

Cognitive Control and Attention:

Neurocognitive Mechanisms of System 1 and System 2 Thinking

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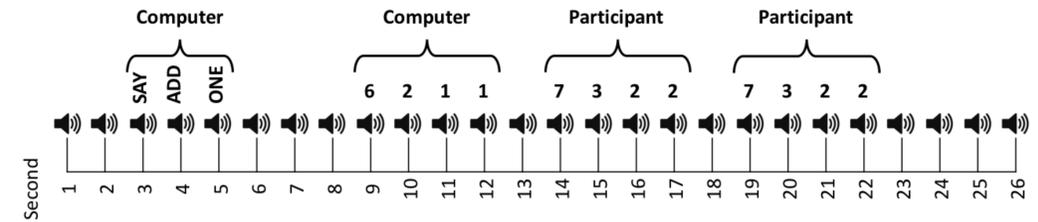


INTRODUCTION

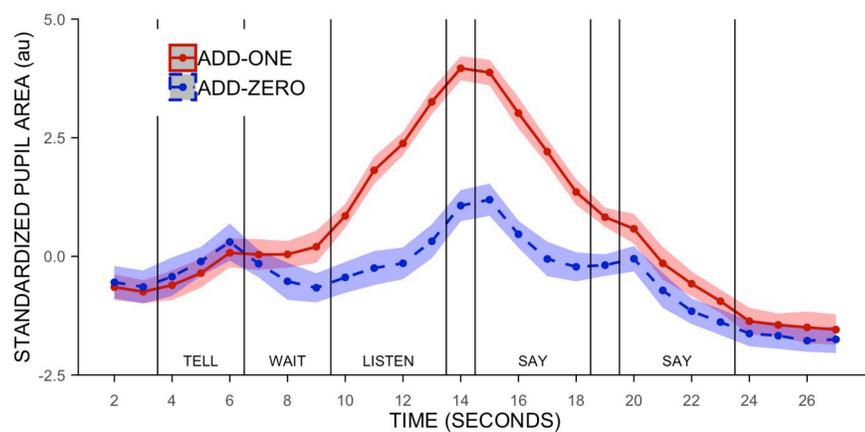
- The decisions we make on a daily basis range from fast, intuitive responses (System 1) to slow deliberations (System 2)¹.
- Pupil dilation is purported to be an effective measure of mental effort, and thus an indicator of System 1 and System 2 thinking¹.
- Advances in neuroimaging have opened the way to more direct measures of brain activity and underlying cognitive mechanisms.
- Using EEG, we analyzed the involvement of cognitive control (frontal theta²) and attention (parietal alpha³) in System 1 and System 2 thinking.
- We hypothesized that we would see larger pupil dilations, increased frontal theta power, and decreased parietal alpha power for System 2 relative to System 1 thinking.

METHODS

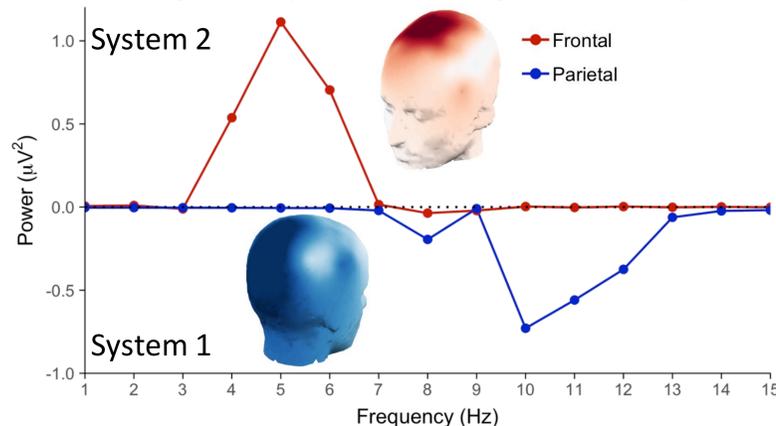
- **Add-One Task:** Participants (n = 29) heard four numbers and were to repeat the numbers in one of two conditions.
 - **Add-Zero Condition:** repeat the numbers as heard.
 - **Add-One Condition:** repeat the numbers after adding one to each of them.
- **Measures:**
 - **Pupil dilation** has been linked to processing load⁴
 - **Frontal theta** has been linked to cognitive control²
 - **Parietal alpha** has been linked to attentional mechanisms³



