Neuronal Activation Complexity as a Biomarker Measure for Depression?

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Background

- Complexity science has been used to study the order and randomness of various biological signals overtime, such as heart rhythm, gait, and electroencephalograms (EEG), and the study of these dynamic changes occurring across time using multiscale entropy (MSE) measures have been suggested to uncover potential biomarkers related to measurable health outcomes (Costa et al., 2005; Yang & Tsai, 2012).

- **Healthy mental functioning** is suggested to be a balance in the pattern of neuronal activation; less complex patterns may be associated with thoughts that are more stereotypical or obsessive, while increased complexity may be related to thoughts that are more impulsive or irrational (Yang & Tsai, 2012).

- Recent research using multiscale entropy analyses of neuronal activations collected by EEG have revealed resting-state differences of activation complexity in those afflicted with mental disease (Alzheimer's) and healthy controls, with differences emerging at different time scales (Yang et al., 2013).

- Depression is associated with cognitive processes related to the ruminative thought behaviors, *brooding* and *reflection* (Treynor et al., 2003), which may theoretically be correlated to the balance of complexity suggested for healthy mental functioning.

  - *Brooding* – Thinking things like "Why do I always react this way?", and passively comparing a current state with an unachieved goal.
    (Stereotypical / Ordered / Less Complex)

  - *Reflection* – Engaging in an internal analysis of personality or thoughts through purposeful cognitive problem solving.
    (**Stochastic / Random / More Complex)**

Is a biomarker for depression evident in the complexity of neuronal firing over time?

There were two primary goals of the current study:

1. Are sub-clinical levels of depression correlated to the complexity of neuronal firing over time?

2. Are the ruminative thought behaviors of brooding and reflection associated with differences in neuronal activation complexity?

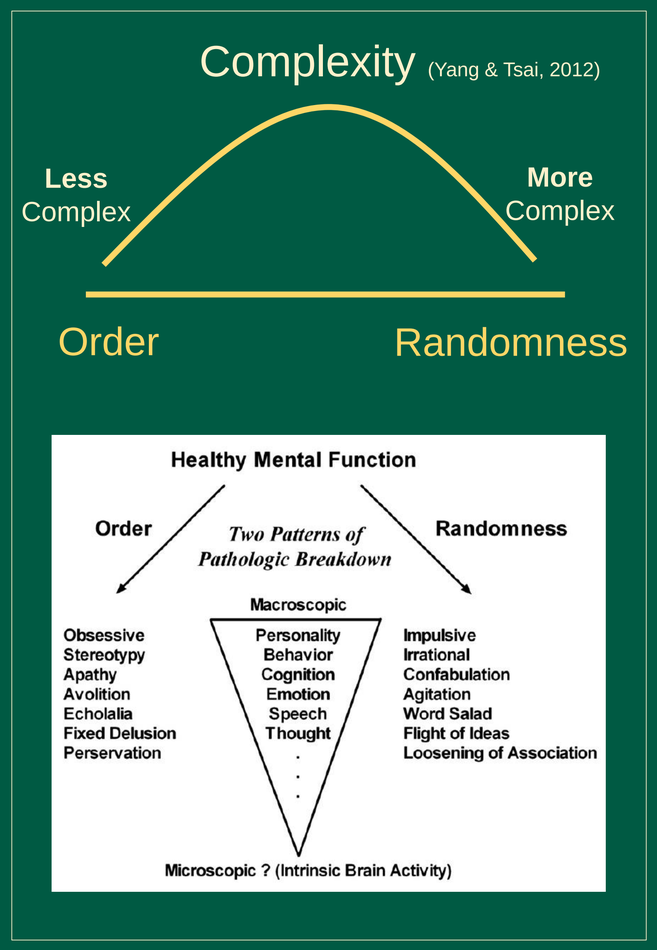
Method

Diagnostic and Symptom Measures

- The Beck Depression Inventory II (BDI-II): *M* = 12.83 , *SD* =10.40
- The Ruminative Response Scale:
  - Brooding: *M* = 11.24, *SD* = 3.83
  - Reflection *M* = 10.87, *SD* = 3.84

Procedure

- After completion of diagnostic measures, participants engaged in an eyes-open / eyes-closed, resting-state task while surface level neural activation was monitored using EEG.
- Data processed using RCMDE procedures (Azami et al., 2017).
- *N* = 63



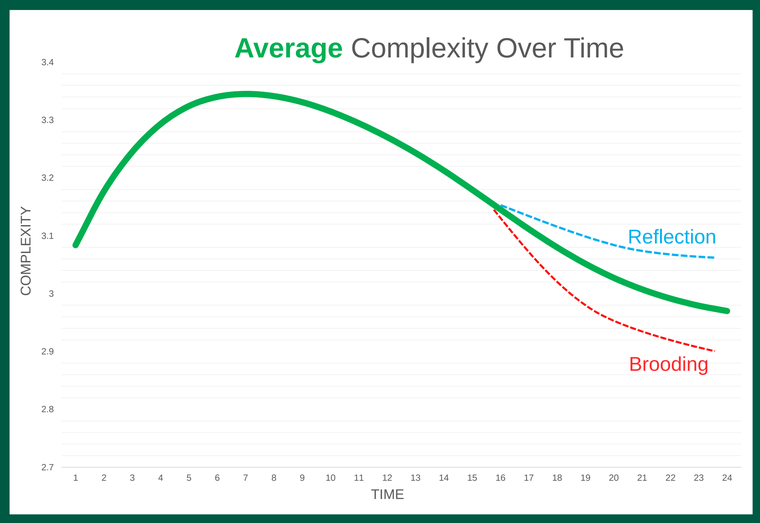
Results

Temporal Complexity

Variable	Short	Long
1. BDI	.080	-.261*
2. Brooding	.093	-.117
3. Reflection	.156	.072

Results cont.

- A significant Scale X BDI interaction was only found in the complexity of activation across the temporal region, F (1, 61) = 5.17, p = .026.
- Higher BDI scores were significantly related to decreased complexity at long time-scales only, p<.05.
- **FUTURE ANALYSIS**:
  - Explore brooding and reflective behavior controlling for depression.



Discussion

- Diagnosis of depression is often dependent upon subjective measures such as self-report surveys.
- The relationship between complexity over-time in the temporal region and depression may suggest evidence of a biomarker.
- Healthy mental functioning and ruminative behaviors may still be related to the complexity of a signal when controlling for depression.
- Future research on mental illness and disease should consider complexity measures to facilitate objective diagnoses.

References

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