camh
Krembil Centre for Neuroinformatics

UNIVERSITY OF TORONTO

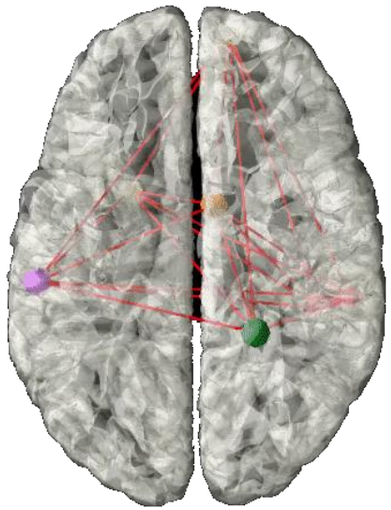
Whole Brain Modelling

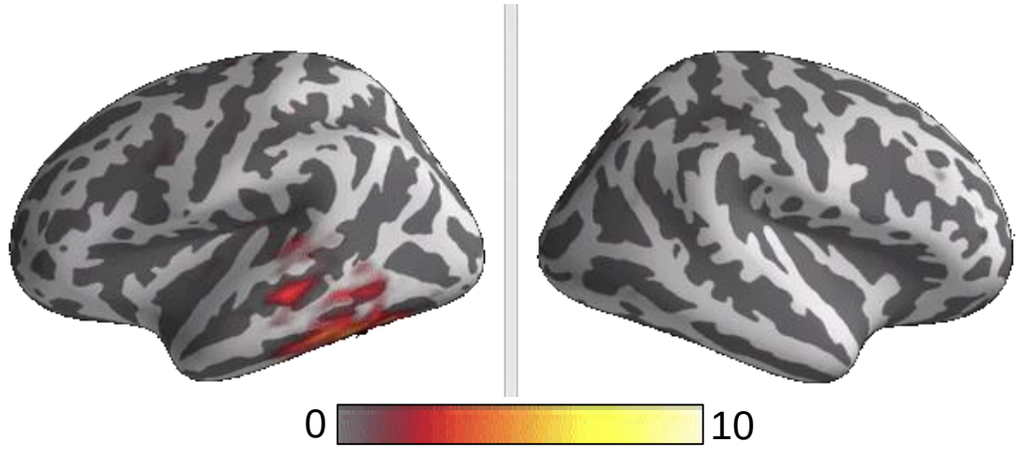
Modelling large-scale brain network dynamics underlying the TMS-EEG evoked response

DAVIDE MOMI
Post-Doctoral Research Fellow
Whole Brain Modelling Group
Krembil Centre for Neuroinformatics
Centre for Addiction & Mental Health(CAMH)
https://davi1990.github.io/
250 College St., Toronto, ON M5T 1R8

@DaveMomi

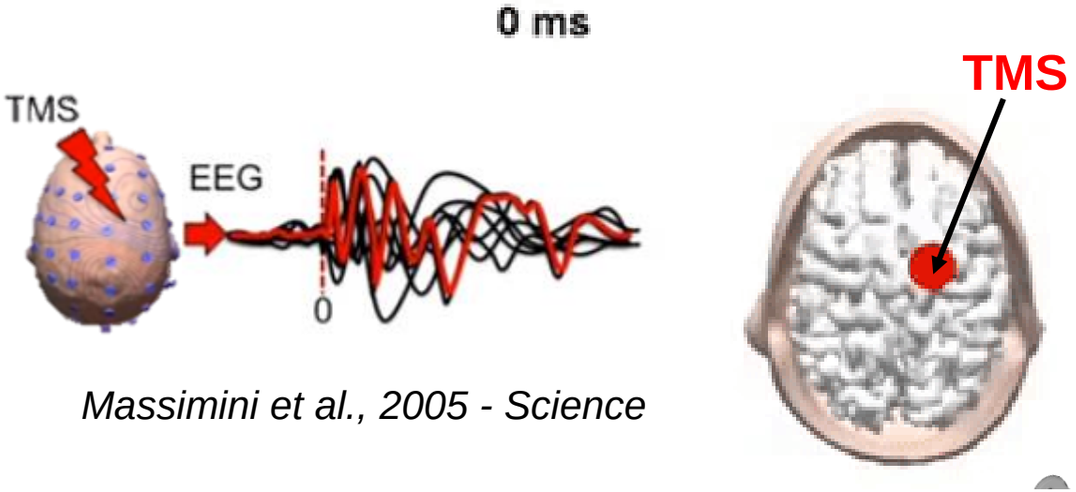
GitHub
@Davi1990



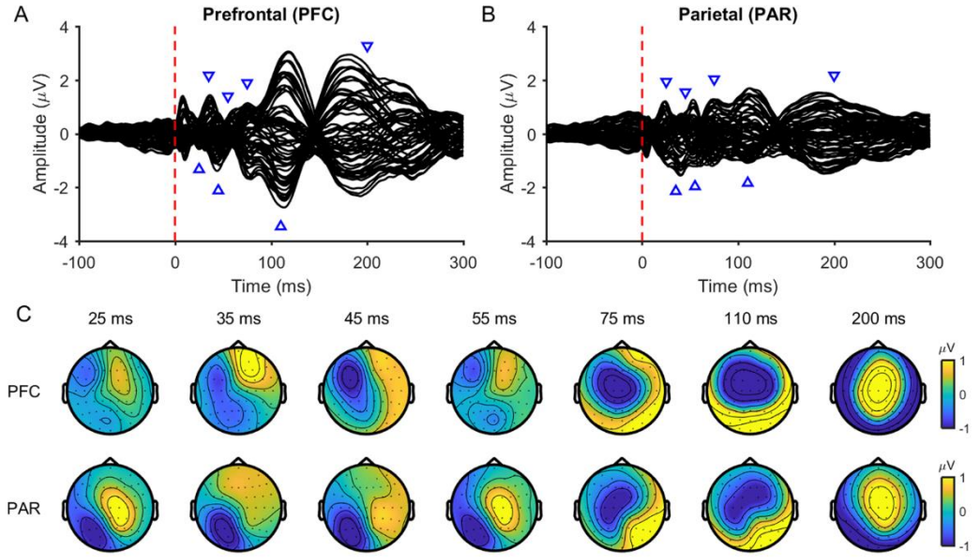


4th International Brain Stimulation Conference 2021
Charleston, South Carolina, USA
9th December 2021

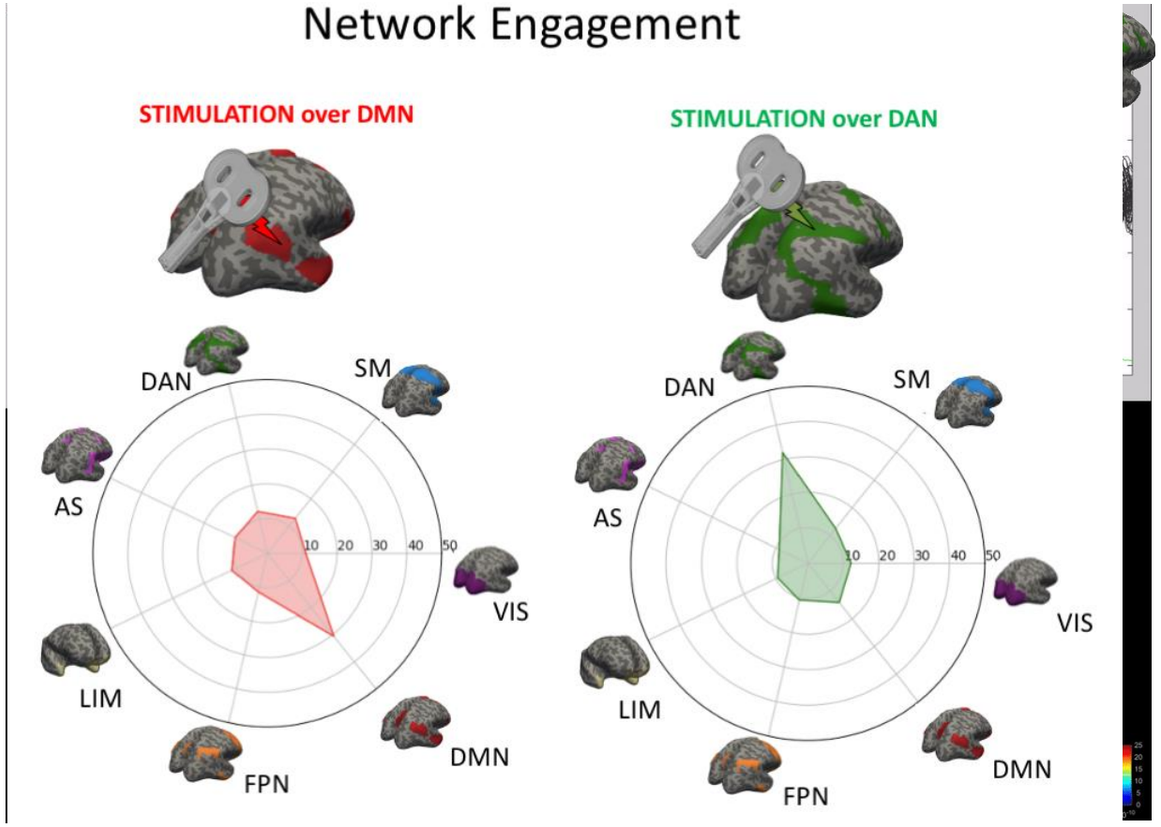
TMS-evoked activity propagates across networks



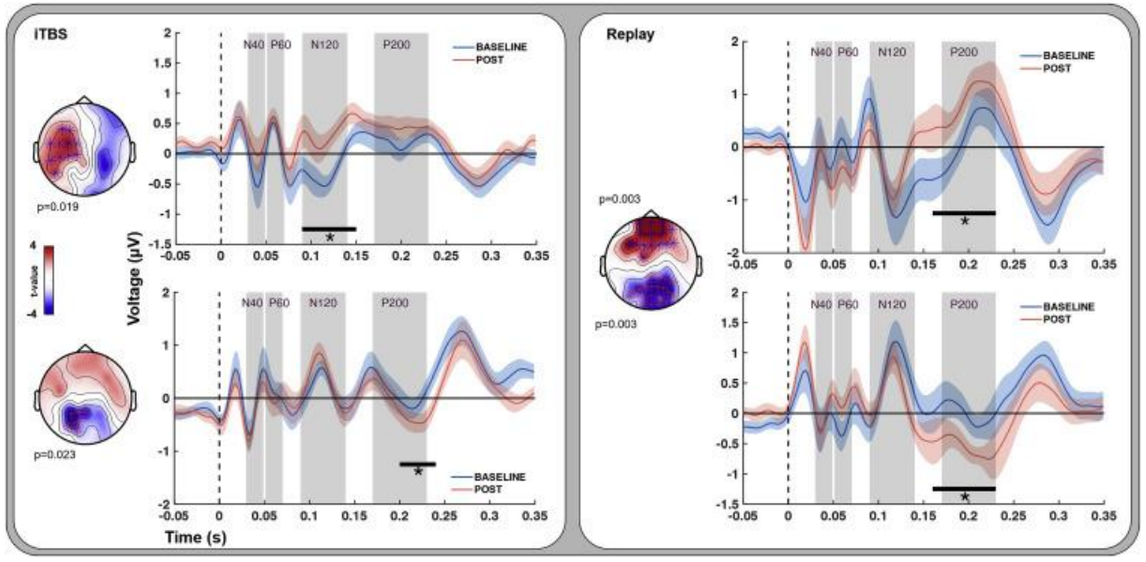
Massimini et al., 2005 - Science



Rogash et al., 2020 – Scientific Reports



Momi et al., 2020 – NeuroImage



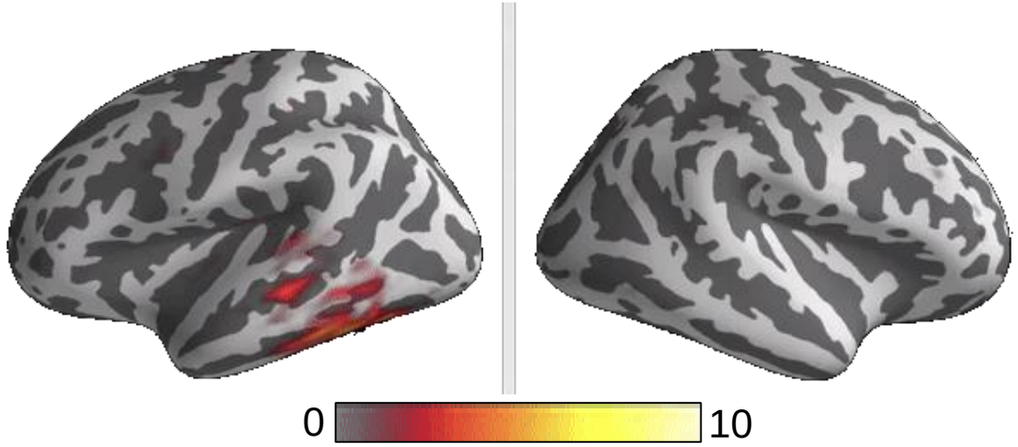
Zrenner et al., 2020 – Brain Stimulation

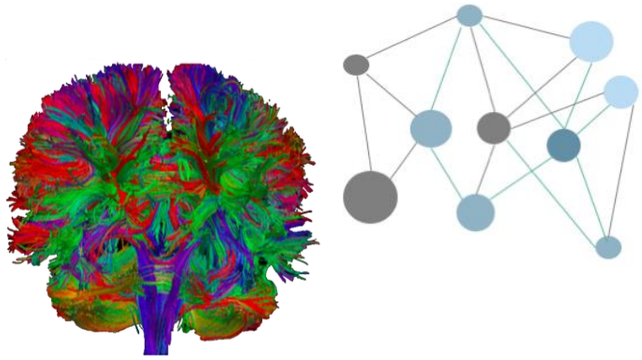
Özdemir, Momi et al., 2020 – PNAS

TMS-EEG responses are highly variable across subjects

Scientific Questions

#1: Are the TEPs due to a local/single node echo of the stimulation or a global/network reverberation?

