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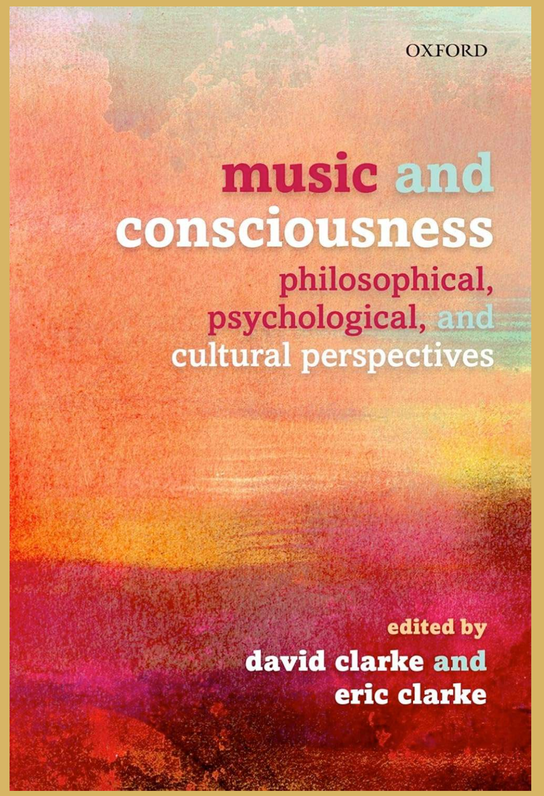
UNIVERSIDADE D
COIMBRA

“Does music simply offer an insight into consciousness—in principle no better or worse than a whole range of human activities….—or does it have a special claim in this respect that may be of broader significance?”

— Clarke & Clarke (Eds.) (2018)

“After finishing the volume, I am left with no definite answer. However, a poetic optimism that is nevertheless difficult to ground is kindled.”

— Simon Høffding (2018)



Høffding, S. (2013). **A musical exploration of consciousness**: Book review of Clarke & Clarke (eds) (2011) Music and Consciousness. Philosophical, psychological, and cultural perspectives. Oxford University Press. *Phenomenology and the Cognitive Sciences*, *12*(4), Article 4.



Pedro Torres Palhares

A Musical Exploration of Consciousness
Mind wandering, Creativity and Brain Dynamics

Tese no âmbito do Doutoramento em Psicologia, especialidade em Neurociência Cognitiva, orientada pelo Professor Doutor Óscar Filipe Coelho Neves Gonçalves e pelo Doutor Sasha D'Ambrosio e apresentada à Faculdade de Psicologia e de Ciências da Educação da Universidade de Coimbra

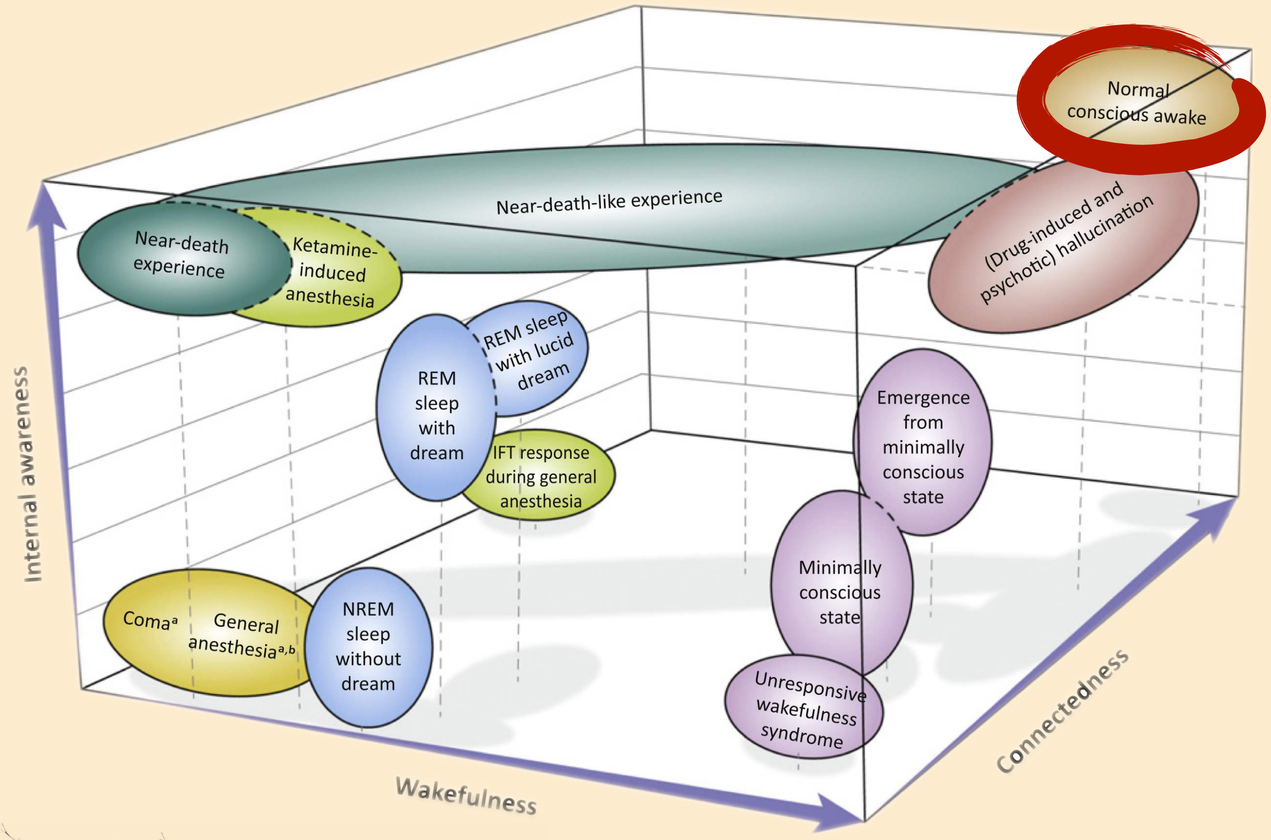
Dezembro de 2025



General Introduction

From clinical states to complex consciousness

(Gonçalves, Sayal, Lisboa, & Palhares, 2024)



Beyond cases of (dis)connected consciousness, there is a largely underexplored domain of complex consciousness experiences within wakefulness:

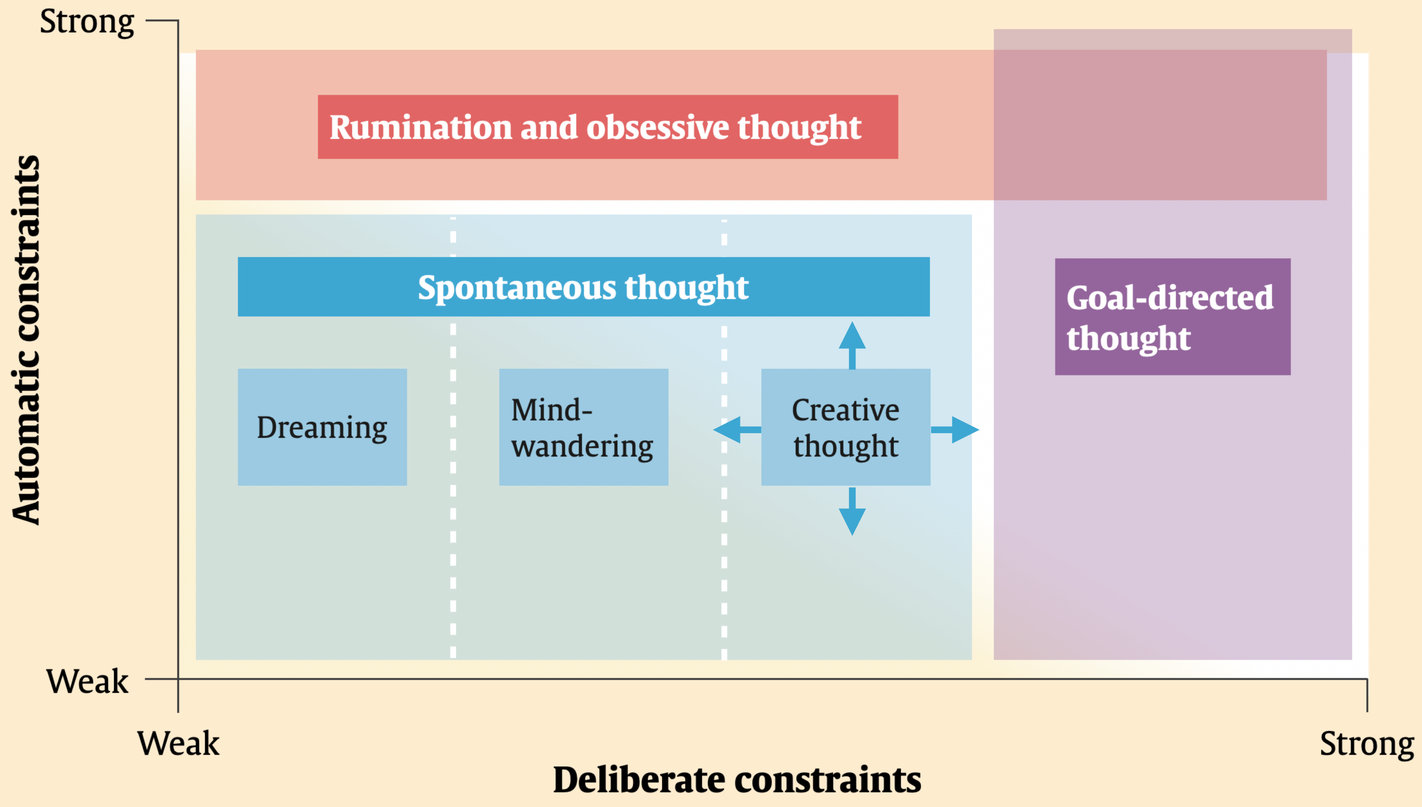
- **Mind-wandering**
  (Smallwood & Schooler, 2015)
- **Creative thought**
  (Beaty et al., 2016)
- **(Musical) absorption**
  (Vroegh, 2019)
- **Awe**
  (van Elk et al., 2019)

Note. Figure from "Near-Death Experience as a Probe to Explore (Disconnected) Consciousness", by C. Martial et al., 2020, *Trends in Cognitive Sciences, 24*(3), 173–183.

General Introduction

Dynamic Framework of Thought — Creativity

(Christoff et al., 2016)



Stages of the creative process (Sawyer, 2012):

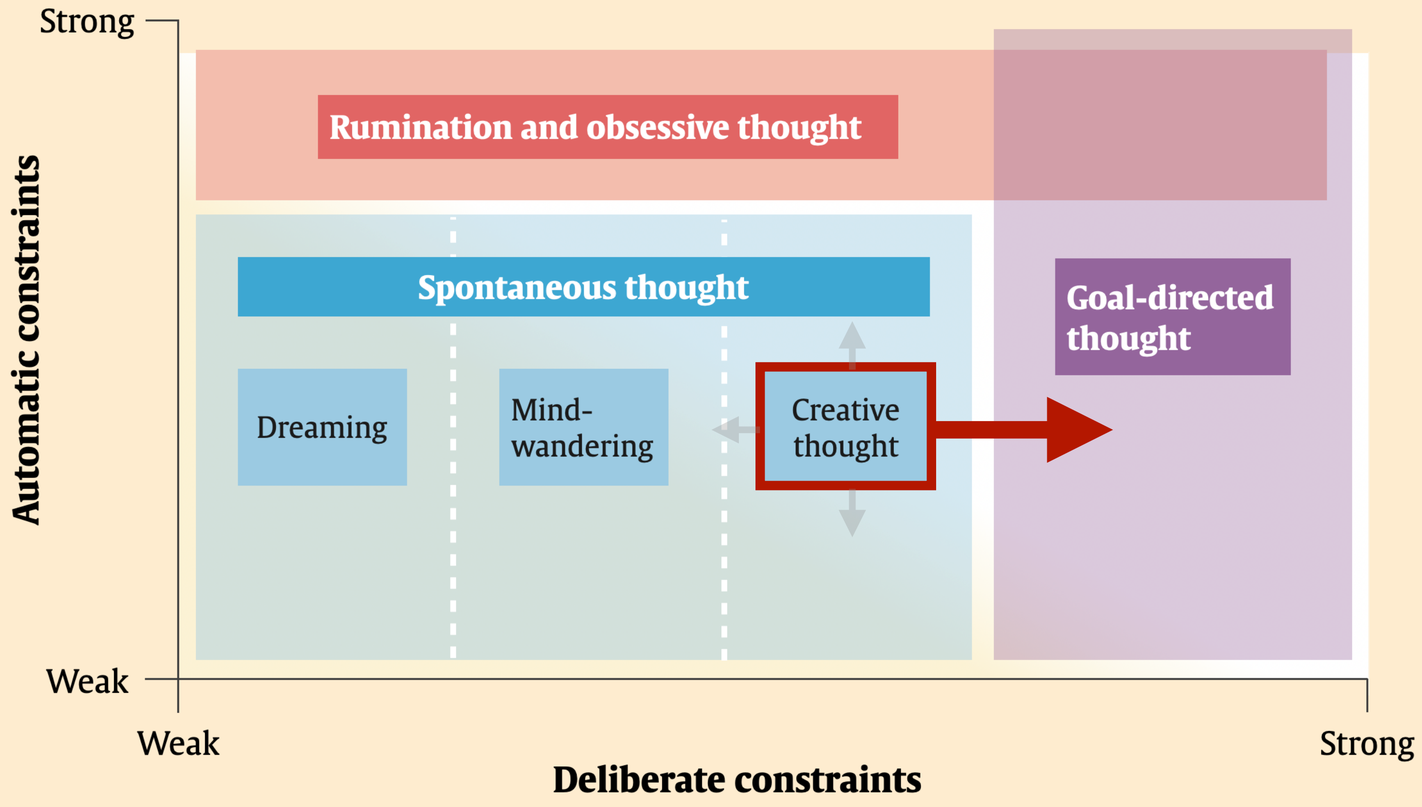
- Problem definition
- Knowledge acquisition
- Gathering of problem related information
- Incubation
- Idea generation
- Idea combination,
- Idea selection
- Idea externalization

Christoff, K., Irving, Z. C., Fox, K. C. R., Spreng, R. N., & Andrews-Hanna, J. R. (2016). Mind-wandering as spontaneous thought: A dynamic framework. *Nature Reviews Neuroscience*, *17*(11), 718–731.