Pupil Dilation and Frequency Analysis

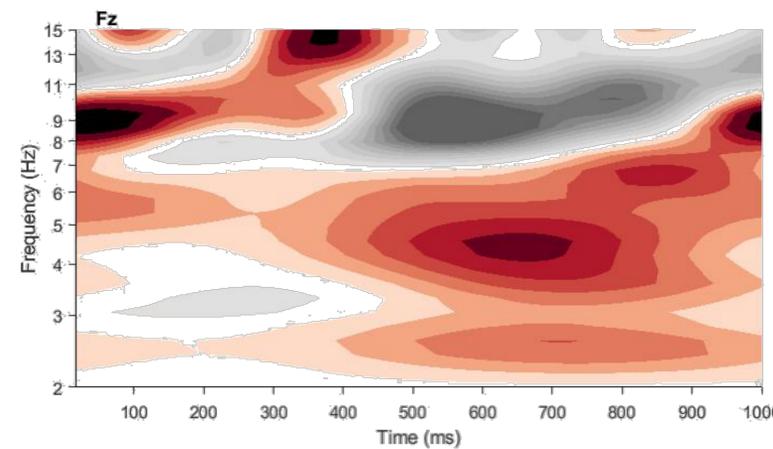


We replicated seminal results from Kahneman et al. (1968) that pupil dilations are larger for System 2 thinking relative to System 1 thinking.

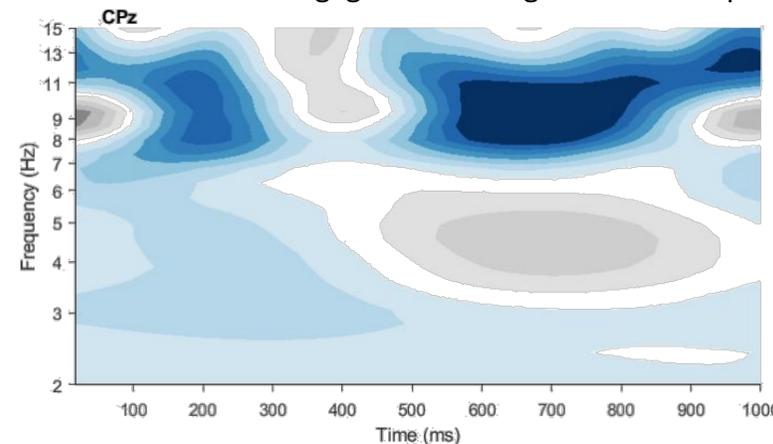


Fast Fourier transforms demonstrated that frontal theta is larger and parietal alpha is smaller for System 2 relative to System 1 thinking.

Wavelets

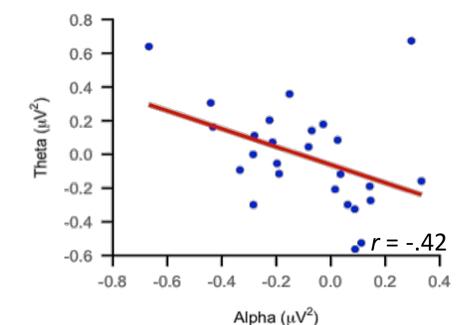
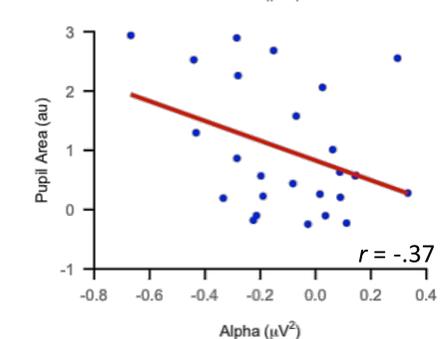
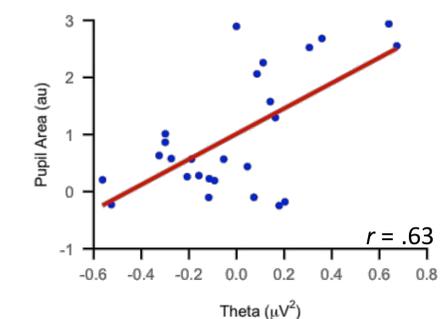


System 2 thinking is characterized by an increase in frontal theta power indicative of the engagement of cognitive control processes.



System 1 thinking is characterized by an increase in parietal alpha power reflecting a release of attentional resources.

Associations



We also demonstrated an association between all measures of interest.

First, this indicated that changes in pupil dilation are, in part, reflective of frontal cognitive control and parietal attentional mechanisms.

Second, these mechanisms operate in conjunction to elicit System 1 and System 2 thinking.

Additionally, there is a concomitant relationship between frontal and parietal neural activity during different modes of thinking.

¹Kahneman, D. (2011). *Straus and Giroux*; ²Cavanagh, J. F. & Frank, M. J. (2014). *Trends in Cognitive Sciences*;

³Klimesch, W. (2012). *Trends in Cognitive Sciences*; ⁴Kahneman, D., Peavler, W. S. & Onuska, L. (1968). *Canadian Journal of Psychology*.

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