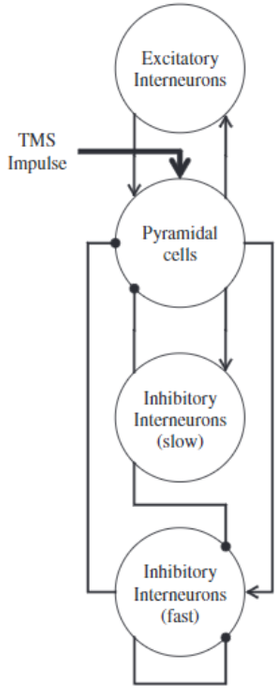


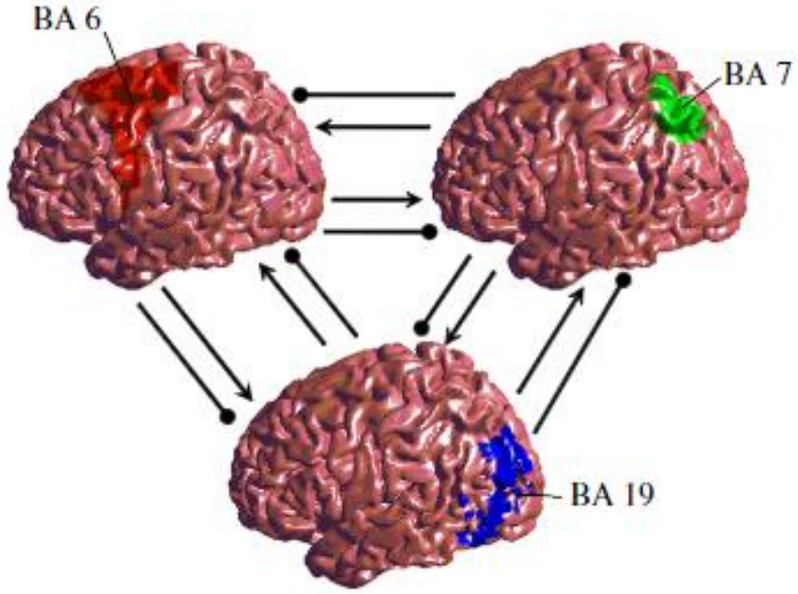


#2: What's the role of the nodes and their connections in shaping the propagation of the TMS-induced signal?

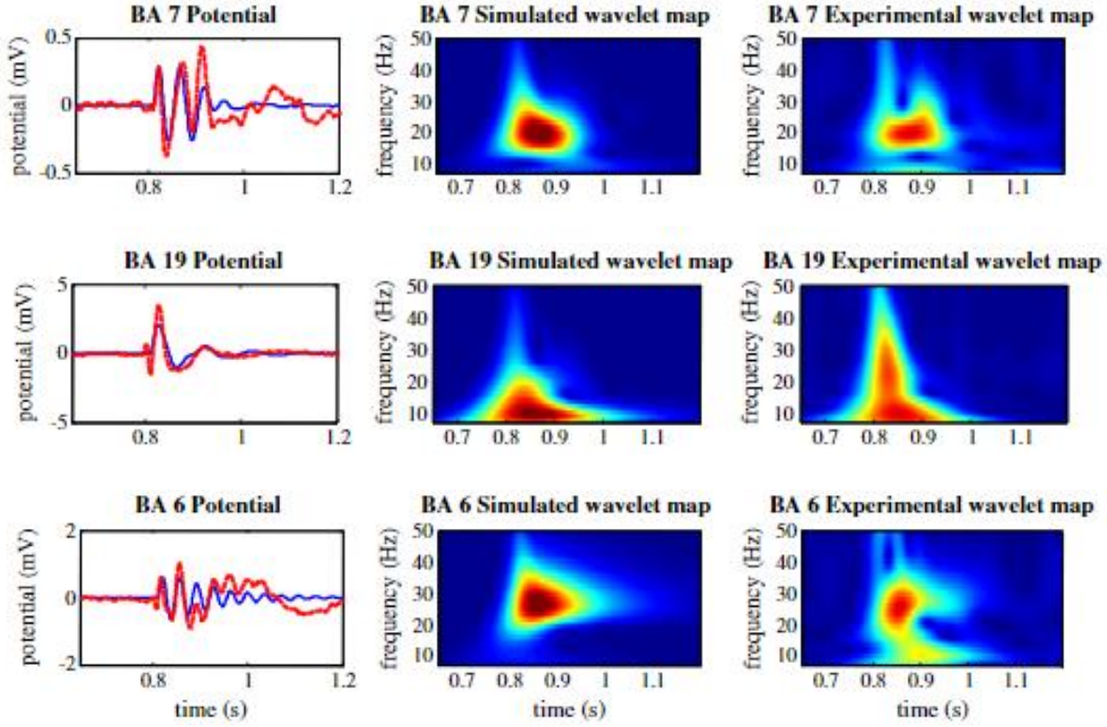
#3: Can the model parameters allow to cluster the subjects based on their TEPs?

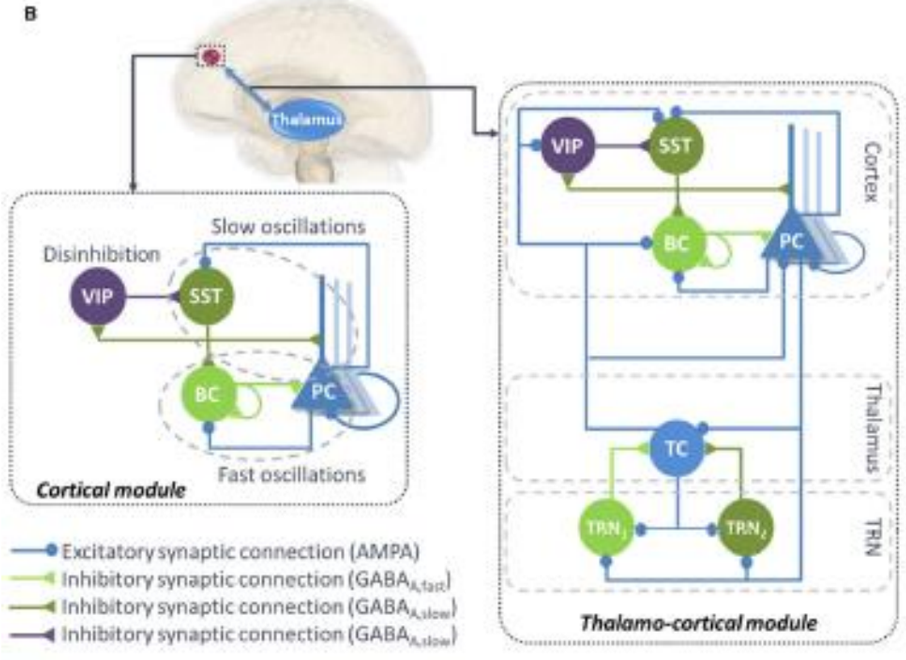
Previous computational models of TMS-EEG