General Introduction

Dynamic Framework of Thought — Creativity

(Christoff et al., 2016)



Creativity research relies on simplified, externally driven tasks

↓

Presupposes a uniformly task-focused mental state

↓

Mind wandering as detrimental to ongoing creative performance

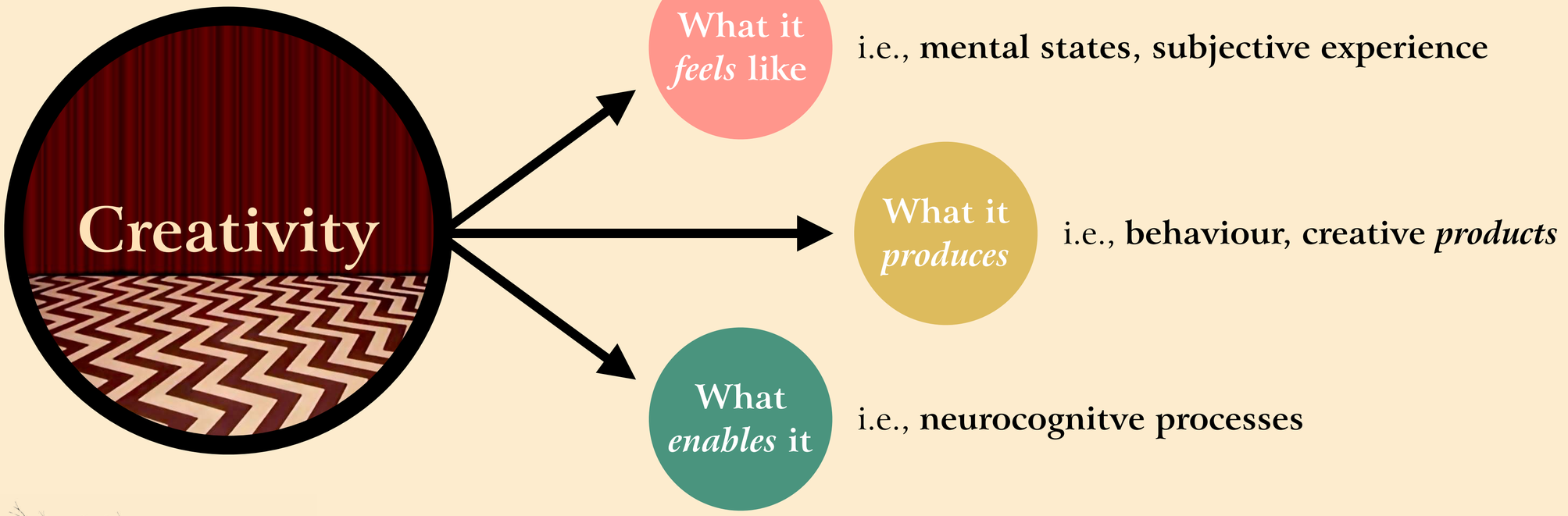
(Hao et al., 2015)

Christoff, K., Irving, Z. C., Fox, K. C. R., Spreng, R. N., & Andrews-Hanna, J. R. (2016). Mind-wandering as spontaneous thought: A dynamic framework. *Nature Reviews Neuroscience*, *17*(11), 718–731.

General Introduction

Capturing and disentangling creativity

Main motivation: To develop novel experimental paradigms that could instantiate and capture creativity without sacrificing its dynamic nature



General Introduction

Thesis Organization — Research Questions

Literature review Palhares, Sas, & Gonçalves (2024)	Why study creativity through music	• What unique affordances does music offer for studying states consciousness and creativity?
Study 1 Palhares, Branco, & Gonçalves (2022) **Study 2** Palhares, Branco, & Gonçalves (under review)	What creativity *feels* like (Mental states) What creativity *produces* (Creative behaviour)	• What is the relationship between mental states and musical creativity? • How is this relationship shaped by expertise?
Study 3 Palhares, D'Ambrosio, & Gonçalves (under review)	What *enables* creativity (Neural processes)	• What brain dynamics underlie creative music performance?

Literature Review

Palhares, Sas, and Gonçalves (2024)

Contents lists available at ScienceDirect

Neuroscience and Biobehavioral Reviews

journal homepage: www.elsevier.com/locate/neubiorev



Music and states of consciousness: A narrative review of the broader significance of music to understanding absorption, mind wandering and creative thought

Pedro T. Palhares [a,b,*], Madalina I. Sas [c], Óscar F. Gonçalves [d]

[a] Proaction Laboratory, Faculty of Psychology and Educational Sciences, University of Coimbra, Portugal
[b] CINEICC, Faculty of Psychology and Educational Sciences, University of Coimbra, Portugal
[c] Centre for Complexity Science, Imperial College London, London, United Kingdom
[d] Brainloop Laboratory, CINTESIS@RISE, CINTESIS.UPT, Universidade Portucalense Infante D. Henrique, Portugal

Palhares, P. T., Sas, M. I., & Gonçalves, Ó. F. (2024). Music and states of consciousness: A narrative review of the broader significance of music to understanding absorption, mind wandering and creative thought. *Neuroscience & Biobehavioral Reviews*, *167*, 105920.

Literature Review

Music as a privileged domain

1. **Music's rich landscape of affordances enables acts of** music listening **and** performance **to uniquely alter conscious states** and facilitate complex conscious experiences.

2. **Musical stimuli and activities allow for versatile, tractable experimental design**

3. Jazz improvisation **reliably instantiates CT in real time,** producing a ***continuous stream of observable and quantifiable creative behaviour***.

Palhares, P. T., Sas, M. I., & Gonçalves, Ó. F. (2024). Music and states of consciousness: A narrative review of the broader significance of music to understanding absorption, mind wandering and creative thought. *Neuroscience & Biobehavioral Reviews*, *167*, 105920.

Study 1

Palhares, Branco, and Gonçalves (2022)

sempre:
Society for Education, Music and Psychology Research

Article

Psychology of Music
1–13
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Mind wandering and musical creativity in jazz improvisation

Pedro T. Palhares[1], Diogo Branco[2] and Óscar F. Gonçalves[1]

Palhares, P. T., Branco, D., & Gonçalves, Ó. F. (2022). Mind wandering and musical creativity in jazz improvisation. *Psychology of Music*, *50*(4), 1212–1224.

