The multiscale dynamics of resting-state brain activity is associated with the performance of dual task standing postural control in older adults

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Introduction

The standing postural control depends upon brain regions that interact with one another over multiple scales of time (Figure 1). The dynamics of brain activity (e.g., electroencephalogram, EEG, signal) during "free-running" condition are "complex," containing patterns with similar structures across multiple temporal scales.

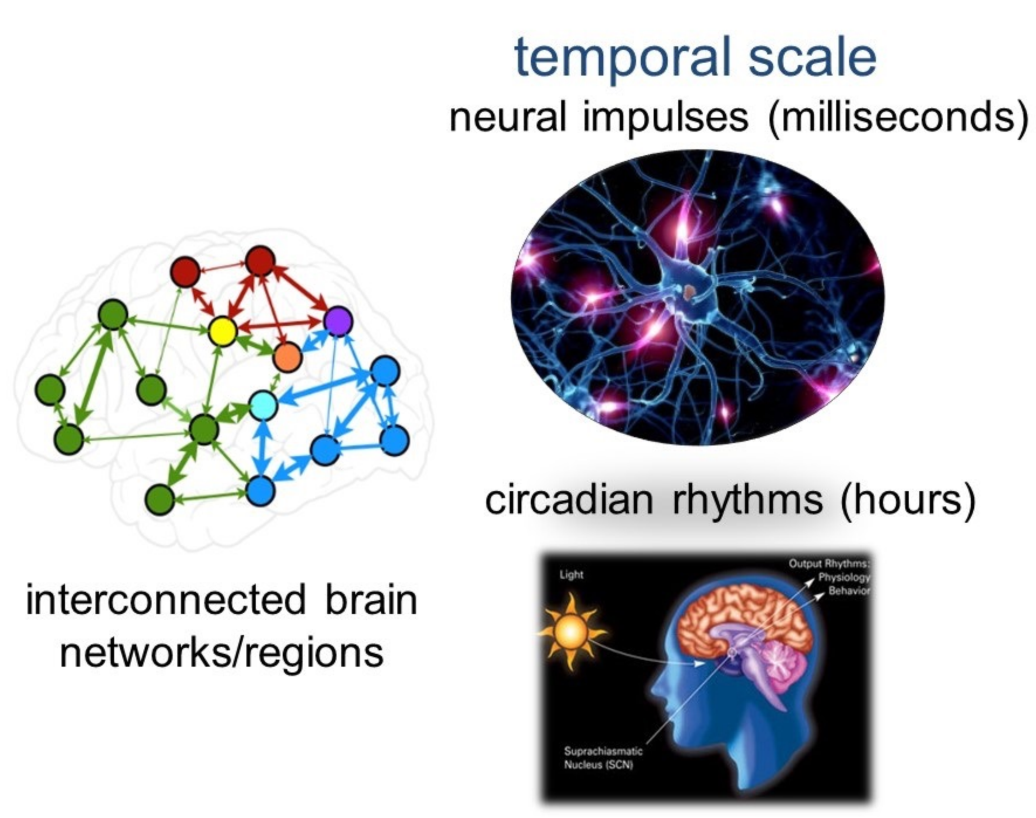

Figure 1. The brain networks are interacting with each other over multiple scales of time.

Such complexity has been linked to the capacity of the brain to adapt to stressors. We here hypothesized that the complexity of EEG signals during quiet sitting (i.e., free running) would predict the ability of older adults to maintain standing posture when stressed by a concurrent cognitive task (i.e. dual tasking).

Methods

Participants (n = 38) were included if they:
- were aged 65-85 years,
- can stand for 5 minutes without personal assistance.
- were without overt illness or disease

EEG recoding: A wireless 32-channel EEG system with sampling rate of 500 Hz (Enobio 32) was used during 6 minutes of quiet sitting with eyes open.

Lempel–Ziv–Welch (LZW) compression technique (Figure 2) was used to quantify the complexity of EEG spectrograms across all the channels. Greater LZW value indicates less compressibility and therefore, greater complexity.