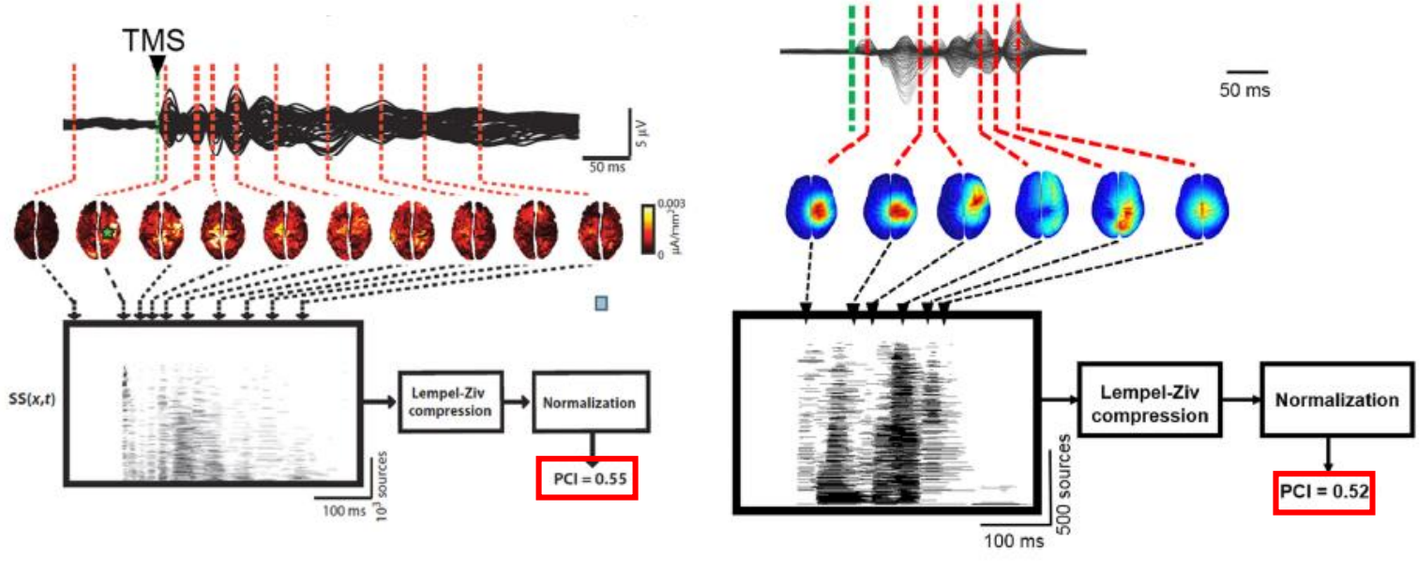




Cona et al., 2011 – NeuroImage



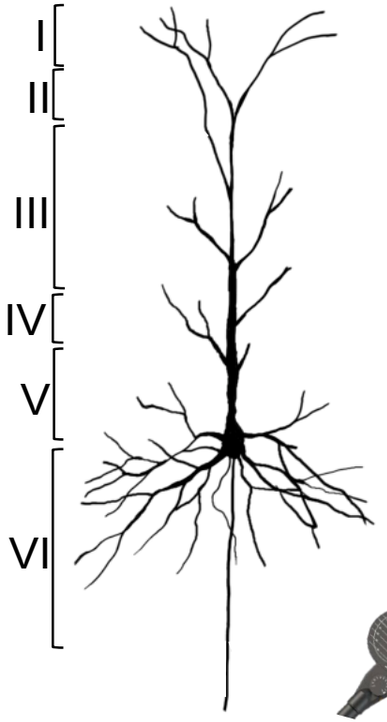


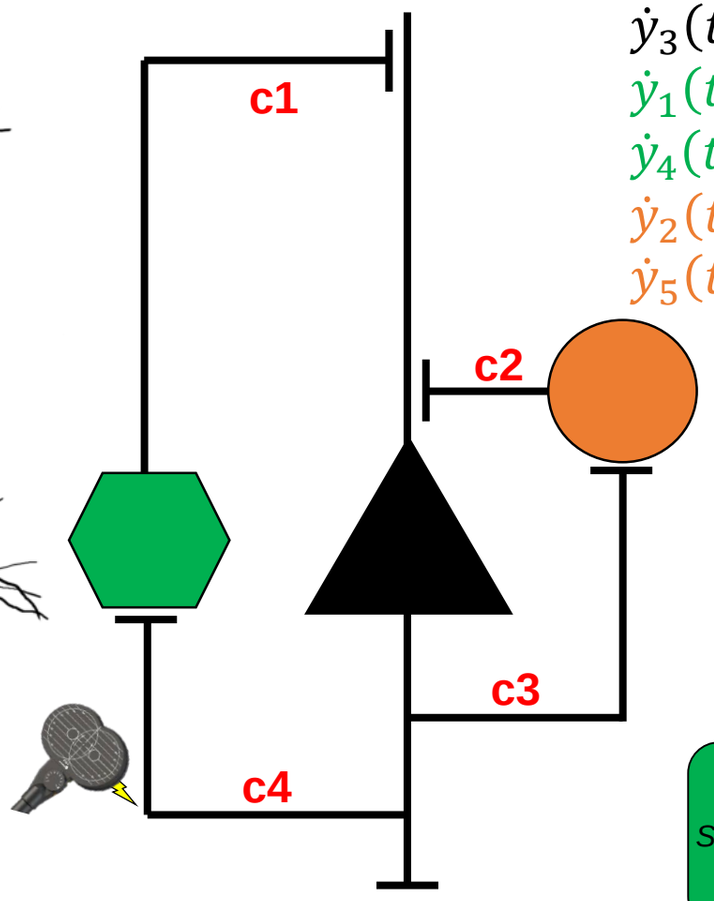


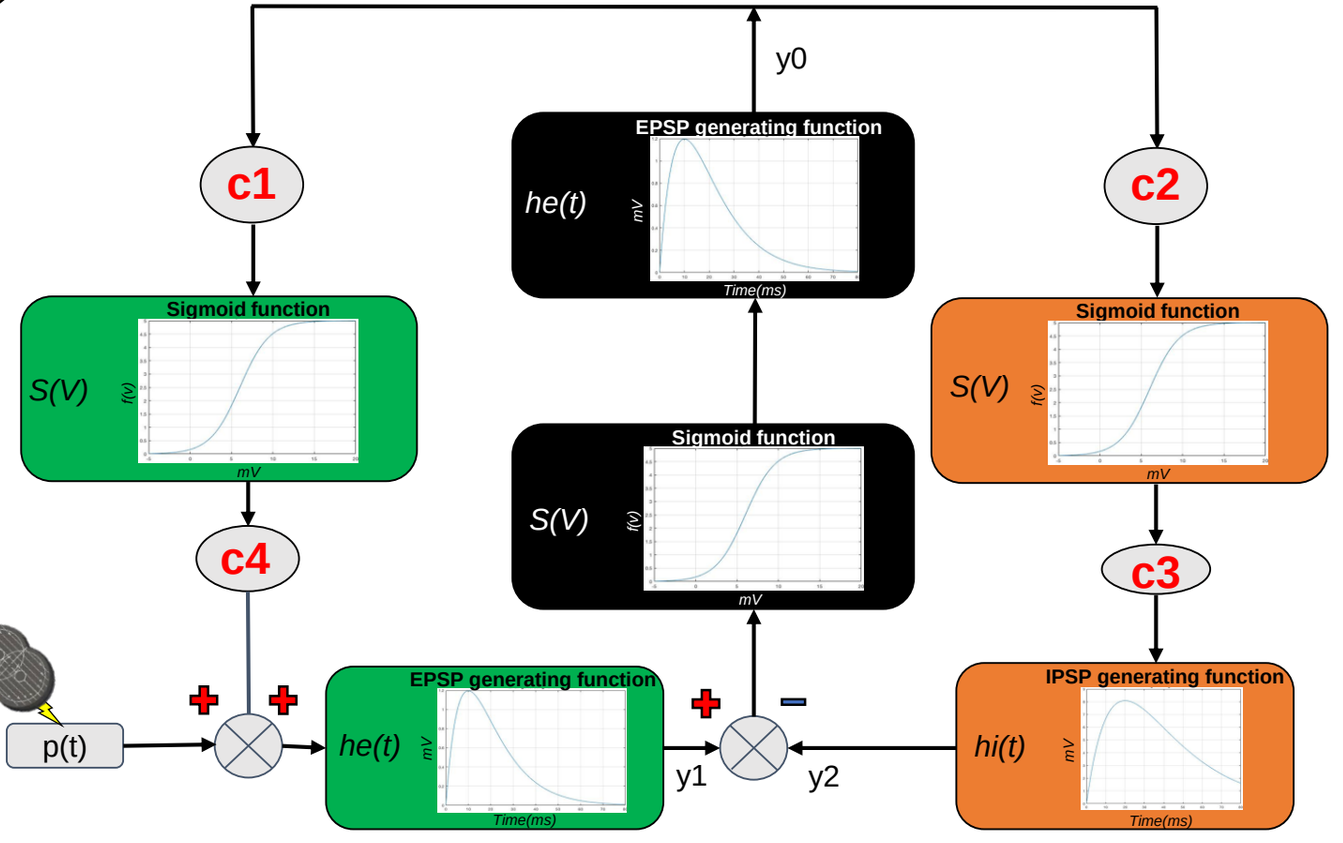
Bensaid et al., 2019 – Frontiers in System Neuroscience

Jansen-Rit model (1995)

$$\dot{y}_0(t) = y_3(t)$$
$$\dot{y}_3(t) = AaSigm[y_1(t) - y_2(t)] - 2ay_3(t) - a^2 y_0(t)$$
$$\dot{y}_1(t) = y_4(t)$$
$$\dot{y}_4(t) = Aa(p(t) + C_2 Sigm[C_1 y_0(t)]) - 2ay_4(t) - a^2 y_1(t)$$
$$\dot{y}_2(t) = y_5(t)$$
$$\dot{y}_5(t) = Bb(C_4 Sigm[C_3 y_0(t)]) - 2by_5(t) - b^2 y_2(t)$$







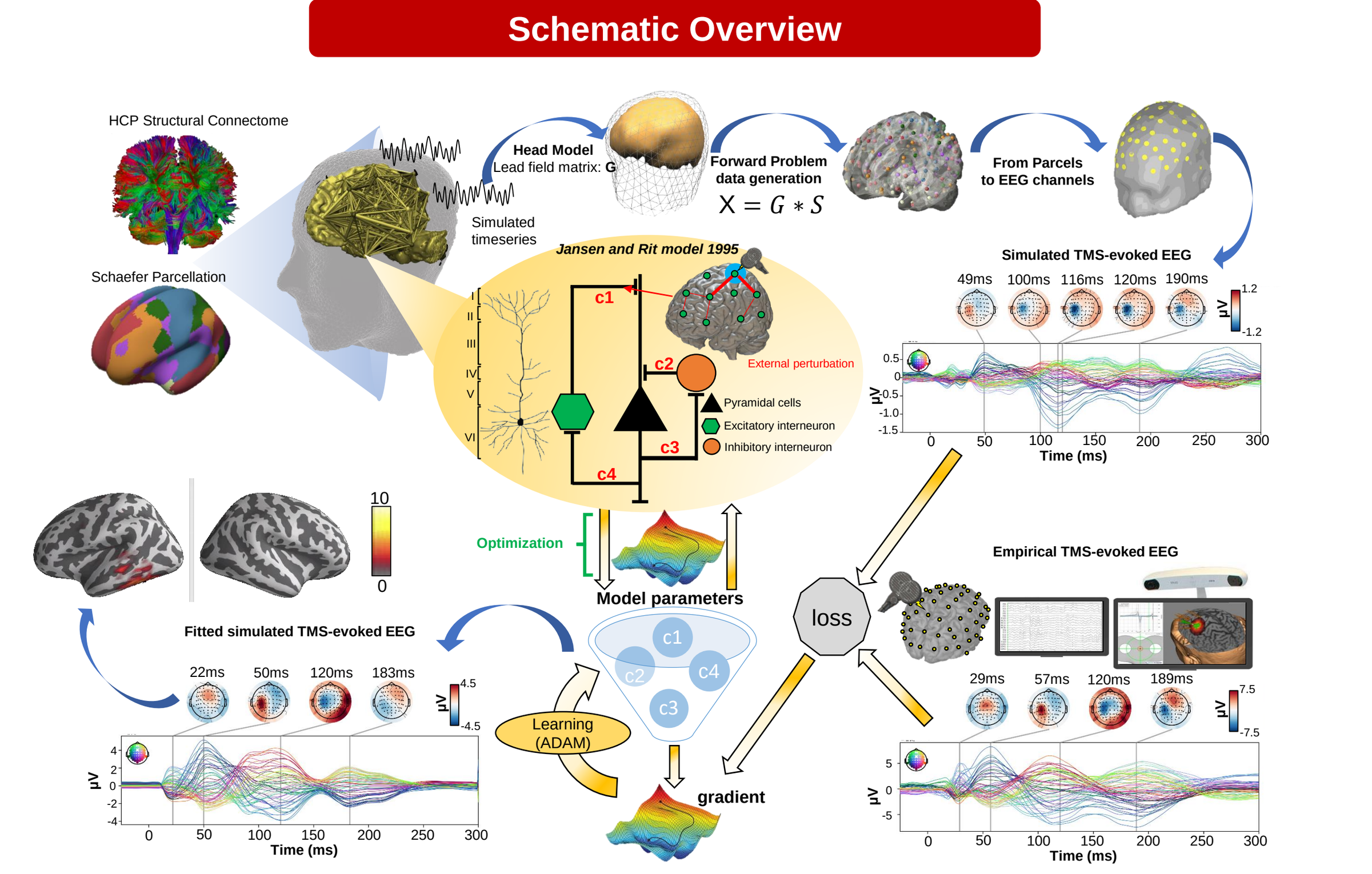
Pyramidal cells

Excitatory interneuron

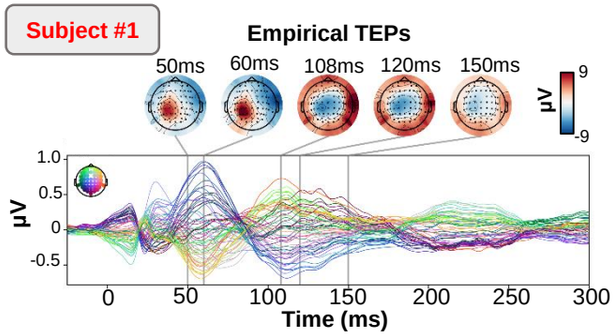
Inhibitory interneuron

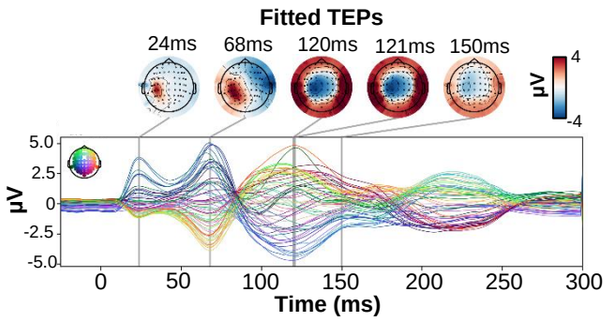
Sorenza Bastiaens

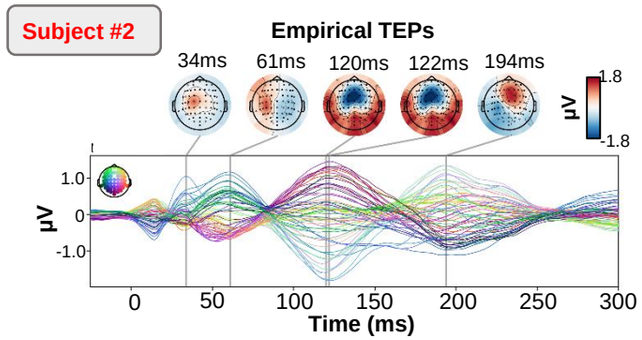
Schematic Overview

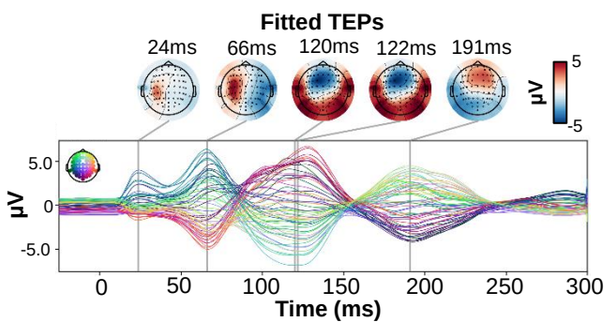


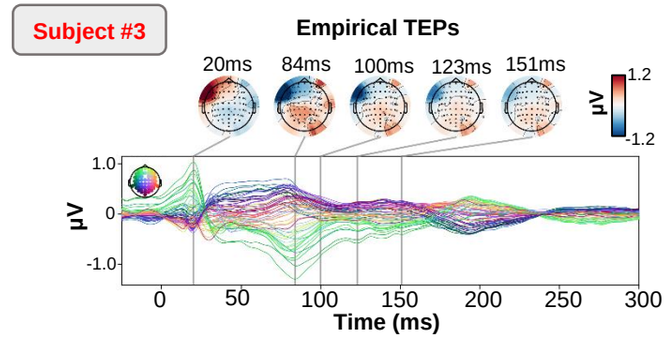
Robust recovery of individual subjects' empirical TEPs propagation patterns in channels space