Study 1
Method

- **Main goal:** Assess the relationship between mental state and musical creativity

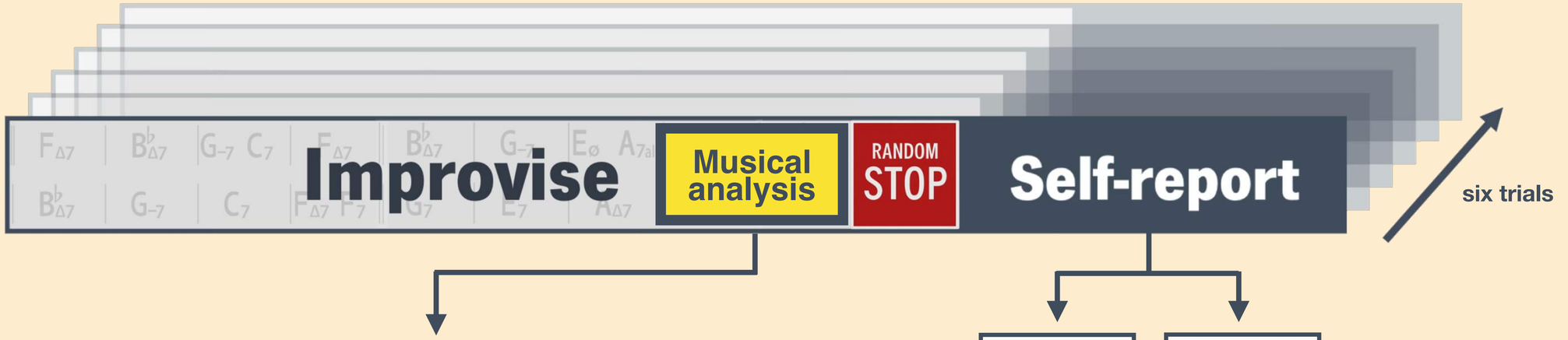
- **Method:** 11 proficient jazz pianists performed a series of jazz improvisation tasks where performance was randomly interrupted by a thought-probe.



Palhares, P. T., Branco, D., & Gonçalves, Ó. F. (2022). Mind wandering and musical creativity in jazz improvisation. *Psychology of Music*, *50*(4), 1212–1224.

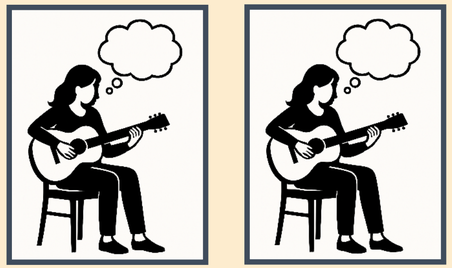
Study 1

Analysis



Two judges rated each trial on:

- **Originality** (ICC = 0.90)
- **Effectiveness** (ICC = 0.84)
- **Overall quality** (ICC = 0.85)



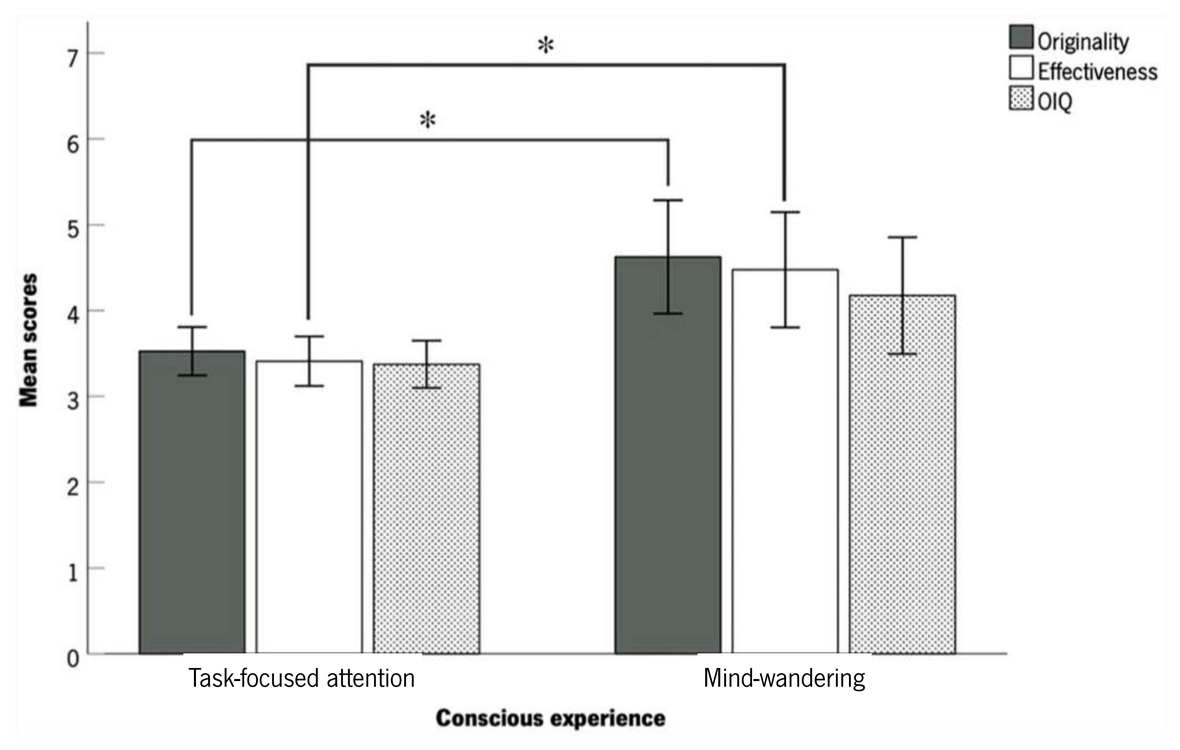
ON-task **OFF-task**

- Perceptual decoupling (1-5)
- Mental navigation (1-5)
- Mental improvisation (1-5)

Intentional Spontaneous

Study 1

Results — Performance ratings by state



Mind wandering was associated with higher creativity, compared to task-focused attention

Note. OIQ = overall improvisational quality

Study 2

Palhares, Branco, & Gonçalves [under review]



Consciousness and Cognition

Mind-wandering facilitates creative performance in a musical improvisation task

--Manuscript Draft--

Manuscript Number:	CONCOG-D-25-00363R1
Article Type:	Full Length Article

Mind-wandering facilitates creative performance in a musical improvisation task

Pedro T. Palhares*[1,2], Diogo Branco[3,4], Óscar F. Gonçalves[5]

[1] Proaction Laboratory, Faculty of Psychology and Educational Sciences, University of Coimbra, Portugal.

[2] CINEICC, Faculty of Psychology and Educational Sciences, University of Coimbra, Portugal.

[3] Faculty of Exact Sciences and Engineering & NOVALINCS, University of Madeira, Portugal.

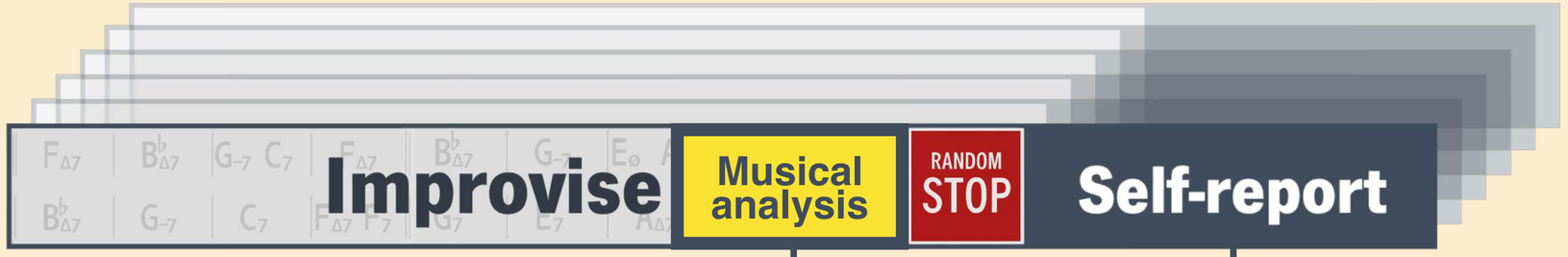
[4] Agência Regional para o Desenvolvimento de Investigação, Tecnologia e Inovação (ARDITI), Portugal.