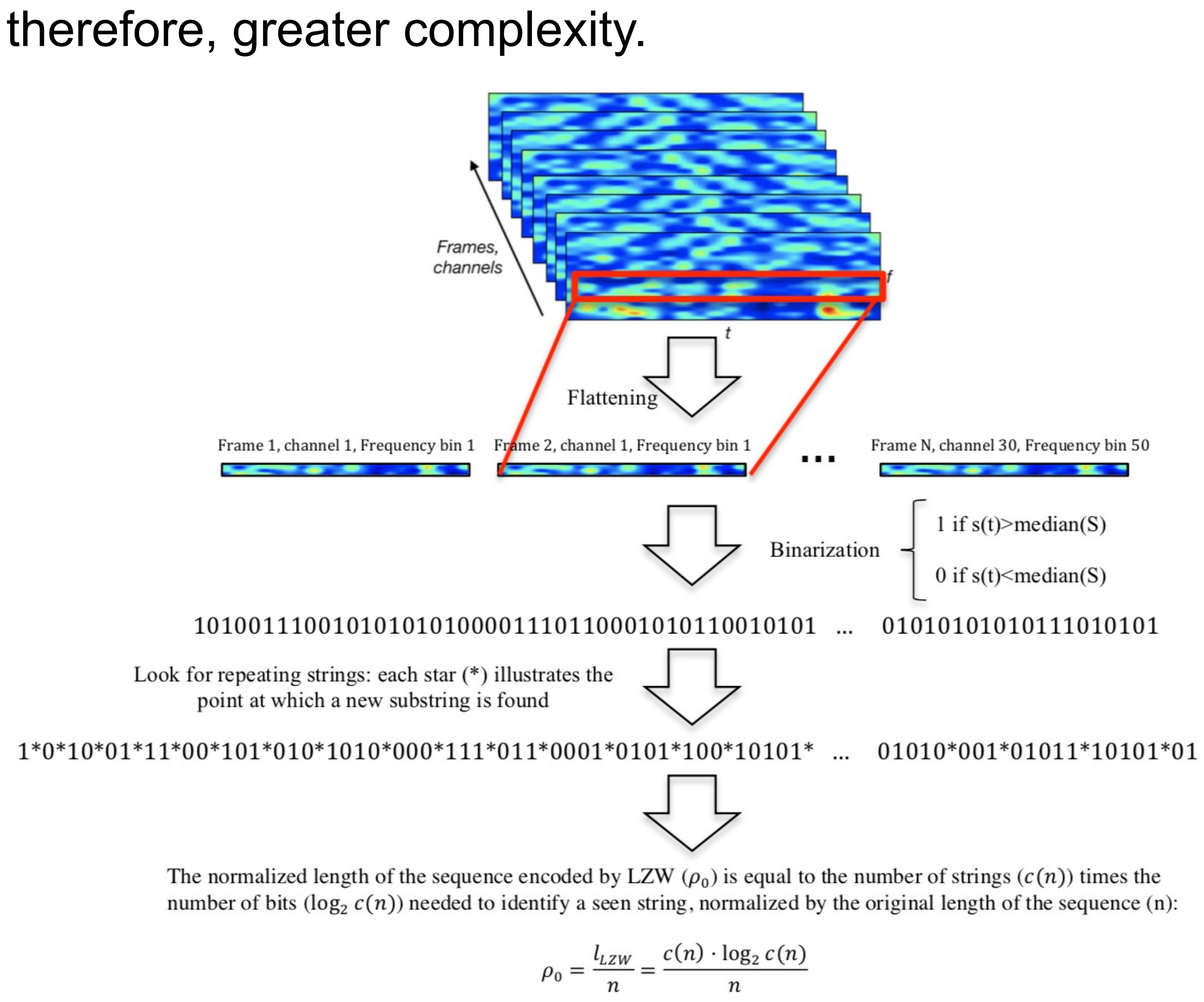

Figure 2. the mathematical process of LZW (Moser et al., 2019).

Standing postural control: Three 60-second standing trials:

1. **Single task (ST):** Standing quietly with eyes open;

2. **Dual task (DT):** Standing and performing serial subtractions of three from a random 3-digit number.

A wearable sensor system (Mobility Lab) was used and average **sway speed** and **area** in each condition were computed.

Results

The averaged dual task cost (i.e., the percent change from single task to dual task condition) of sway speed was 38±61% and the cost to sway area was 97±87% (mean ± S.D.).