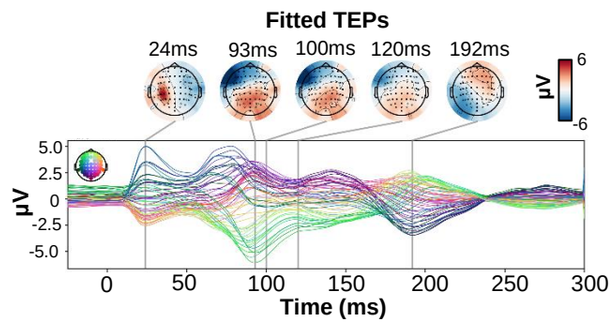


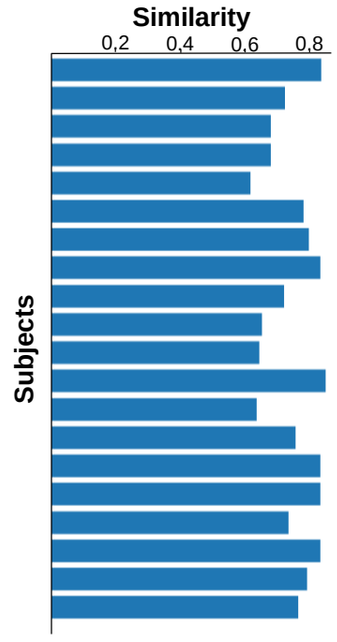


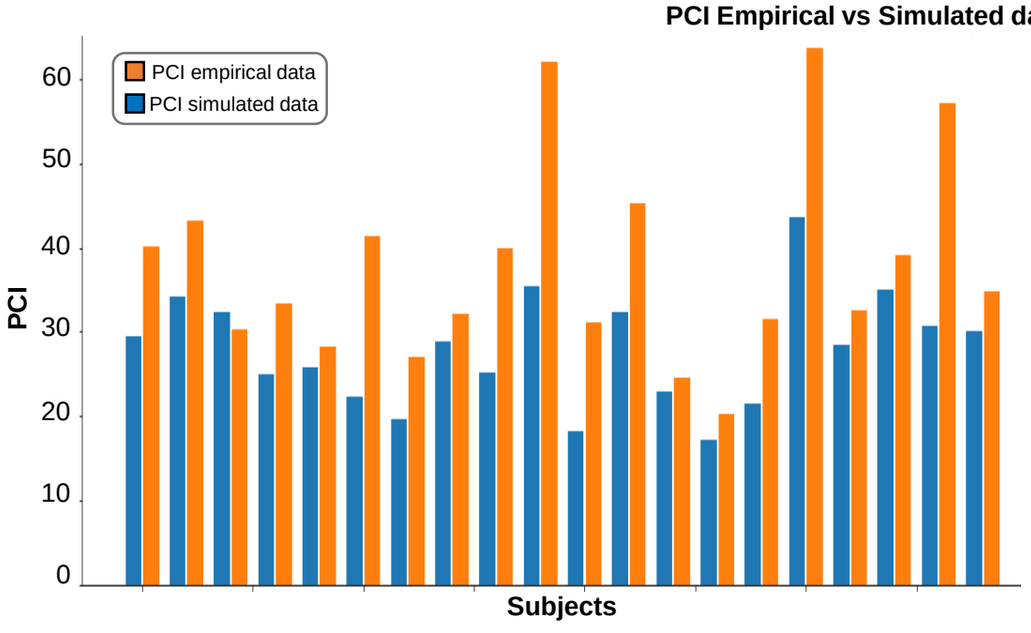


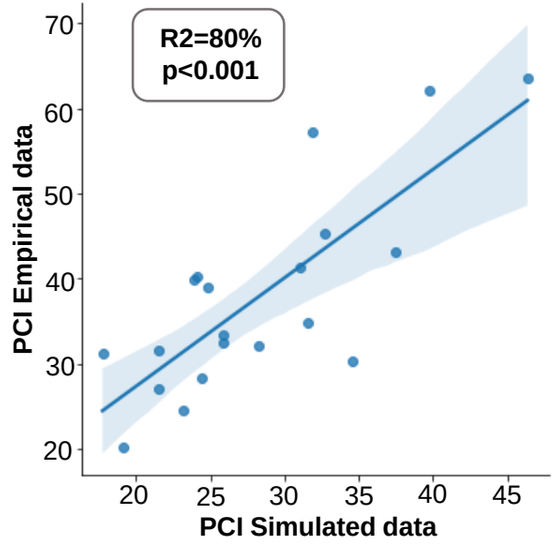


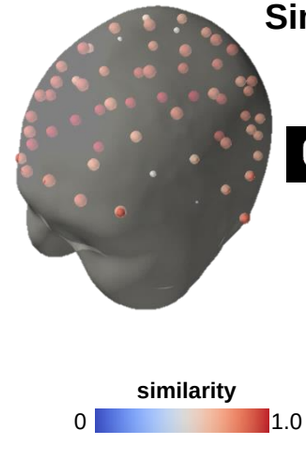






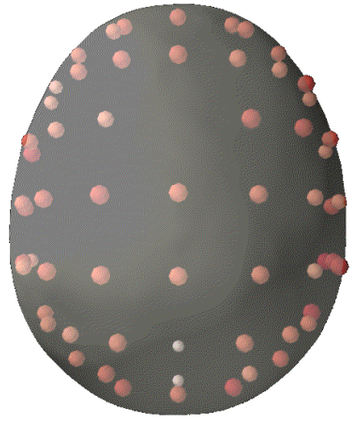




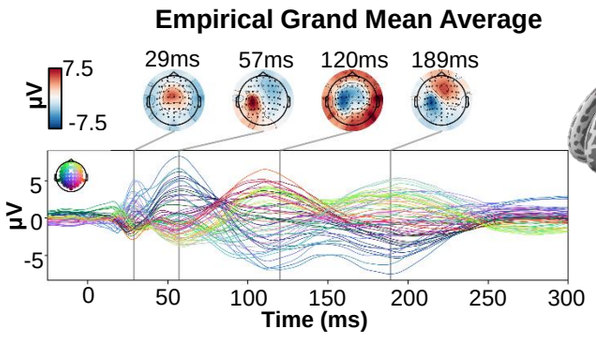


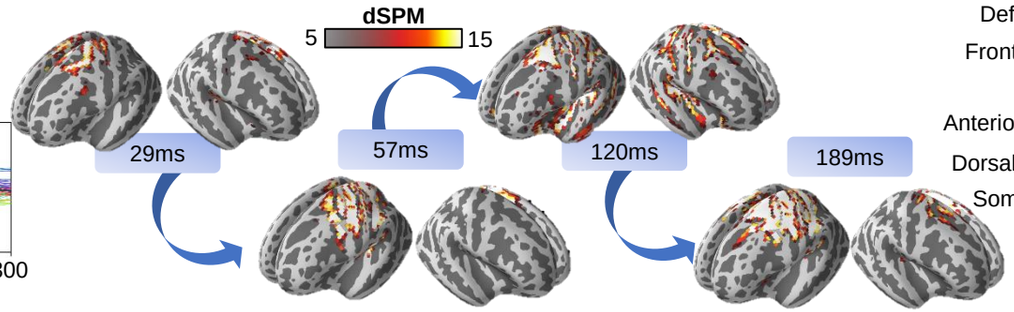
Similarity across channels

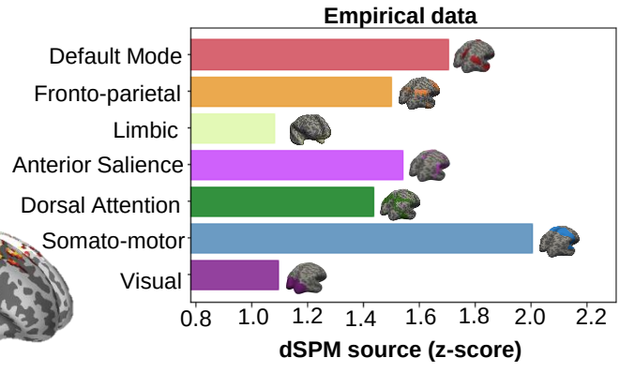
0.02ms/0.03ms

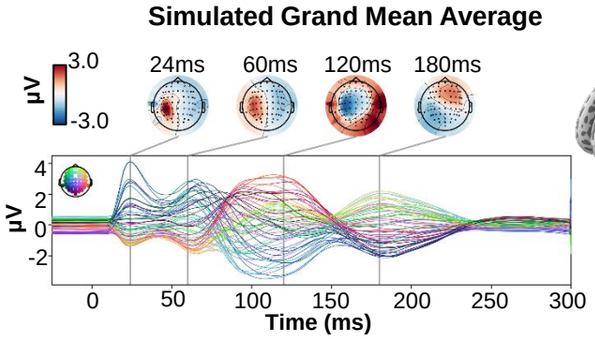


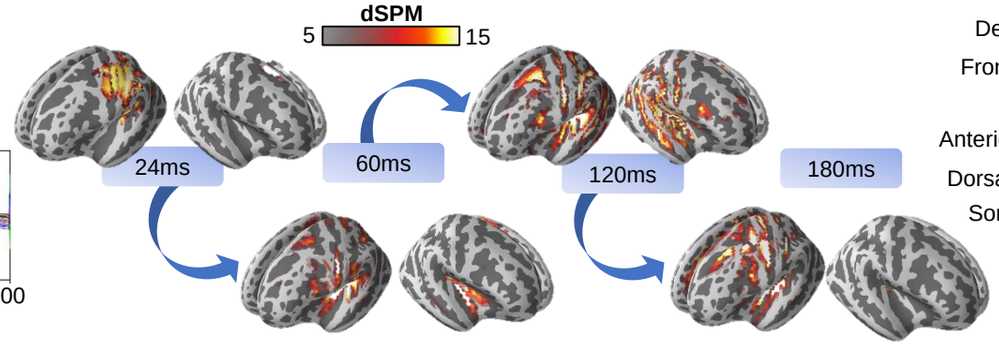
Robust recovery of individual subjects' empirical TEPs propagation patterns in source space