[5] RISE-HEALTH, Brainloop Laboratory — CINTESIS.UPT, Universidade Portucalense Infante D. Henrique, Portugal

Palhares, P. T., Branco, D., & Gonçalves, Ó. F. (2025). Mind-wandering facilitates creative performance in a musical improvisation task. [Manuscript under review]

Study 2

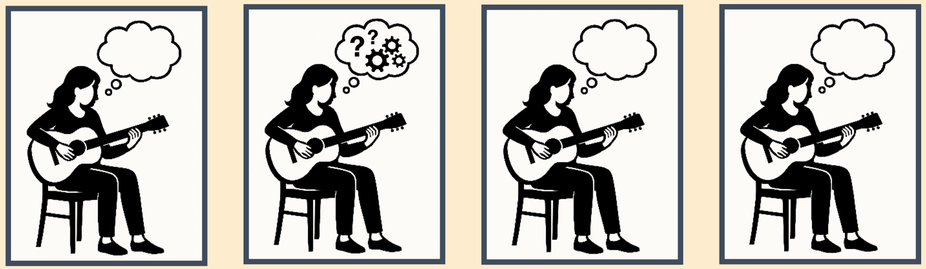
Method



52 jazz musicians with varied levels of expertise performed a similar jazz improvisation task

Two judges rated each trial on:

- <u>Creativity</u> (ICC = 0.77)
- **Originality** (ICC = 0.81)
- **Effectiveness** (ICC = 0.86)
- <u>Expressiveness</u> (ICC = 0.82)
- **Overall quality** (ICC = 0.88)

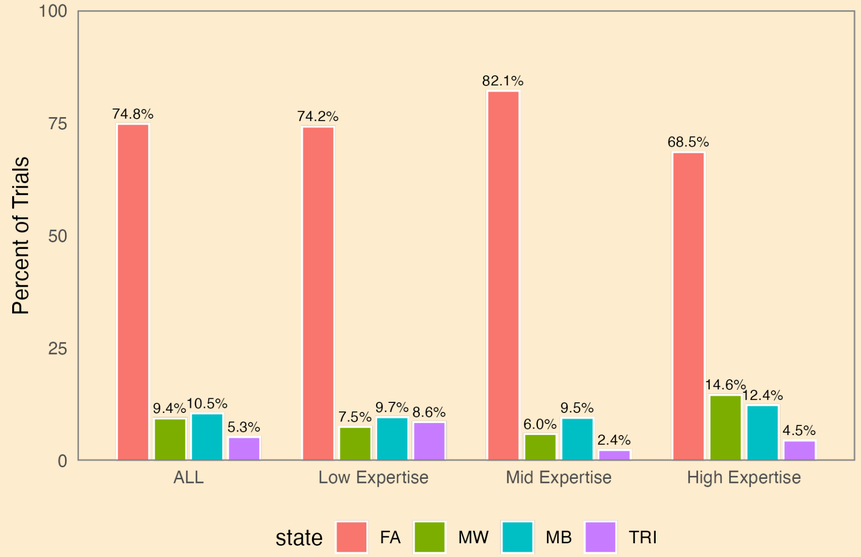


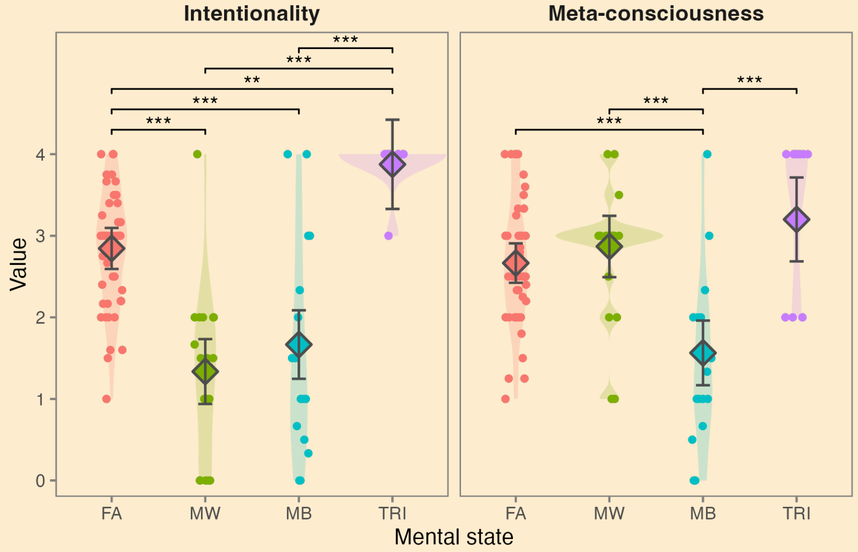
- Perceptual decoupling (1-5)
- Mental navigation (1-5)
- Mental improvisation (1-5)

- Intentionality (1-5)
- Meta-consciousness (1-5)

Study 2

Results — Mental state profiles



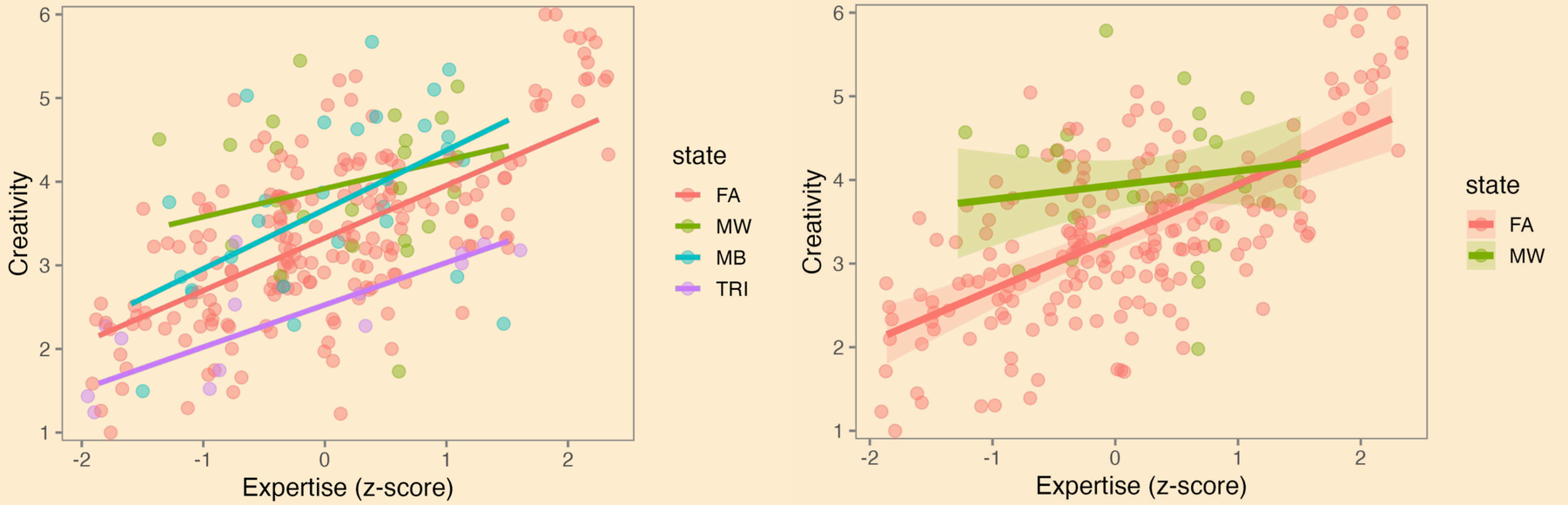


Focused attention was the most reported state

<u>Mental states were phenomenologically distinct</u>

Study 2

Results — Model-predicted creativity



Functional heterogeneity across states in their relationship with creativity:

*mind-wandering > mind-blanking > **focused attention** > task-related interference*

Expertise moderated effects

Study 3

Palhares, D'Ambrosio, and Gonçalves [under review]



bioRxiv

THE PREPRINT SERVER FOR BIOLOGY

New Results

TMS-EEG reveals causal dynamics of the premotor cortex during musical improvisation

Pedro T. Palhares, Sasha D'Ambrosio, Óscar F. Gonçalves

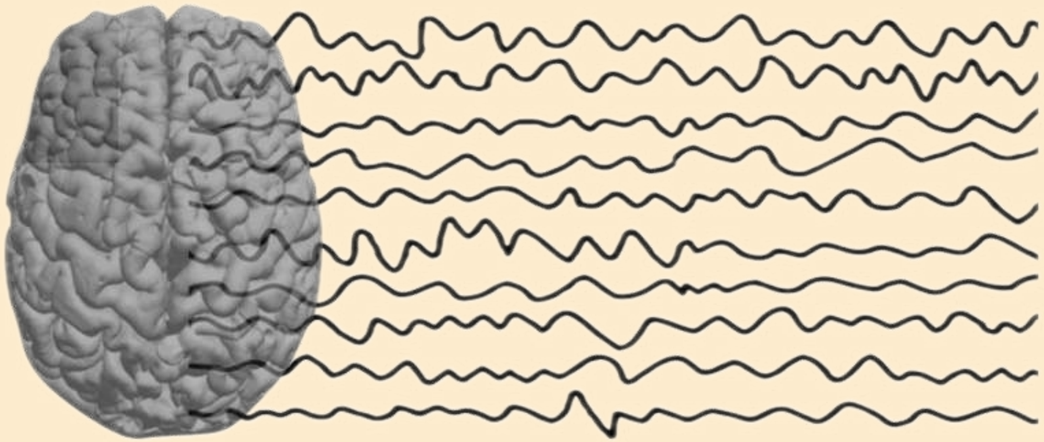
doi: https://doi.org/10.1101/2025.10.04.680222

Palhares, P. T., D'Ambrosio, S., & Gonçalves, Ó. F. (2025). TMS-EEG reveals causal dynamics of the premotor cortex during musical improvisation. [Manuscript under review at Annals of the New York Academy of Sciences]

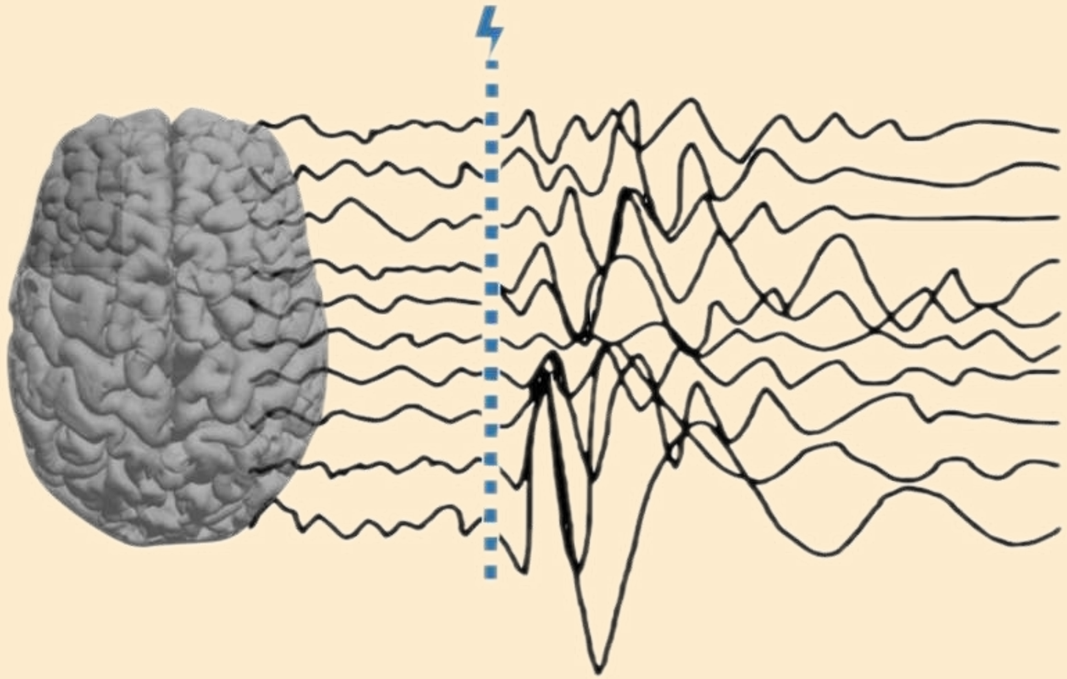
Study 3

Background — Why TMS-EEG?