Older adults with greater complexity of resting-state global brain activity exhibited smaller dual task costs to sway speed (r^2=0.23, p=0.03, Figure 3).

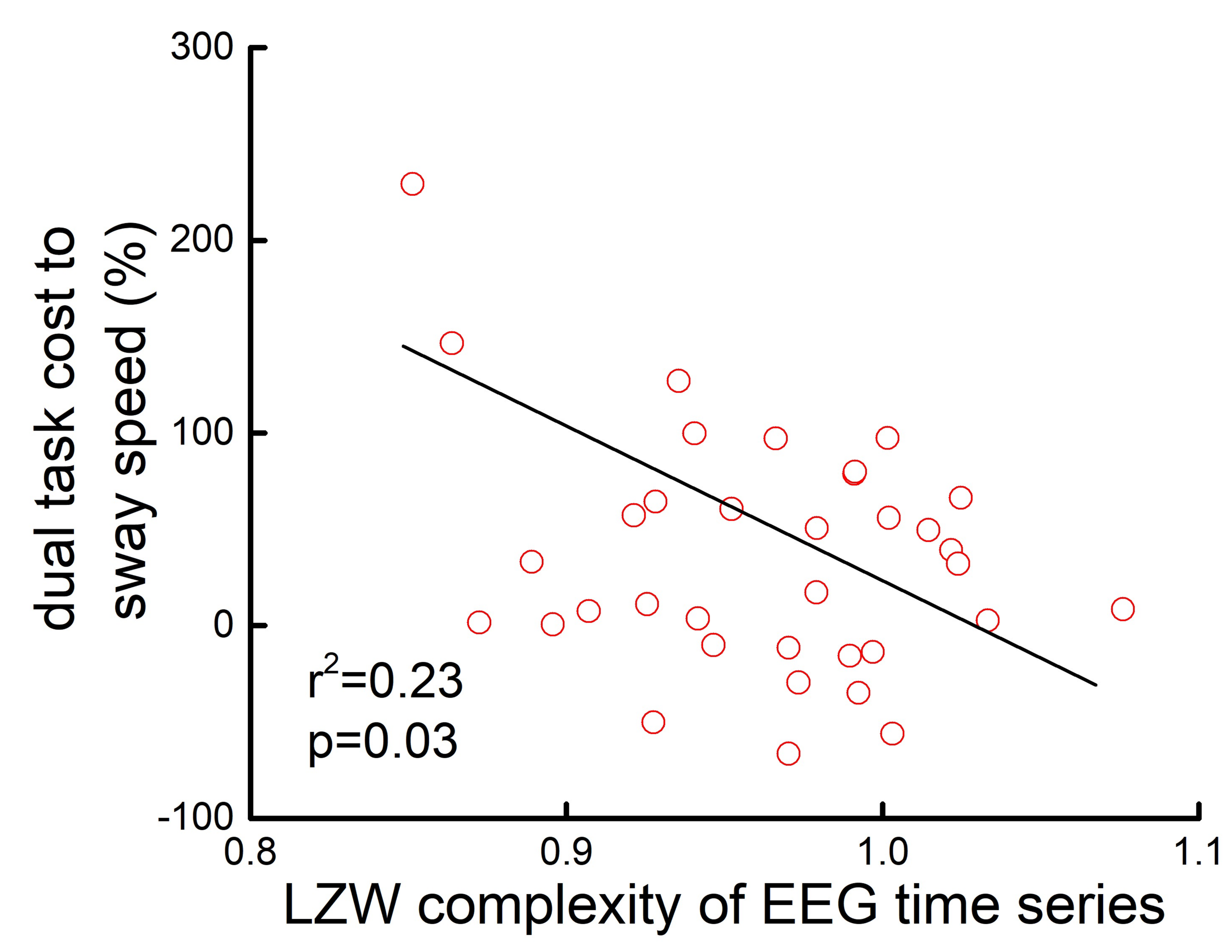

Figure 3. Older adults with greater LZW complexity of EEG has lower dual task costs to sway speed.

Similarly, those with greater complexity of resting-state global brain activity exhibited less sway area specifically within the dual task condition (r^2=0.46, p=0.01, Figure 4).

