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Nonlinear neural dynamics in the observed random variability of saccadic latencies

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Introduction:

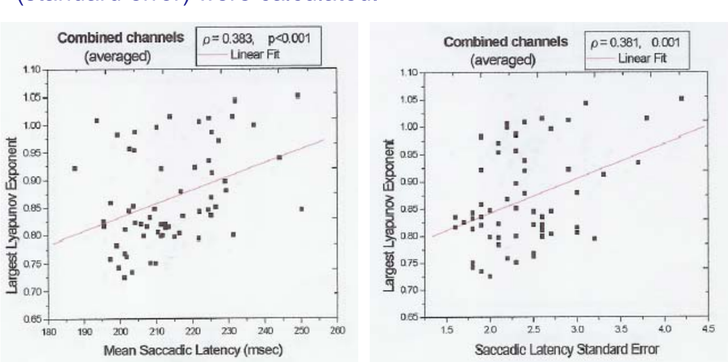
Behavioural reaction times to stimuli are much longer than can be justified by a simple summation of nerve conduction times and synaptic delays, and it is clear that decision processes involving higher cortical regions are involved in delaying responses. Reaction times are also unexpectedly variable from trial to trial, and their recinormal distribution has been shown to be Gaussian (Carpenter 1981).

In an organism faced with a complex environment filled with numerous stimuli competing for attention, random variability in response times will result in a randomisation of attention (and consequently, of behaviour). According to game theory such random element in behaviour would carry evolutionary advantages in competitive situations, and it is possible that the nervous system purposefully makes use of a randomness-generating mechanism (Carpenter 1999).

Possible candidates for such a mechanism include nonlinear chaotic dynamics. This study investigates the possibility of a chaotic neural mechanism being responsible for generating the observed random variability in saccadic reaction times.

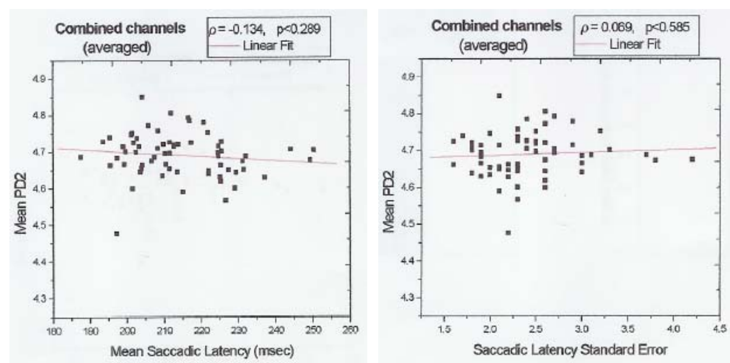
Method:

Electroencephalographic (EEG) measurements were recorded from four subjects performing a saccadic reaction time task. Two nonlinear measures, the Point Correlation Dimension (PD2) and the Largest Lyapunov Exponent (LLE) were calculated for the EEG times series, and the correlation coefficients for the relationship of these measures to saccadic latency and latency variance (standard error) were calculated.

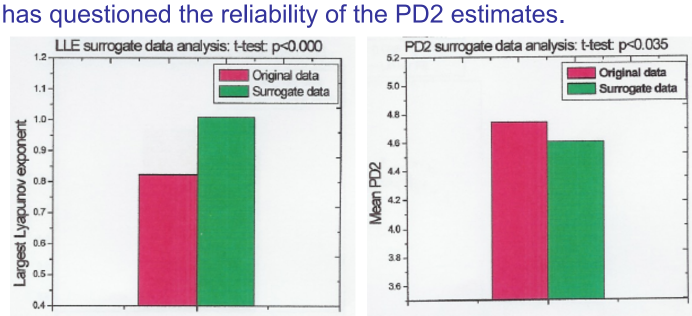


Results:

A significant positive correlation was identified between LLE estimates of the EEG and saccadic latency and saccadic latency variance, but no consistent correlation was found for the PD2 estimates.



Subsequent confirmatory analysis with phase-randomised surrogate data has supported the validity of the LLE results, but has questioned the reliability of the PD2 estimates.



Discusssion:

As one of the two nonlinear EEG measures used in this study was shown to correlate with saccadic latency measures, the possibility that a chaotic neural mechanism is the source of the observed variability is partially supported. However, as saccadic latencies show a greater diurnal variability than what would be expected from looking at short-term, trial-to-trial variation, and EEG measures also vary significantly over the course of the day, an alternative explanation would be that both variables are affected by fluctuations in some other physiological function.

References:

Carpenter, R. H. S. (1981). Oculomotor Procrastination. Eye Movements: Cognition and Visual Perception. D. F. Fisher, R. A. Monty and J. W. Senders. Hillsdale, Lawrence Erlbaum: 237-246.

Carpenter, R. H. S. (1999). "A neural mechanism that randomises behaviour." Journal of consciousness studies **6**(1): 13-22.

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