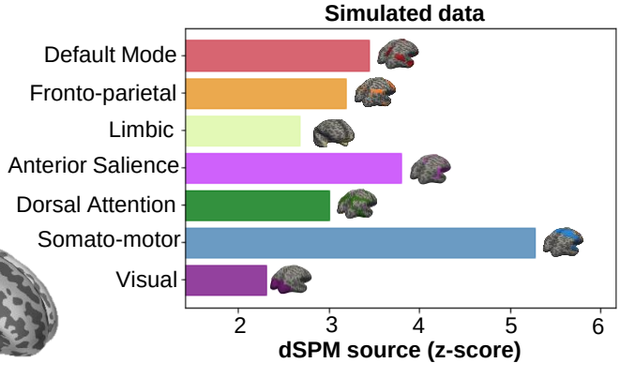




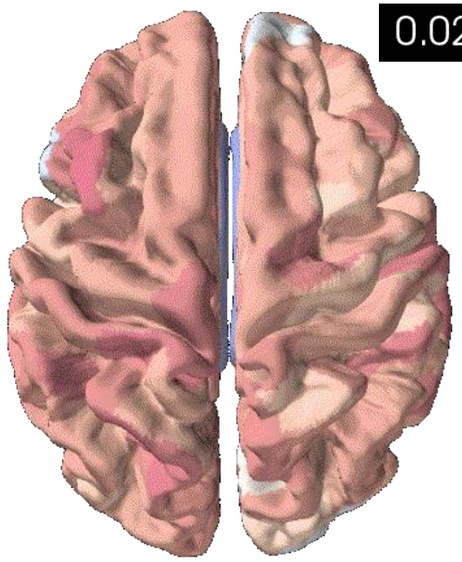




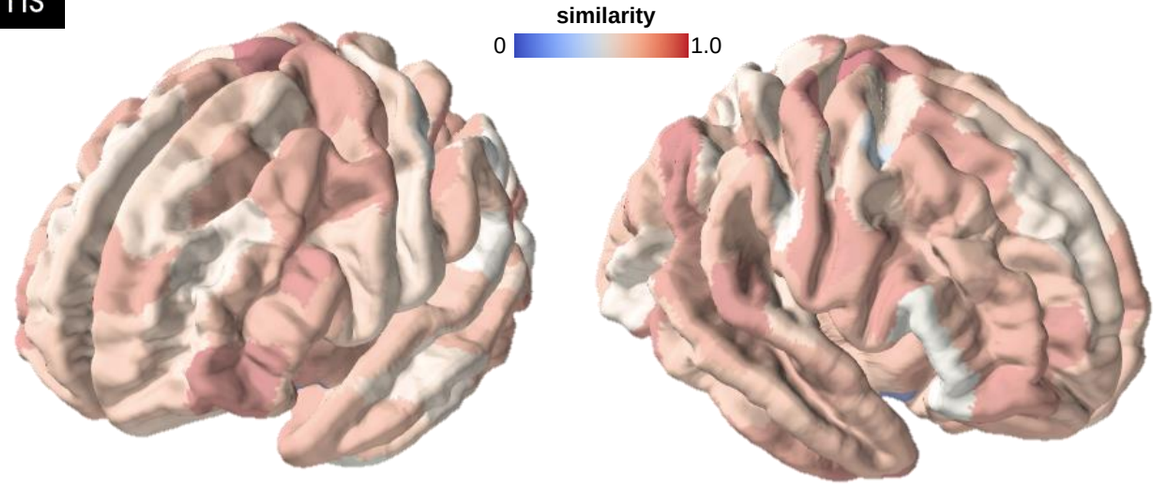




Similarity across nodes

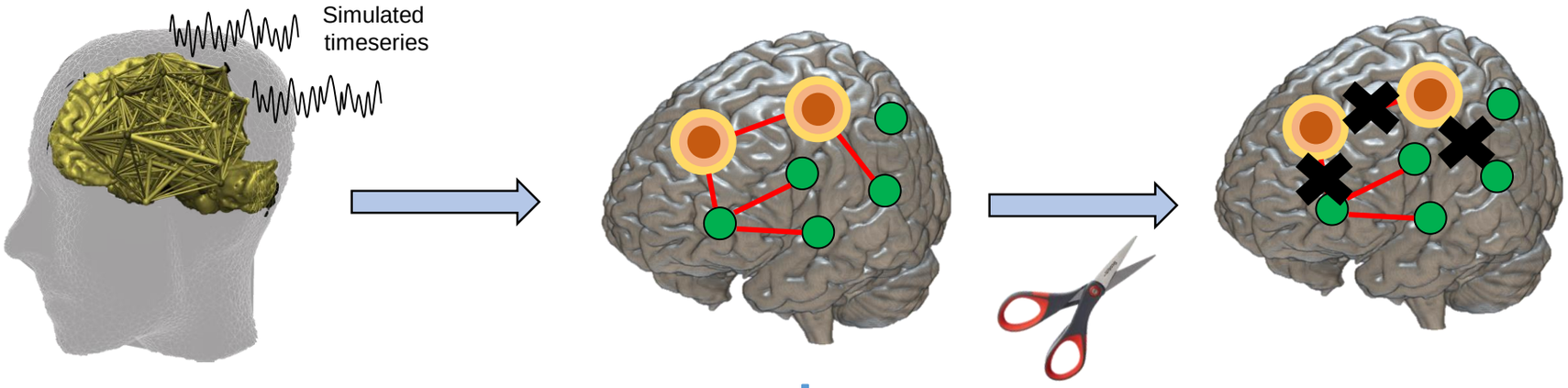


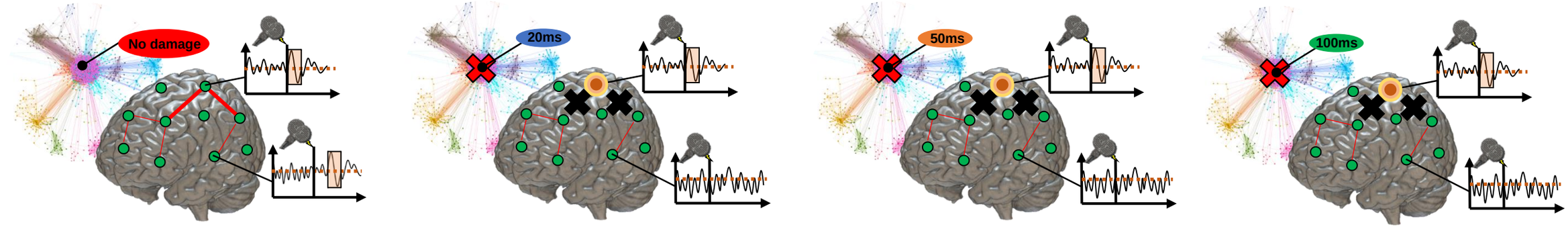
0.02ms/0.03ms



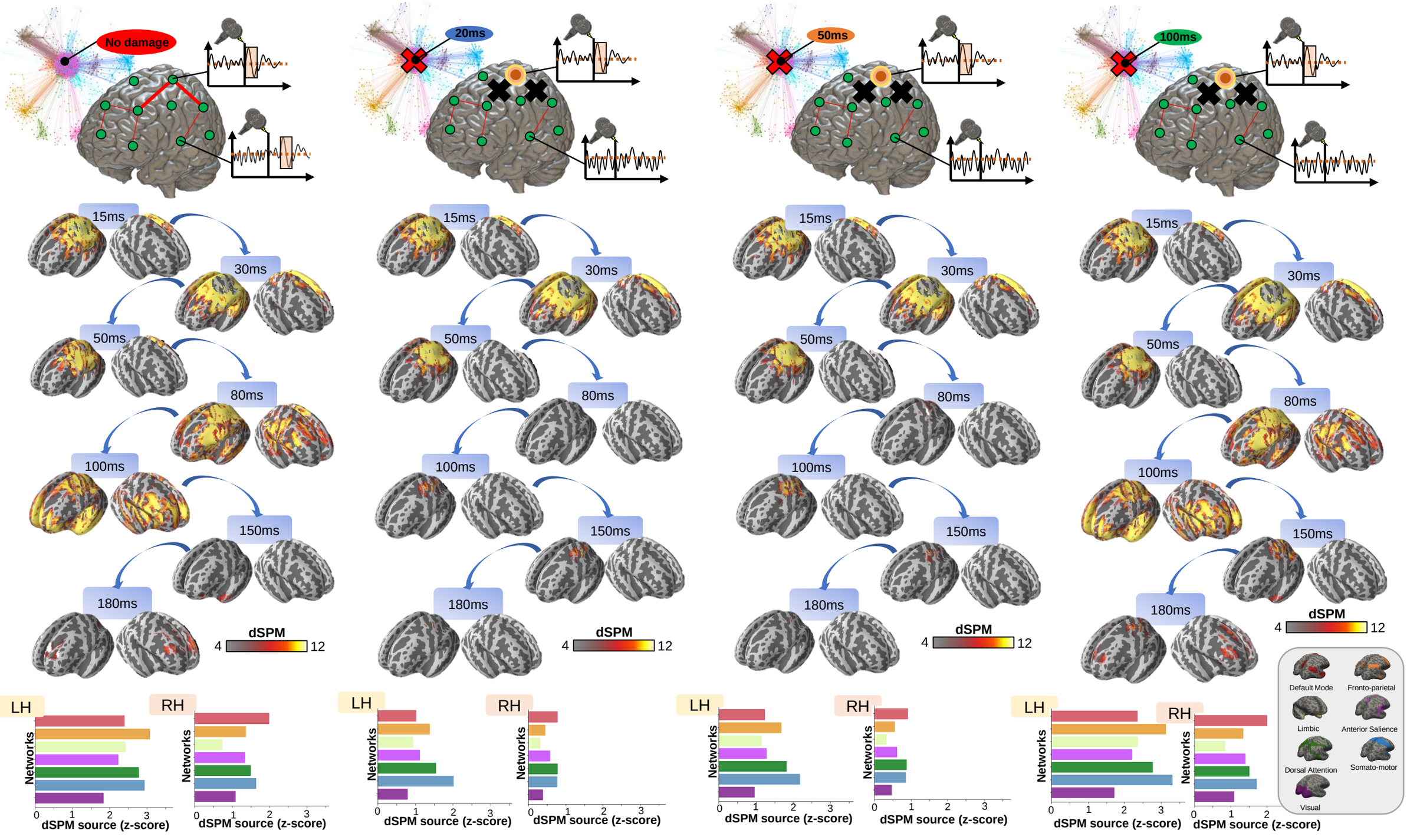
Dissecting the propagation of the TMS-induced signal

#1: Are the TEPs due to a local/single node echo of the stimulation or a global/network reverberation?

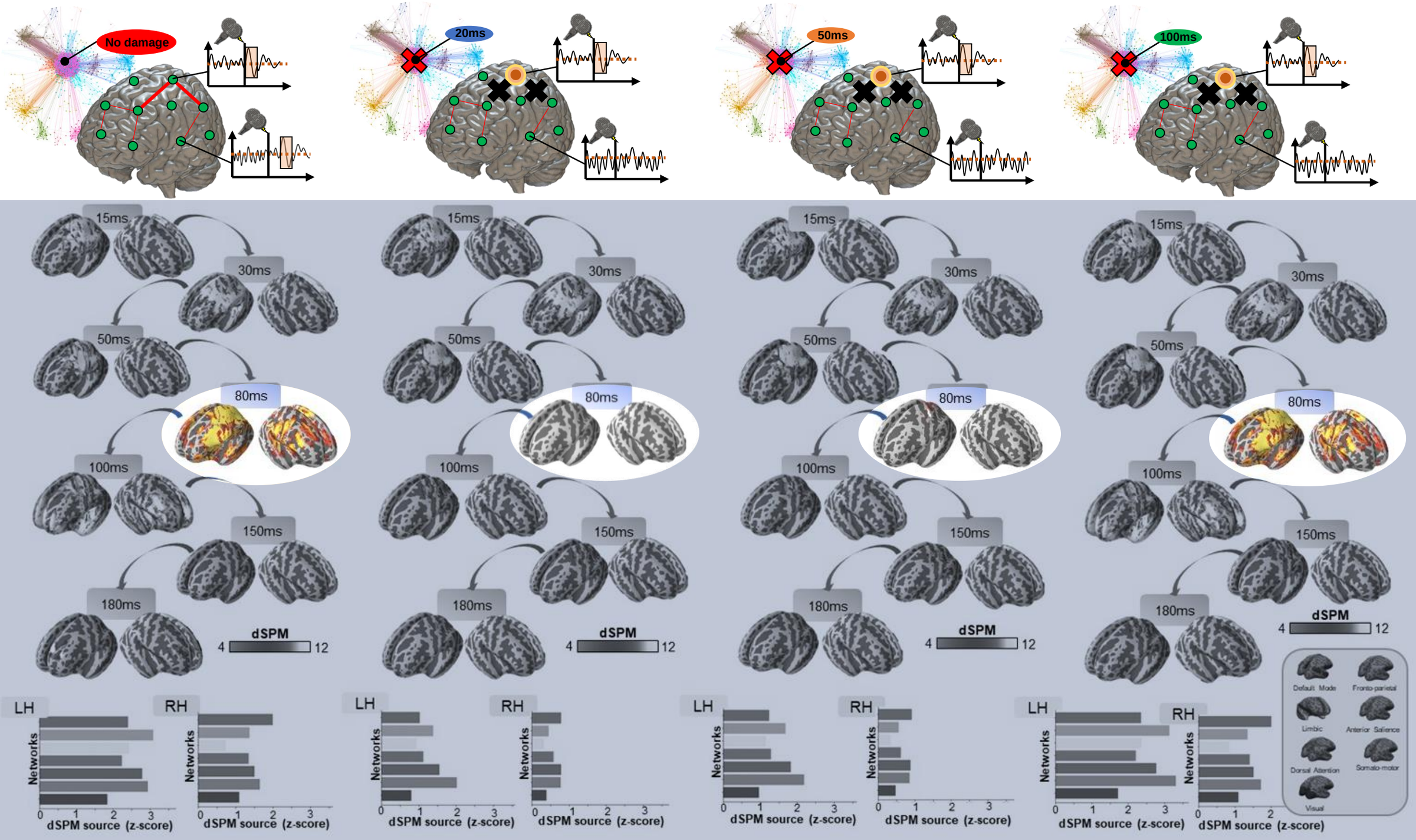




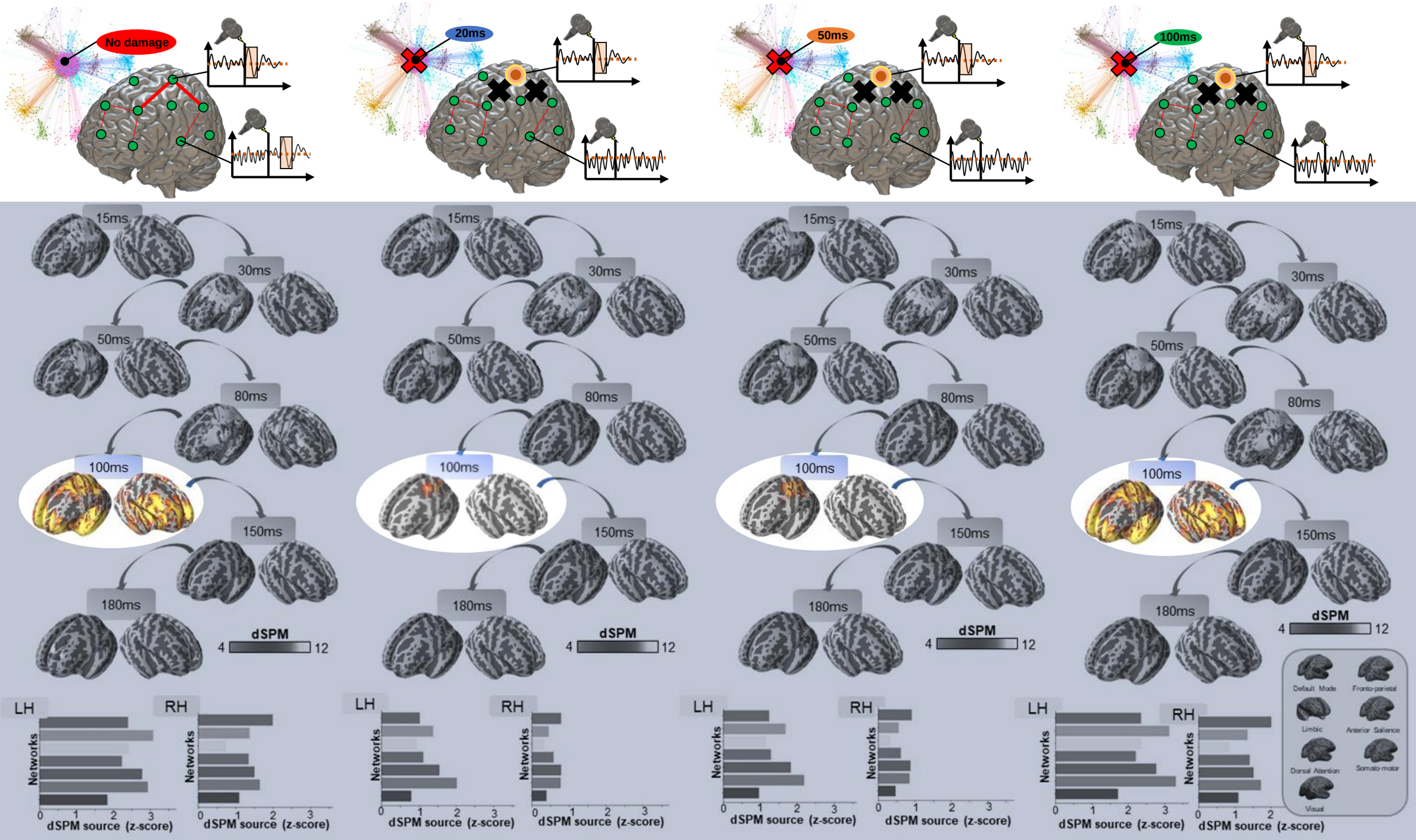
Dissecting the propagation of the TMS-induced signal



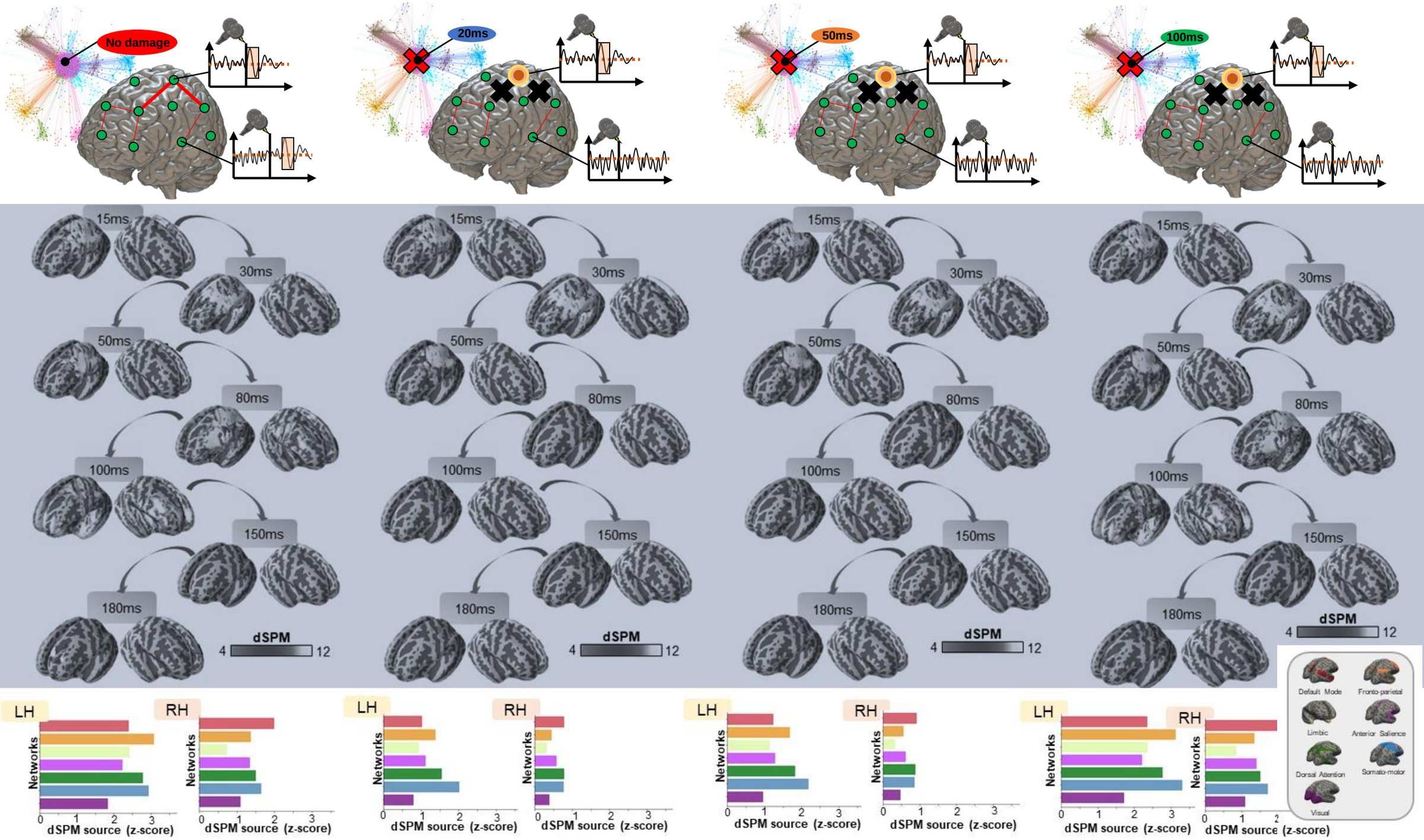
TEP at 80ms is a network reverberation response



