

In the heart of creativity: divergent thinking and HRV in computerized Alternative Uses Task - an EEG-ECG pilot study



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Introduction

Creativity:

- The elusive concept and ill-defined problem of **creativity**
- Guilford's pioneer **psychometric approach** to creativity studies¹
- **Divergent thinking** as a reliable indicator of creative potential²
- **Novelty/originality** as a crucial constituent and metric of creativity measured by **statistical originality**³
- More responses = more novel responses and higher average novelty score³

HRV studies:

- **Heart rate variability (HRV)**: beat-to-beat variations in heart rate⁴
- A measure of **neurocardiac function** that reflects sympathovagal balance, psychological resiliency and behavioral flexibility⁴
- **High HRV** associated with good physical and psychological health, well-being and improved performance⁴
- HRV RMSSD index inversely associated with **idea originality**⁵
- However: **LF/HF ratio** related to psychophysiological balance⁴

EEG signal complexity studies:

- No creativity studies applying complexity analysis up to date

Aim of the Study/Hypotheses

- **Reveal neurocardiac correlates of divergent thinking**
- Expected higher complexity in more creative individuals
- Expected higher HRV in more creative individuals

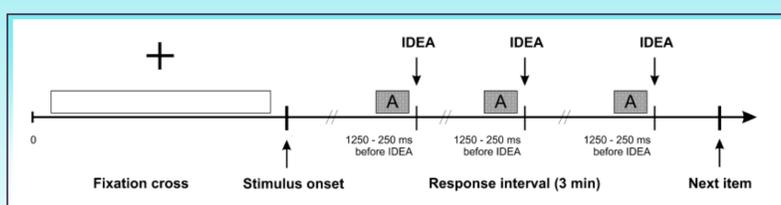
Methods

Participants:

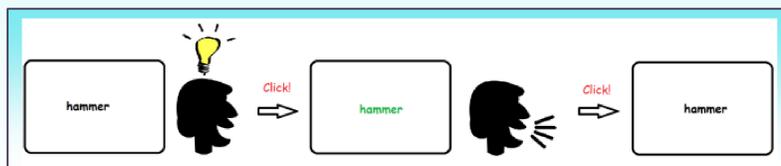
- N = 31 (F = 19, 61.29%), age 19-36 (M = 23.00, SD = 3.73)

Alternative Uses Task:

- A computerized version of Guilford's Alternative Uses Task (AUT)⁶
- „List as many alternative uses for the item presented as you can think of in 3 minutes”
- 5 items (umbrella, shoe, soap, pen, brick)



- Idea button to eliminate speech artifacts from EEG recordings
- EEG epochs of -1250 to -250 ms prior to the reported idea



- Responses evaluated on number (NO) and originality (ORI)
- ECG recorded upon the AUT task and a prior resting period

Signal analysis

1. **HRV analysis** of the ECG signal in **time- and frequency-domain** (FFT and autoregression [AR] power spectrum standard frequency bands: VLF, LF and HF), as well as applying non-linear methods
2. **Higuchi's fractal dimension (HFD) analysis** of the EEG signal measures the complexity of time series⁷, estimating brain function complexity dynamics, due to particular sensitivity to signal fluctuations

Results

1. CREATIVITY ANALYSIS

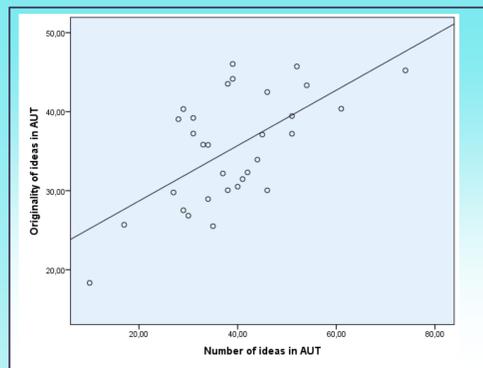


Fig.1. Correlation between **NO** and **ORI** of ideas ($r = 0.622$, $p < 0.001$)

2. HRV ANALYSIS

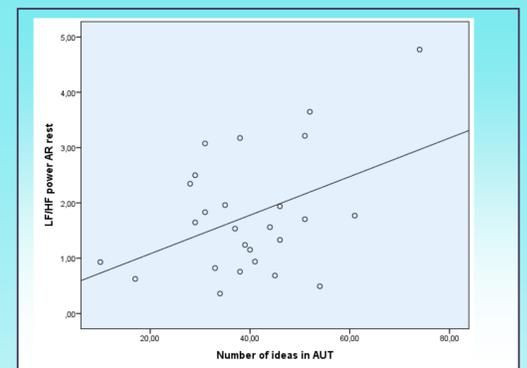


Fig.2. Correlation between **NO** of ideas and **LF/HF (AR)** at rest ($r = 0.425$, $p = 0.030$)

Other correlations include:

- **ORI** and **TINN** at rest ($r = 0.398$, $p = 0.044$),
- **ORI** and **RR triangular index** upon AUT ($r = 0.402$, $p = 0.046$),
- **ORI** and **Shannon Entropy index** upon AUT ($\rho = -0.442$, $p = 0.027$)

3. HFD COMPLEXITY ANALYSIS

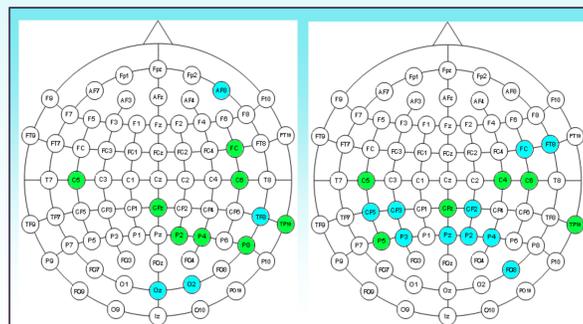


Fig.3. Difference in signal complexity **HFD** between more and less creative individuals with respect to **number** (left) and **originality** (right) of ideas

- Green-marked electrodes: $p < 0.05$
- Blue-marked electrodes: $p < 0.01$

Conclusions

- Originality of ideas correlated positively with LF/HF ratio, a measure of psychophysiological balance, determining the quality of bodily functioning. This suggests that HRV training techniques, such as HRV-biofeedback, might have a positive impact on improving creativity levels.
- More creative individuals (both concerning originality and number of ideas) exhibit higher complexity and therefore lower regularity of the EEG signal obtained during divergent thinking task. This possibly depicts higher complexity of neuronal processes involved in creative thinking.
- Influence of HRV-biofeedback training on EEG signal complexity can be expected.

Acknowledgements

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