Spontaneous EEG



Perturbational EEG

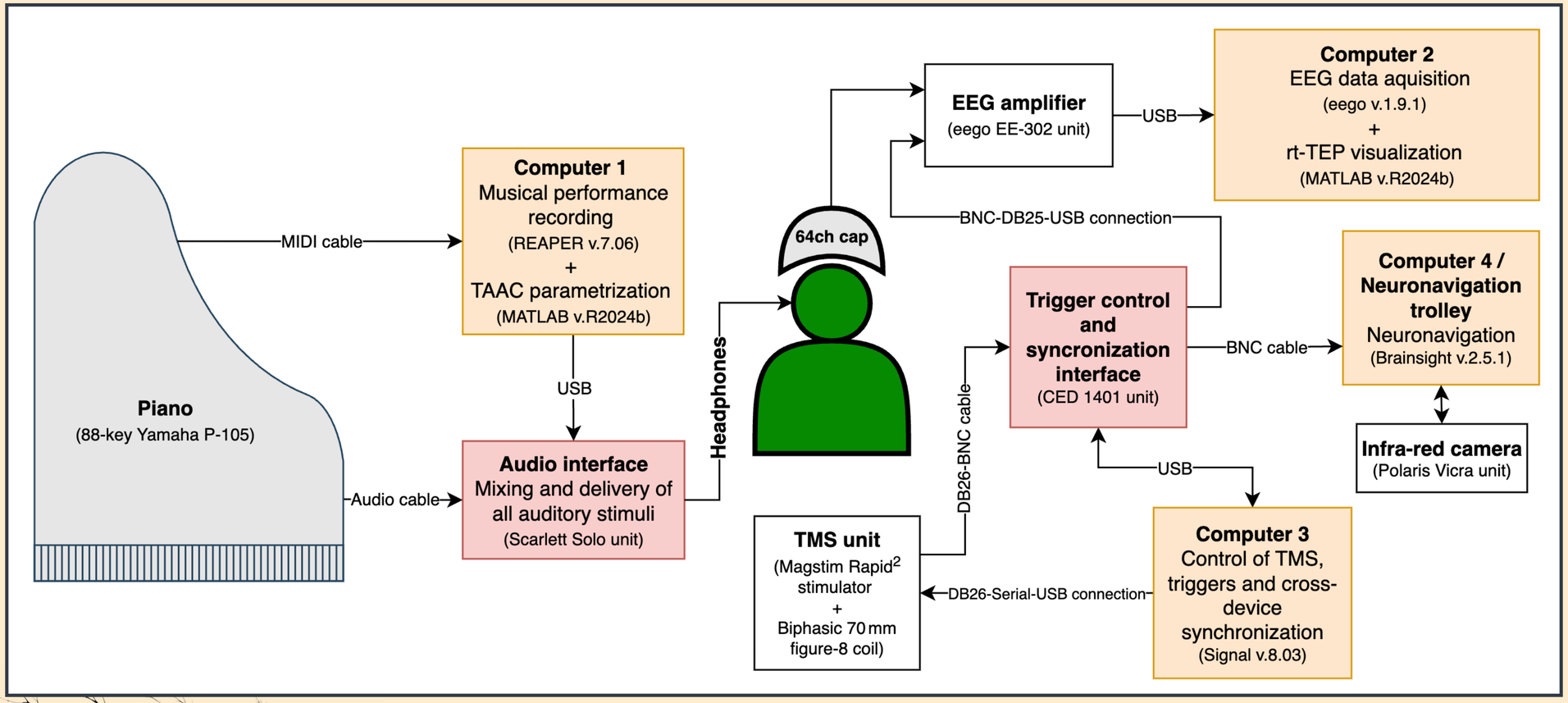


Note. From “The spatiotemporal evolution of TMS-evoked potentials reflects direct cortical activation” by M. Fecchio et al., 2025, *bioRxiv*

Study 3

Main goals

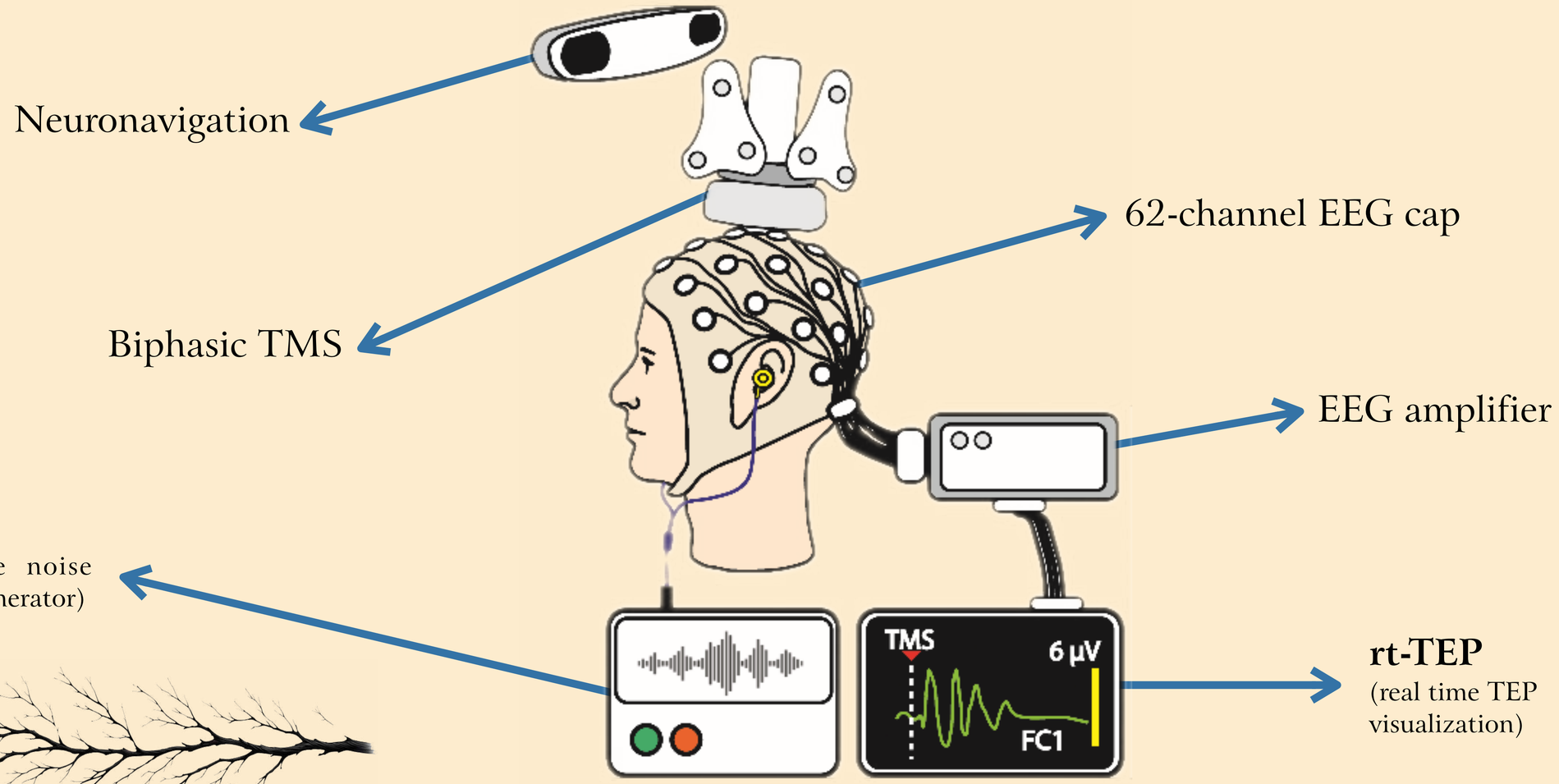
1. Successfully conducting TMS-EEG data acquisition during musical performance



Study 3

Main goals

1. **Successfully conducting TMS-EEG data acquisition during musical performance**



Study 3
Main goals

1. Successfully conducting TMS-EEG data acquisition during musical performance ✅

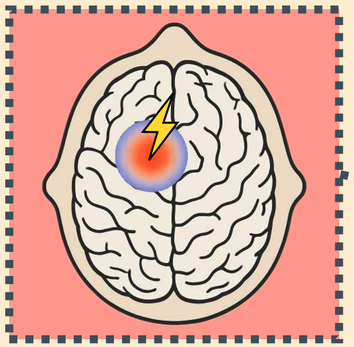
2. **Using TMS-EEG to probe intrinsic properties of the *premotor cortex* during acts of musical improvisation and sight reading**

    2.1. **Local properties —** Local Mean Field Power, Phase-locking Factor, Correlated Components Analysis

    2.2. **Global properties —** Perturbational Complexity Index (PCI)

Study 3

Method (n = 5 professional jazz pianists)



ROI: Left dorsal premotor cortex

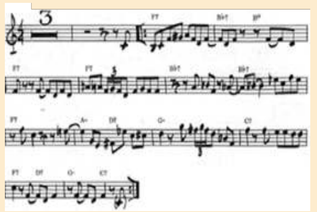
Stimulation parameters: 200 pulses/condition (110–115% RMT); <2 mm spatial error, <1° angular deviation



Piano improv.