TEP at 100ms is a local echo of the stimulus

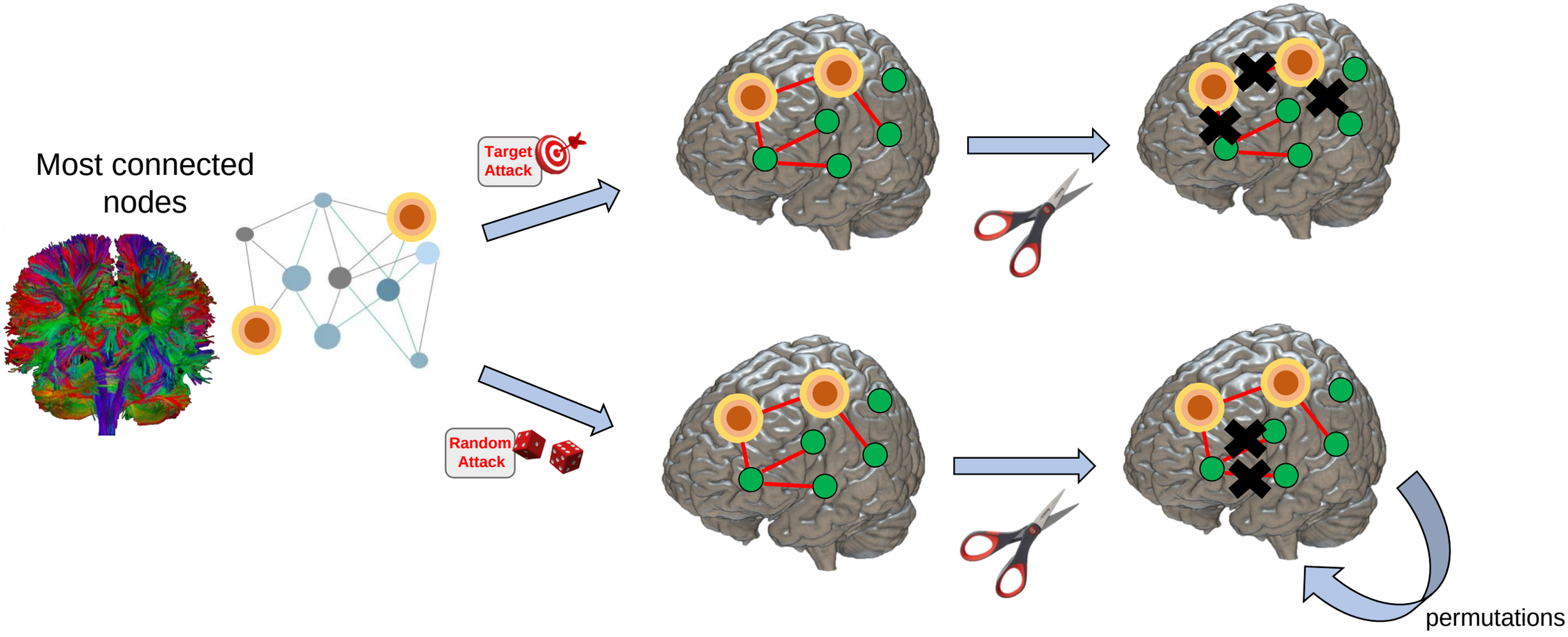


Networks propagation is affected by earlier lesions

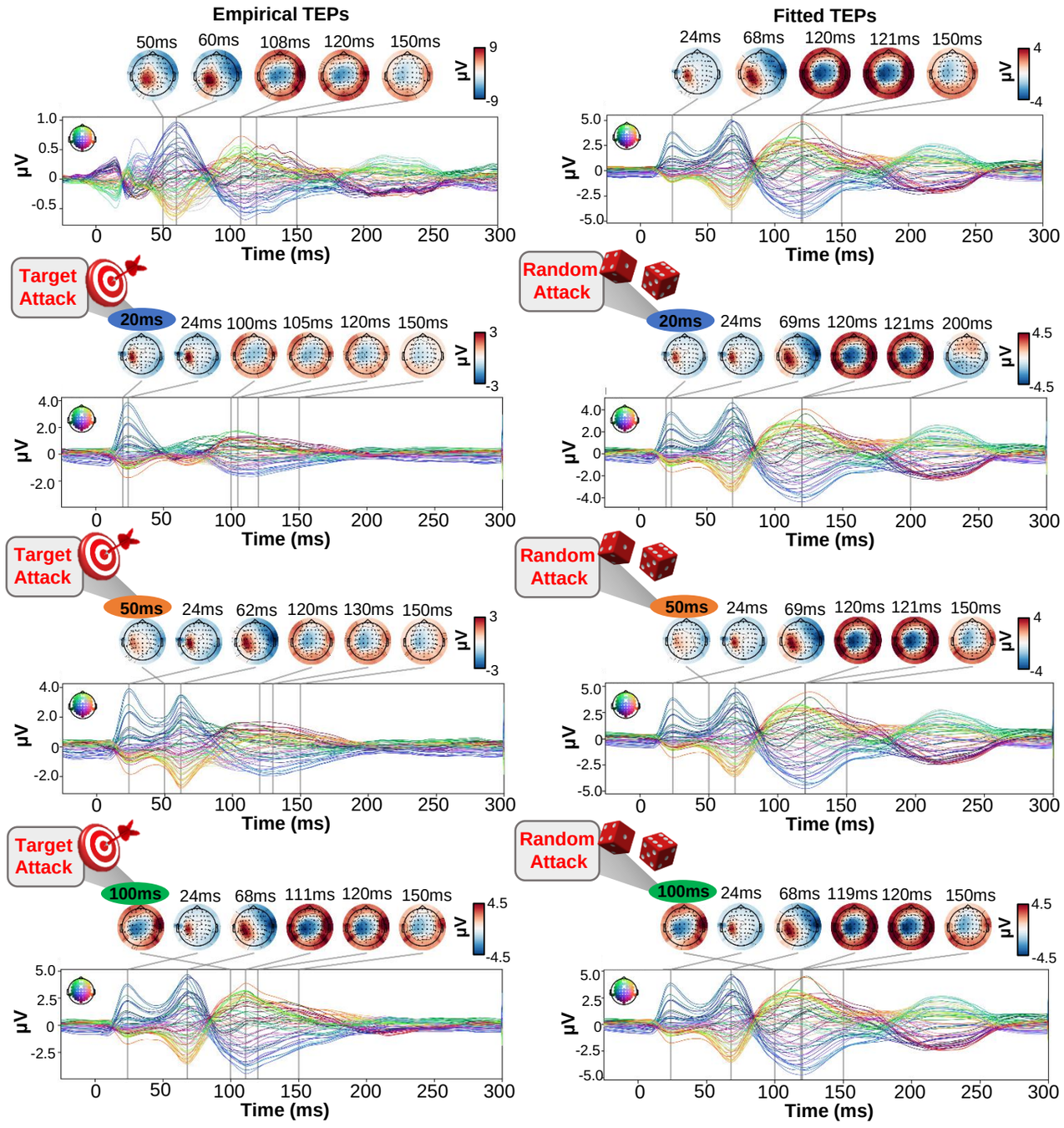


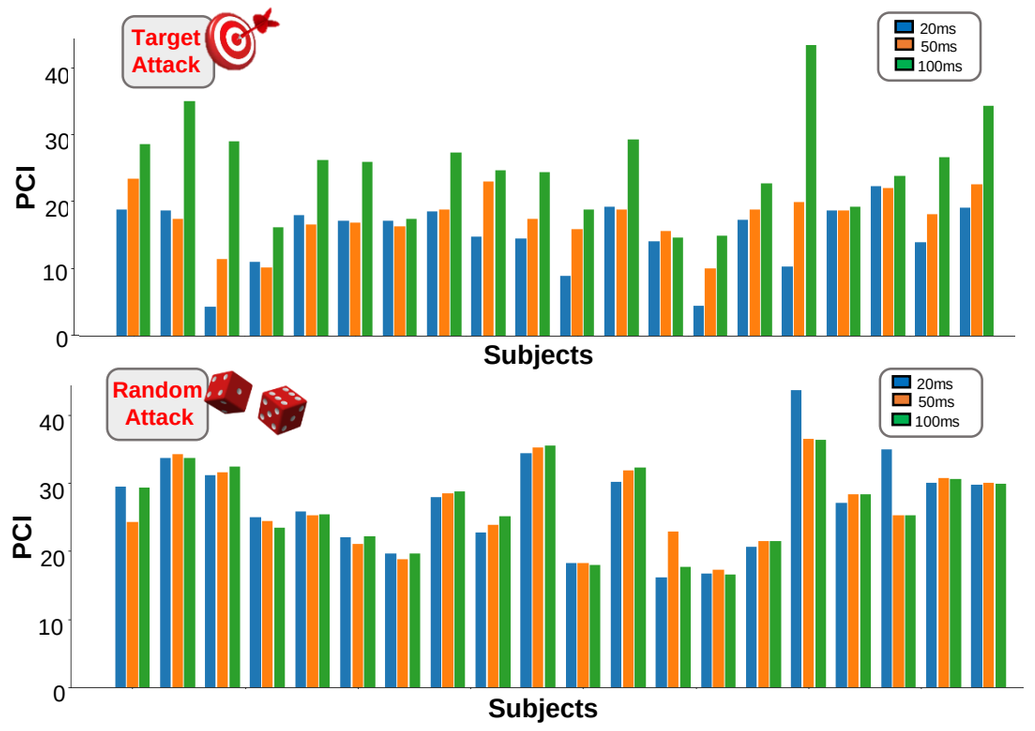
Target vs Random Attack

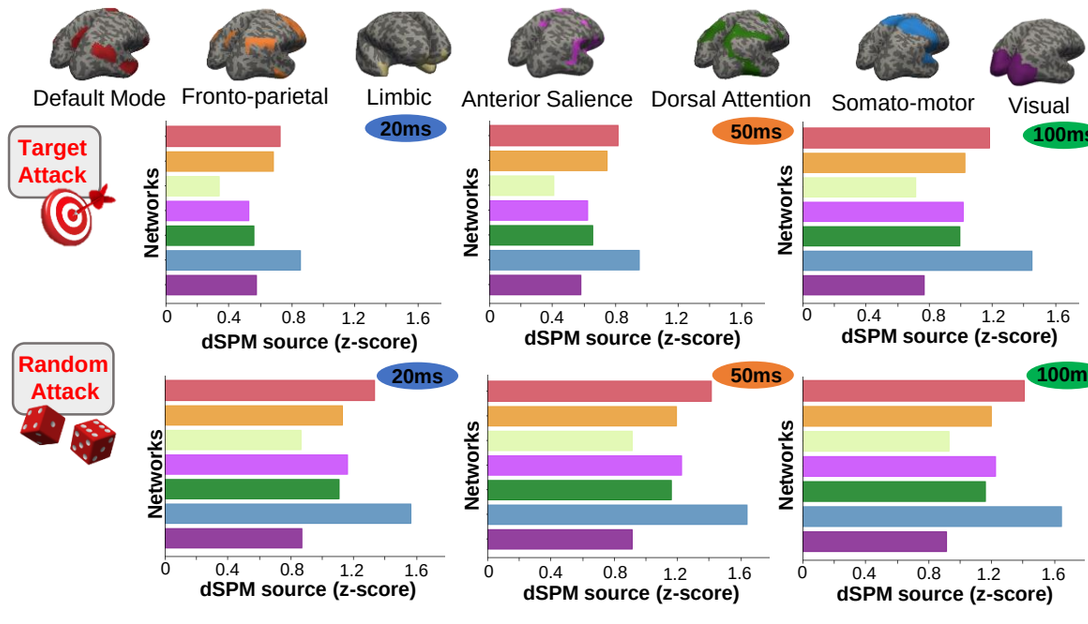
#2: What's the role of the nodes and their connections in shaping the propagation of the TMS-induced signal?



