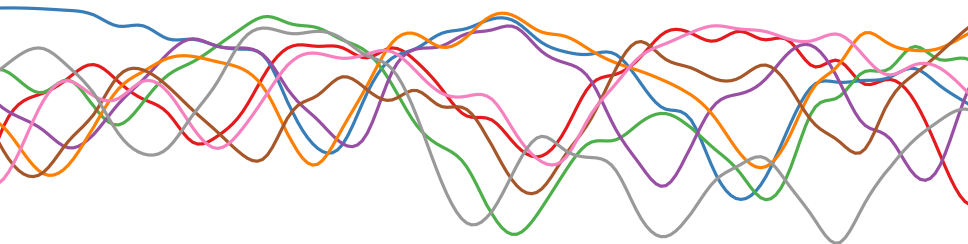


THE ENTROPIC BRAIN

COMPLEXITY IN THE BRAIN AND IN MUSIC



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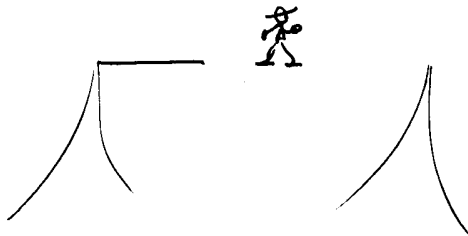


INTRODUCTION

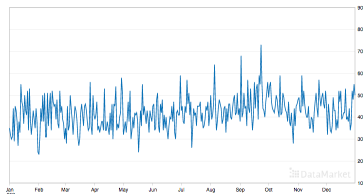
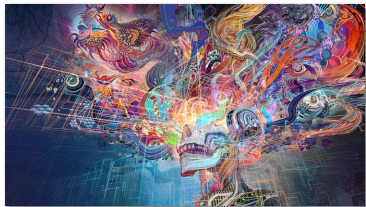
WHY STUDY IMPROVISATION

Life is one long improvisation.

Henrik J. Jensen, ca. 2017



THE ENTROPIC BRAIN



Richness of
experience



Signal
diversity

frontiers in
HUMAN NEUROSCIENCE

HYPOTHESIS AND THEORY ARTICLE

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The entropic brain: a theory of conscious states informed by neuroimaging research with psychedelic drugs

Robin L. Carhart-Harris^{1*}, Robert Leech², Peter J. Hellyer², Murray Shanahan³, Amanda Feilding⁴, Enzo Tagliazucchi⁵, Dante R. Chialvo⁶ and David Nutt¹

HOW DO WE MEASURE ENTROPY?

- Lempel-Ziv complexity: Measure of complexity for time series data.



Loosely speaking: counts number of “patterns” in the signal.



High LZ



Low LZ



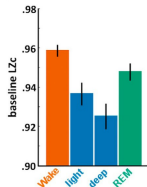
LZ quantifies *complexity as signal diversity*.

ENTROPY AND CONSCIOUSNESS

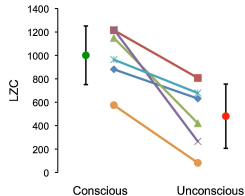


Entropy consistently **decreases** when consciousness is lost, and **increases** when consciousness is richer.

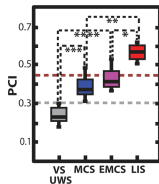
Sleep



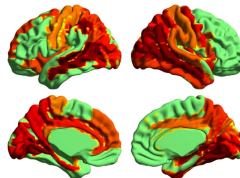
Anaesthesia



Coma



Psychedelics



Primary state

(Andrillon, 2016; Hudetz, 2016; Sarasso, 2014; Schartner, 2017)

CORTÁZAR'S THE PURSUER

(EL PERSEGUIDOR)

*Hell no, I don't get lost when I'm playing. Only the place changes. It's like in an elevator, you're in an elevator talking with people, you don't feel anything strange, meanwhile you've passed the first floor, the tenth, the twenty-first, and the city's down there below you, and you're finishing the sentence you began when you stepped into it, and between the first words and the last ones, there're fifty-two floors. **I realized that when I started playing I was stepping into an elevator, but the elevator was time, if I can put it that way.***

Julio Cortázar, 1959



Does improvisation induce a primary conscious state?

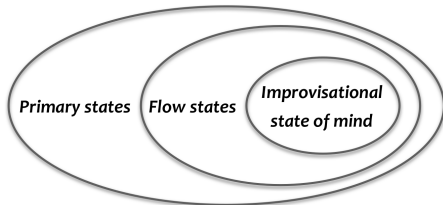
MUSICAL IMPROVISATION

DRIVING HYPOTHESIS

An improvisational
state of mind



- ▶ **Flow** (Csikszentmihalyi, 1975)
 - *“The holistic sensation that people feel when they act with total involvement.”*
- ▶ **Primary state** (Carhart-Harris, 2014)
 - *“Relinquishing of the ego’s usual hold on reality.”*



THE EXPERIMENT

- ▶ We organised a chamber music trio concert.
- ▶ Pieces were played twice, in **strict** and **let-go** conditions.