Sight-reading



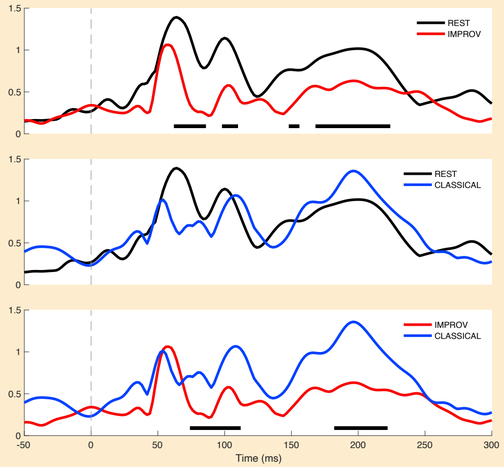
Resting state



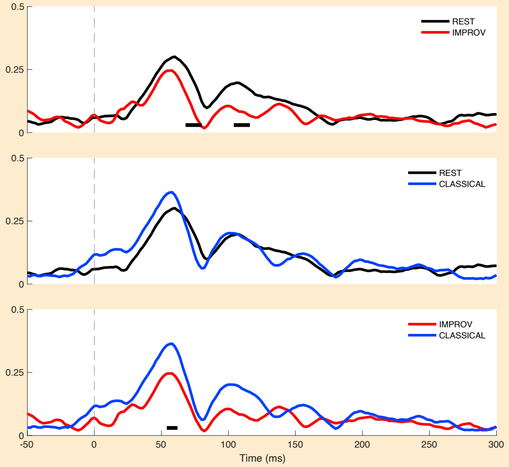
Study 3

Results — Local measures (premotor cortex)

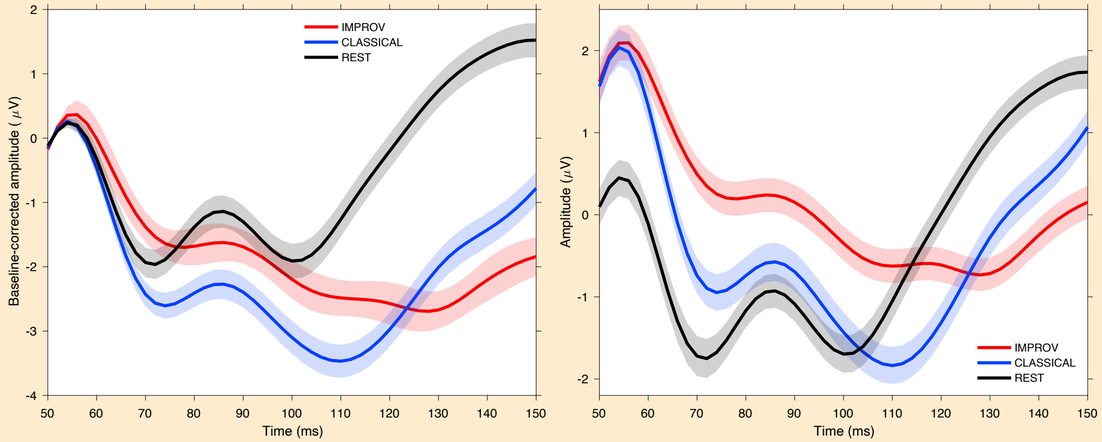
Local Mean-Field Power



Phase-locking Factor



Correlated Components Analysis



<u>Distinct PMd perturbational signature during improvisation</u>:

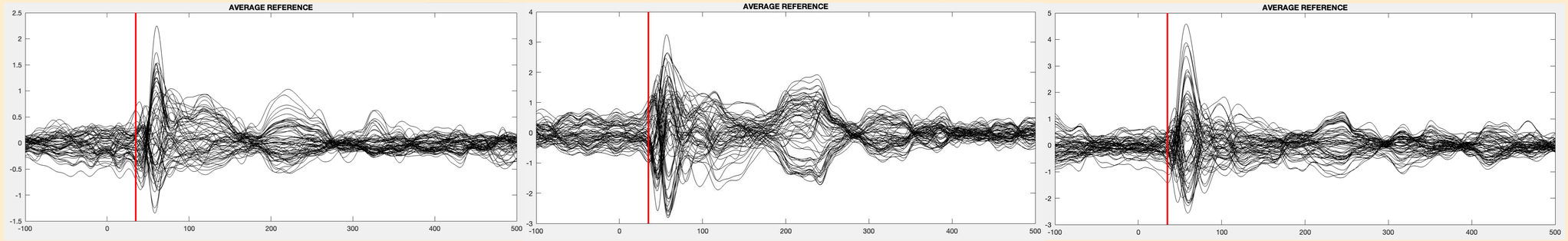
reduced excitability, increased response variability, but preserved early component structure

PMd maintains its fundamental computational architecture but operates in a less excitable, more selective regime during improvisation

Study 3

Results — Global brain complexity

Rest | Sight-reading | Improvisation



<u>Improvisation was associated with the lowest levels of brain complexity:</u>

Rest > Sight-reading > Improvisation

Expert-level creative cognition involves cortical efficiency rather than complexity

Note. In each butterfly plot, each trace corresponds to the average TEP of a single EEG channel in a representative subject

General Discussion

Main contributions

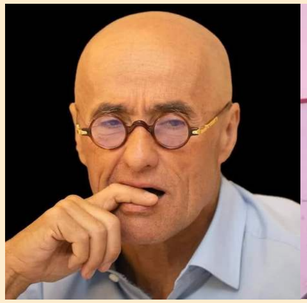
	Methodological	Empirical	Conceptual
Study 1 ***Study 2***	Real-time experience sampling linking mental states to creative output	Mind-wandering enhances ongoing creative performance	Spontaneous thought has adaptive value in ecological contexts
Study 2	Refined multi-dimensional state taxonomy	Functional differences within on/off-task states	Expansion of Dynamic Framework of Thought
Study 3	First TMS-EEG application during complex motor performance	Causal evidence of PMC dynamics during creative cognition	Creative states involve cortical efficiency, not complexity



What *enables* creativity
(Neural processes)

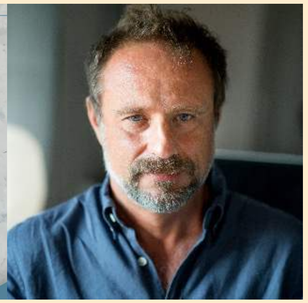
Music is a privileged window into consciousness and creativity

Acknowledgements









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PORTA JAZZ

CONSERVATÓRIO DE MÚSICA DE COIMBRA

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academia VALENTIM DE CARVALHO

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Thank you for your attention!