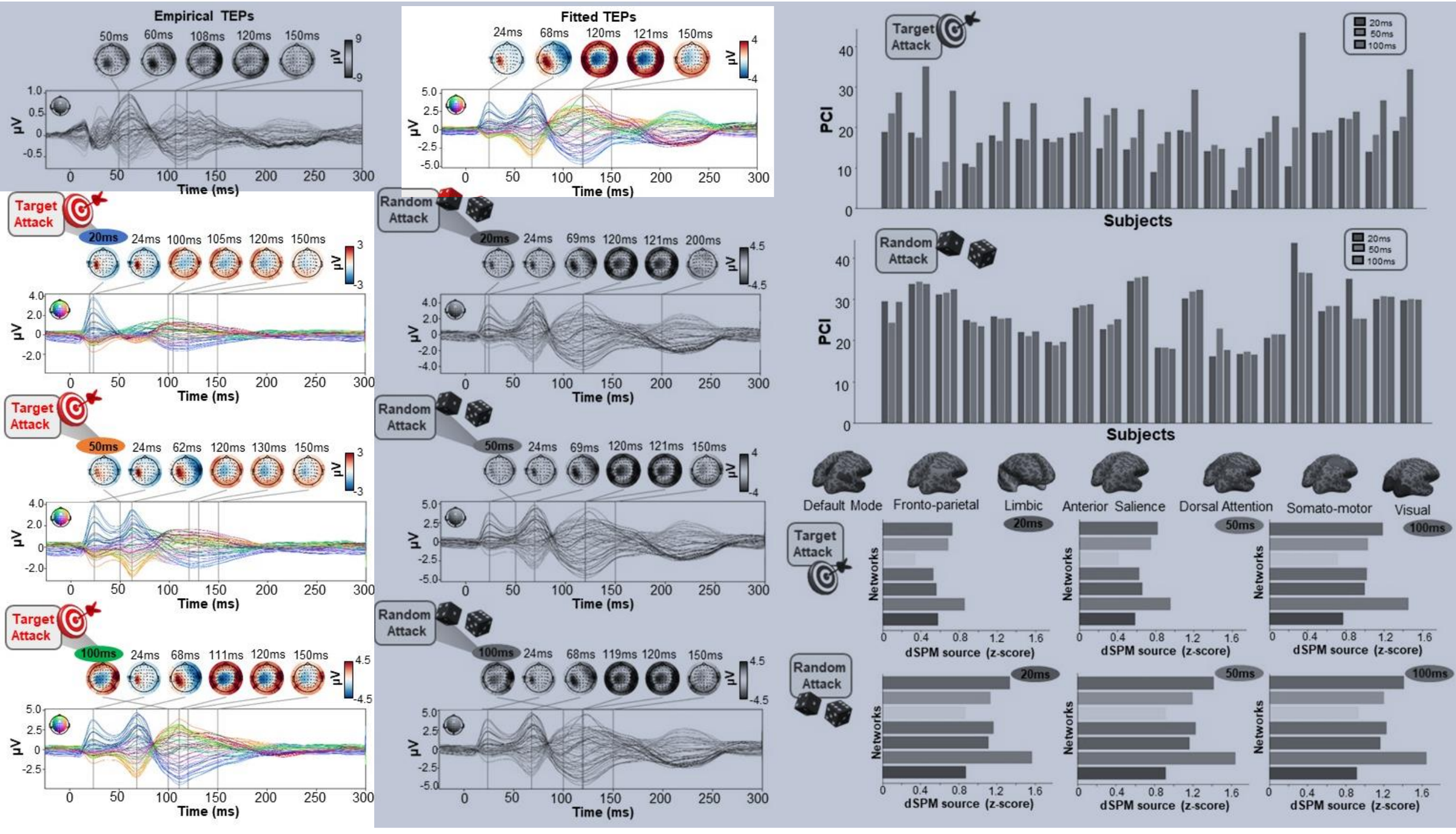
Target vs Random Attack



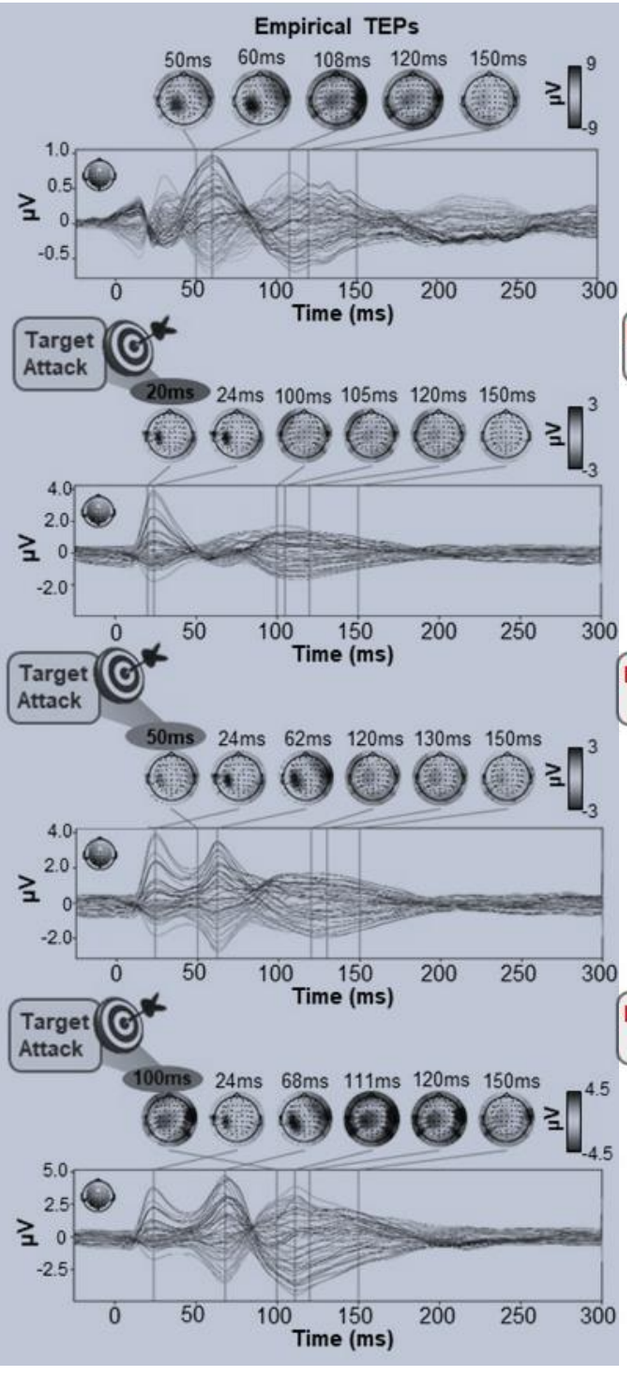


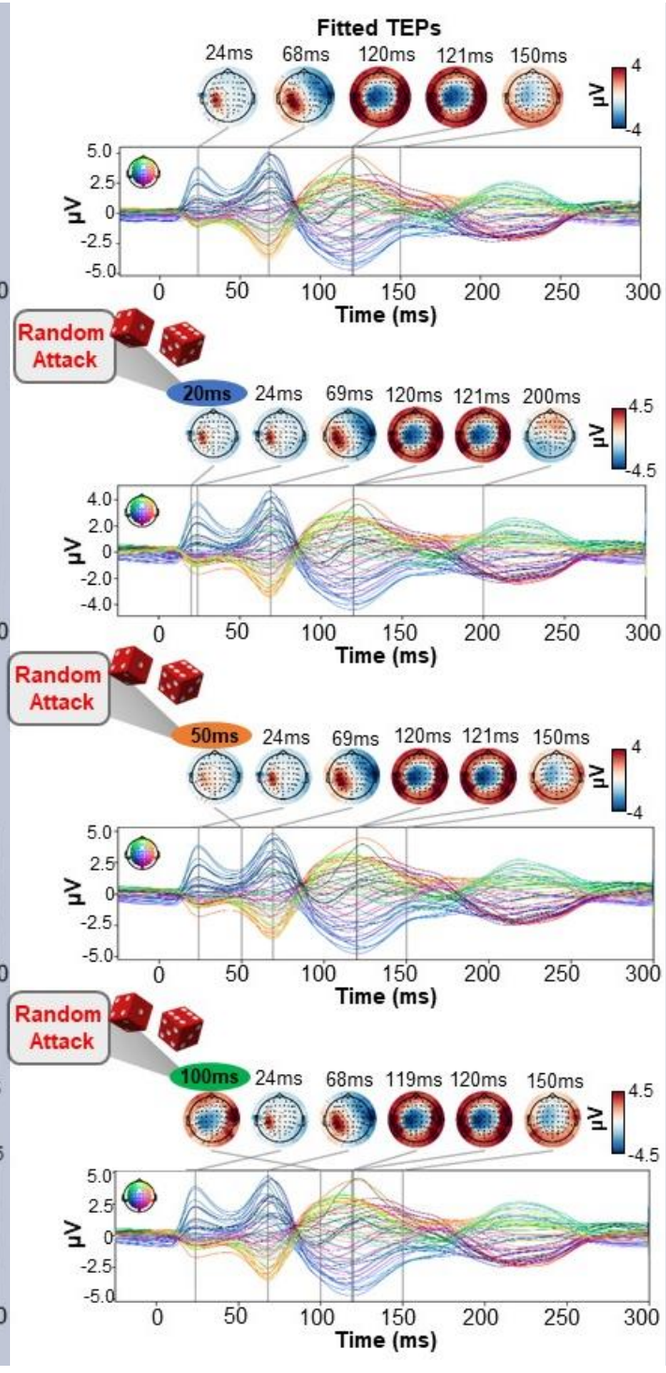


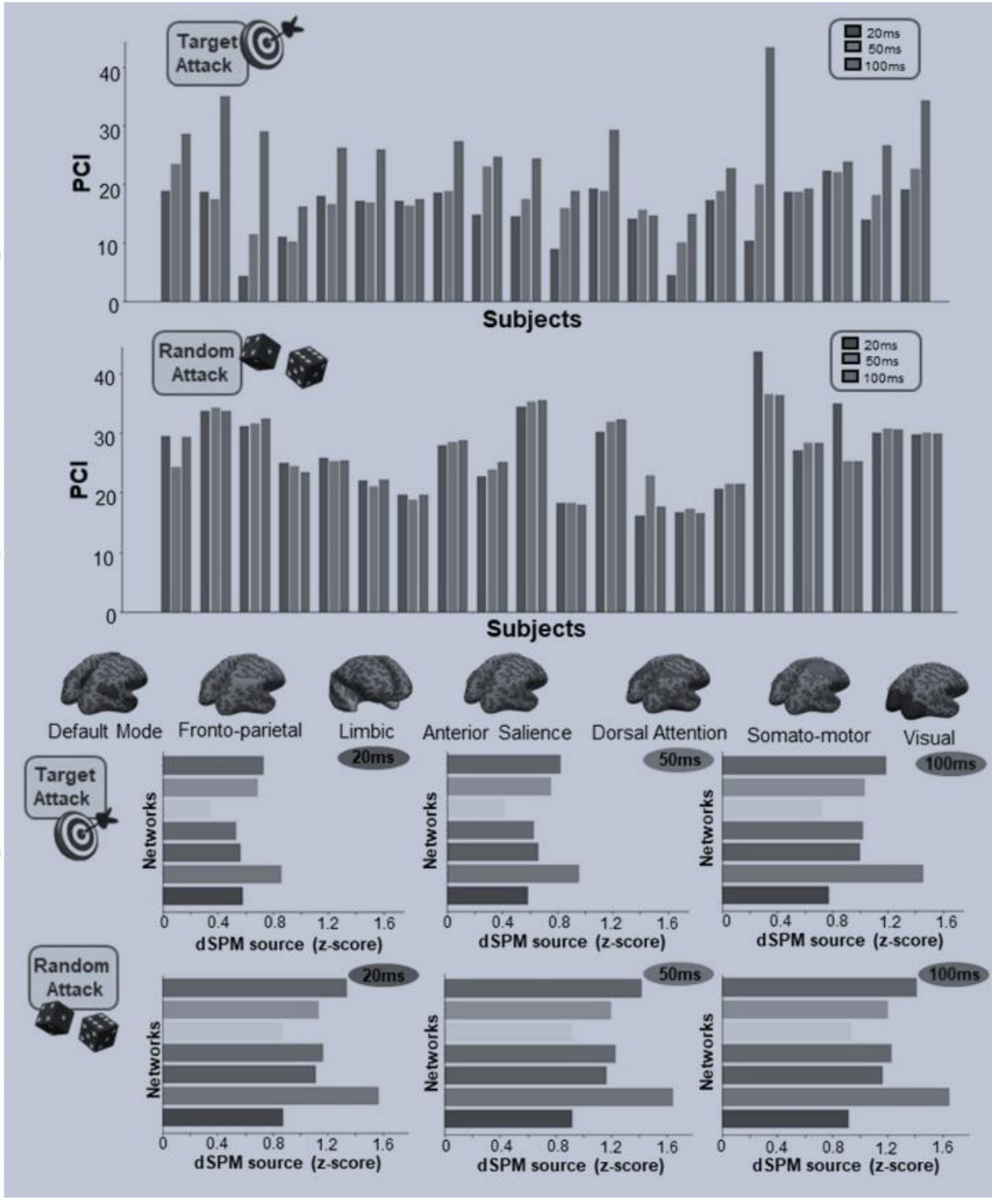
Target Attacks affect TMS-induced activity in a time-dependent manner



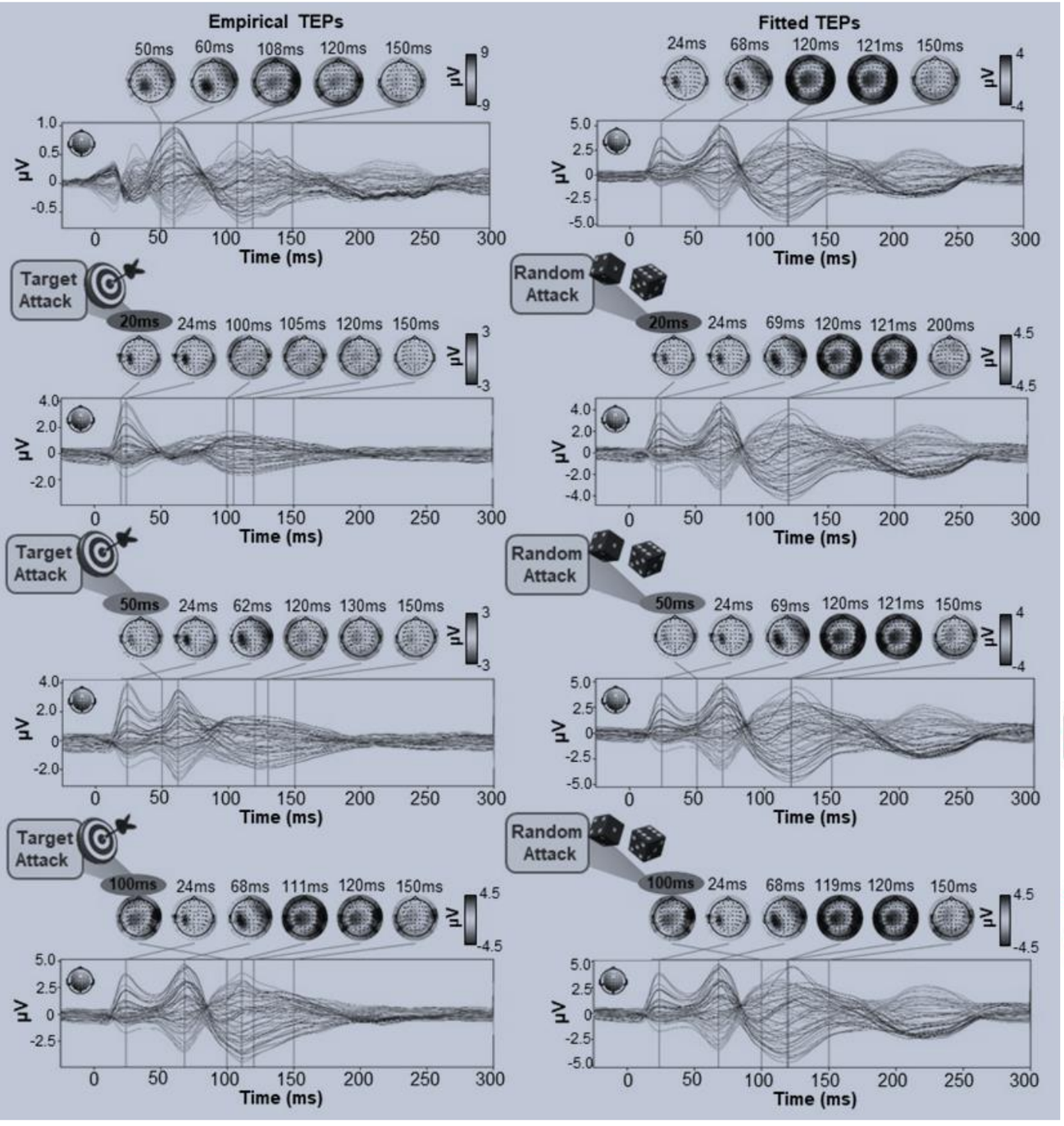
Random Attacks do not affect TMS-induced activity