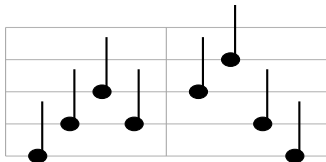


(Dolan *et al.*, 2018)

THE EXPERIMENT

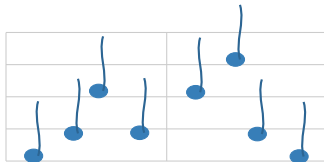
Same piece. Two different mindsets.

STRICT



*Precise. Controlled.
Following the score faithfully.*

LET-GO



*Free. Spontaneous.
Trusting one's musical instincts.*

(Dolan *et al.*, 2018)

RESULTS

SUBJECTIVE REPORTS

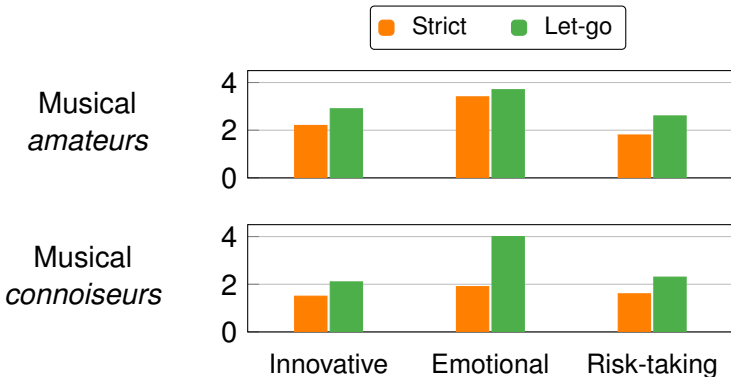


- ▶ In the **strict** performance:
 - ...*very little sense of connection between the performers...*
 - ...*increased performance anxiety and internal critical chatter...*

- ▶ In the **let-go** performance:
 - ...*greater sense of connection...*
 - ...*Trust in my own musical instincts and capability...*
 - ...*the freedom of the 'let go' mindset allowed me to create a wider range of colors and dynamics...*

POST-PERFORMANCE QUESTIONNAIRE

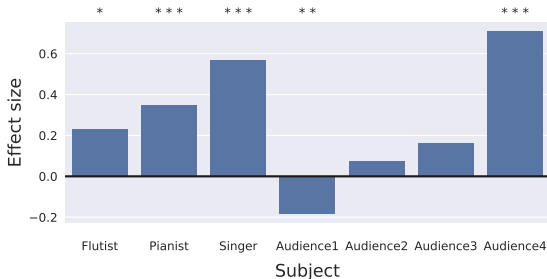
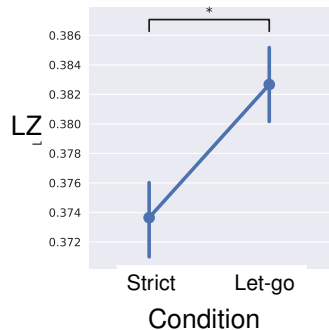
- Audience rated performance as more innovative, more emotional and more musical.



NEUROIMAGING RESULTS I



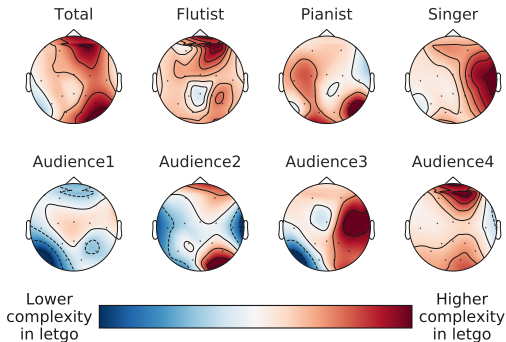
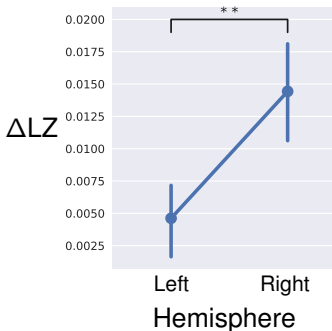
Improvisation consistently increases brain entropy.



NEUROIMAGING RESULTS II



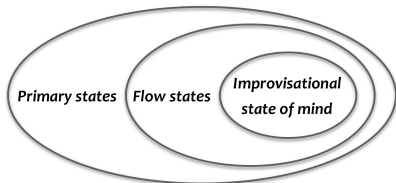
Entropy increase is located in the right hemisphere.



WRAP-UP

CONCLUSIONS

- ✓ Tools from complexity science help us understand the fundamental science of consciousness.
- ✓ Data supports the existence of an *improvisational state of mind*, which is a state of flow and a primary state.



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Thank you for listening!