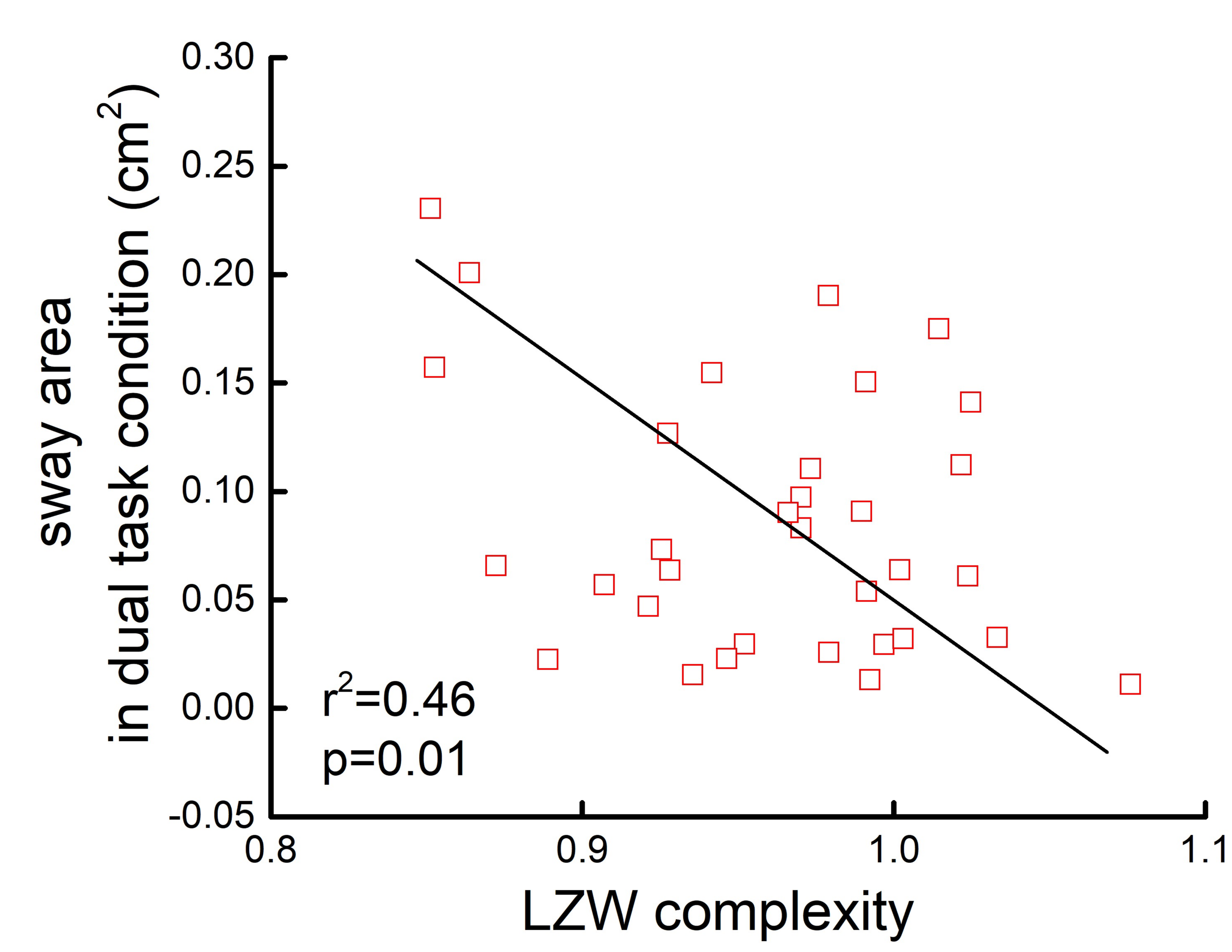

Figure 4. Older adults with greater LZW complexity of EEG has smaller sway area in dual task condition.

This relationship was independent of participant age. No association was observed between the complexity and the sway metrics in single task condition.

Conclusions

The complexity of resting-state global brain activity, as measured by the LZW metric of EEG, correlates with the ability to maintain standing postural control specifically when engaged in a cognitive dual task stressor.

Future studies are warranted to:
1. examine the relationship between LZW and other metrics of complexity (e.g., multiscale entropy);
2. determine the sensitivity of such metrics to cognitive-motor decline and falls in aging and disease.