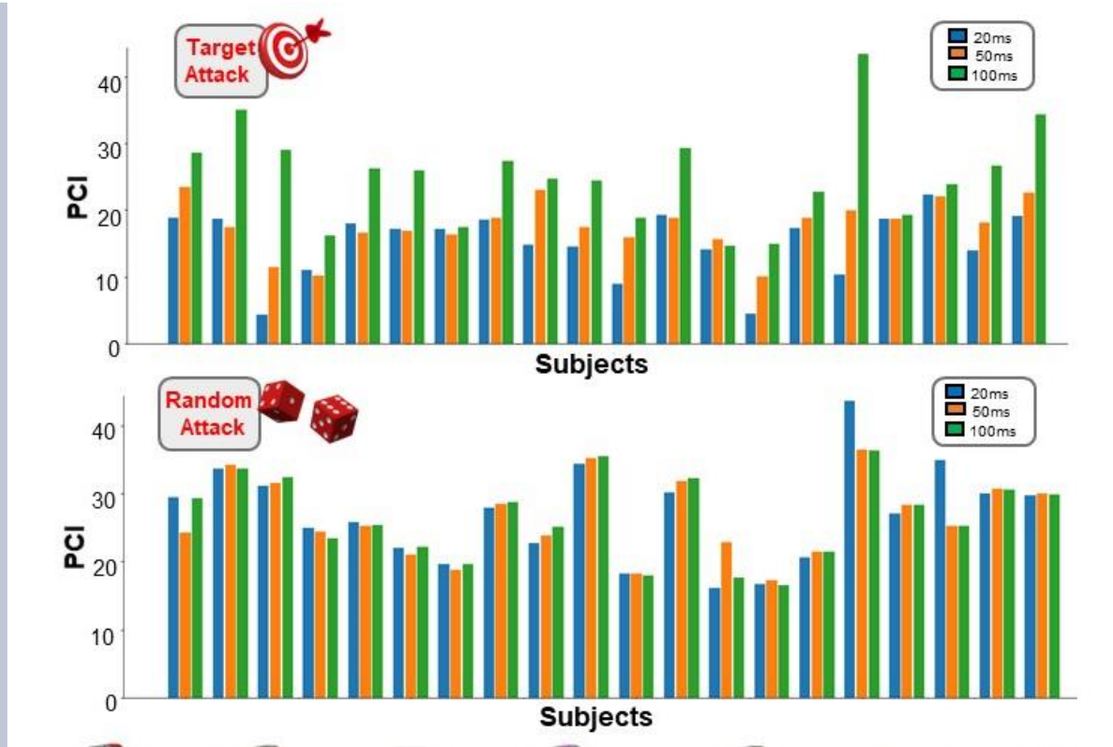


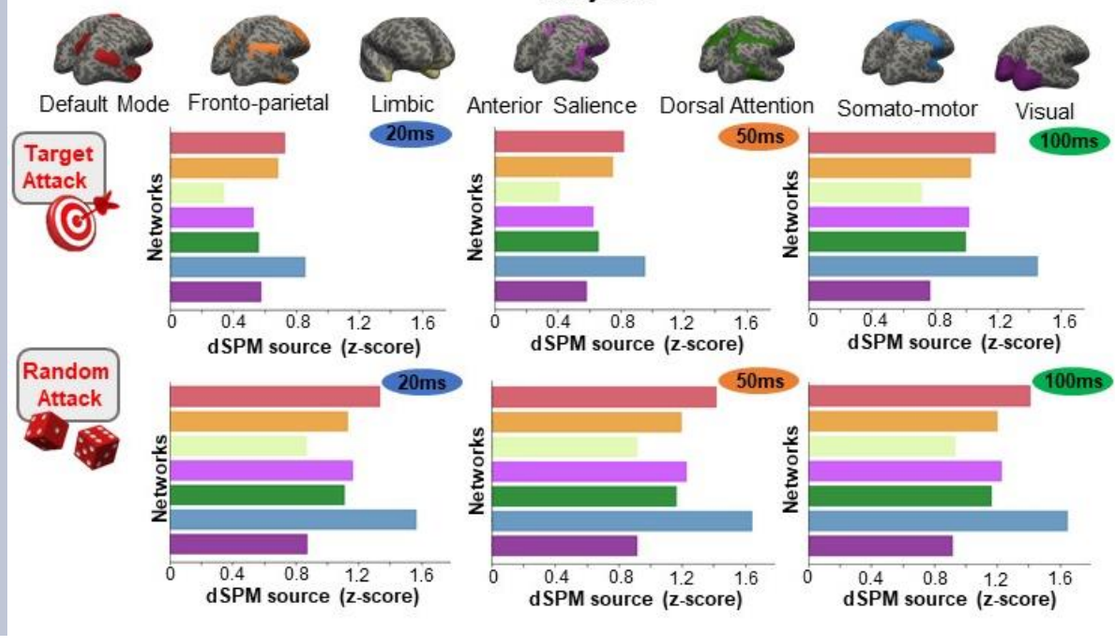




Target vs Random Attack differences



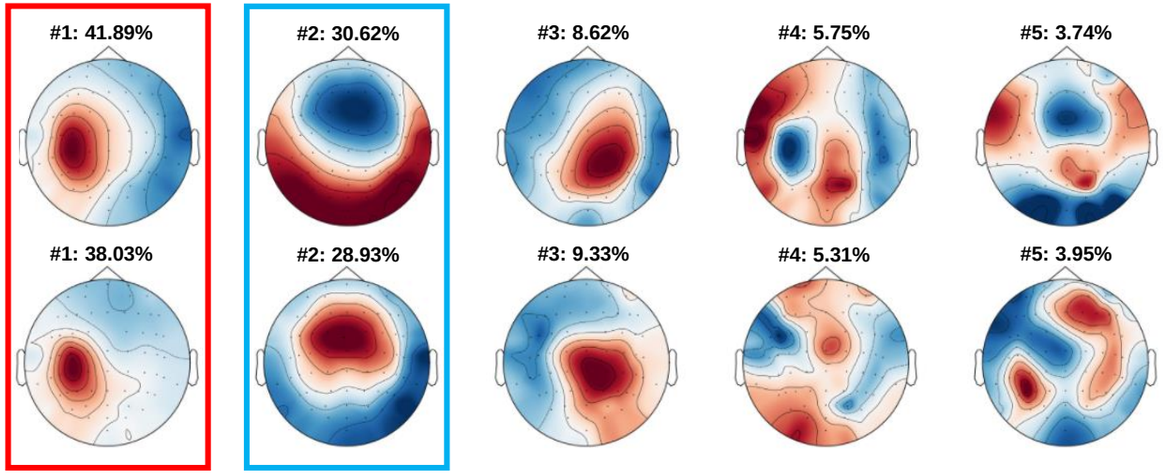


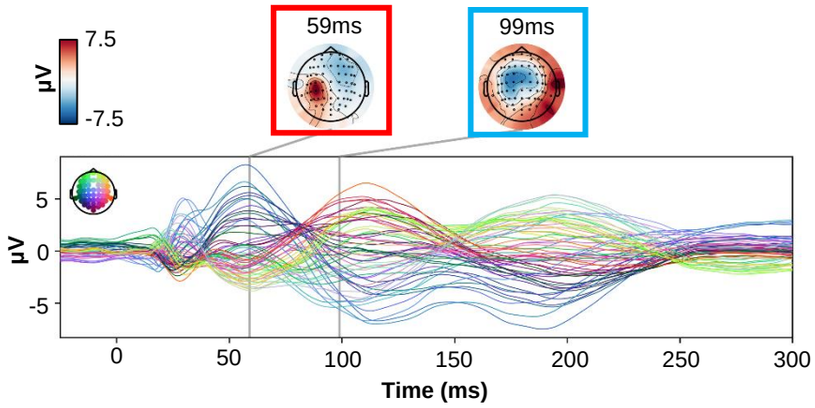


Model parameters allow identification of subjects' TEPs clusters

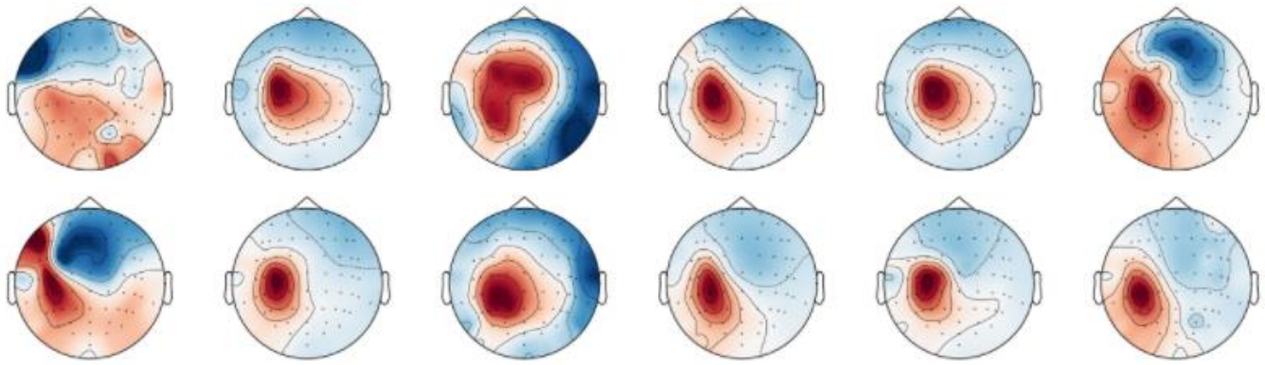
#3: Can the model parameters allow to cluster the subjects based on their TEPs?

SVD simulated (TOP) and empirical (BOTTOM)

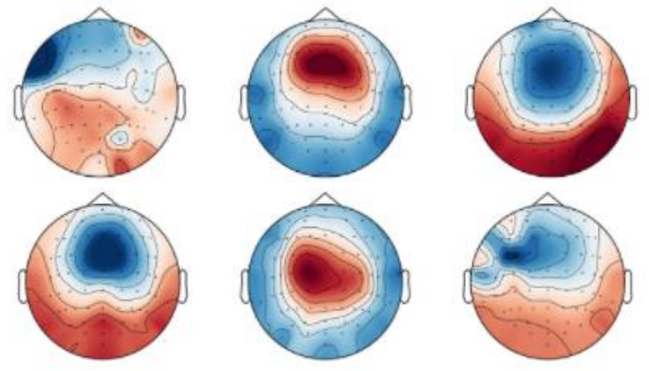




Cluster #1



Cluster #2



Conclusions

- We have demonstrated **fast and robust recovery** of individual subjects' empirical **TEPs propagation patterns in model-generated activity** time series both at channels and source level

#1: Are the TEPs due to a local/single node echo of the stimulation or a global/network reverberation?

→ Depending on time, TEPs are driven by either a **local echo response** of the TMS or **network reverberation**

#2: What's the role of the nodes and their connections in shaping the propagation of the TMS-induced signal?

← **Time and Space** (Target vs Random) are both important for shaping the **TMS-induced signal propagation**

#3: Can the model parameters allow to cluster the subjects based on their TEPs?

→ PLS analysis revealed that **model parameters can classified subjects** based on their TMS-induced propagation patterns

Acknowledgements

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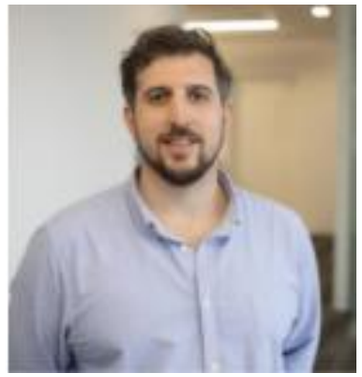


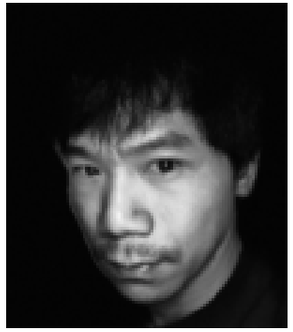
Dr. John Griffiths
Team Leader

camh
Krembil Centre for Neuroinformatics

Whole Brain Modelling

Shreyas Harita
PhD Student

Sorenza Bastiaens
PhD Student



FuTe Wong
PhD Student

Hussain Ather
PhD Student

Dr. Zheng Wang
Data Analyst

Taha Morshedzadeh
M.Sc. Student

Frank Mazza
M.Sc. Student

Kevin Kadak
M.Sc. Student

Parsa Oveisi
M.Sc. Student

Andrew Clappison
M.Sc. Student