecture.
- Future studies shall consider other cognitive variables, as well as source-localized signals.

References

1. Garrett, D. D., Epp, S. M., Perry, A., & Lindenberger, U. (2018). Local temporal variability reflects functional integration in the human brain. NeuroImage, 183, 776–787.
2. Ma, M. K.-H., Fong, M. C.-M., Xie, C., Lee, T., Chen, G., & Wang, W. S. (2021). Regularity and randomness in ageing: Differences in resting-state EEG complexity measured by largest Lyapunov exponent. Neuroimage: Reports, 1(4), 100054.

Acknowledgement This work is supported by PolyU Dean's Reserve P0034986 awarded to Prof. William Shiyuan Wang. It is partially supported by the Research Institute of Smart Ageing.