Insight sui meccanismi della meditazione da studi fMRI, EEG e MEG con monaci buddhisti Theravada

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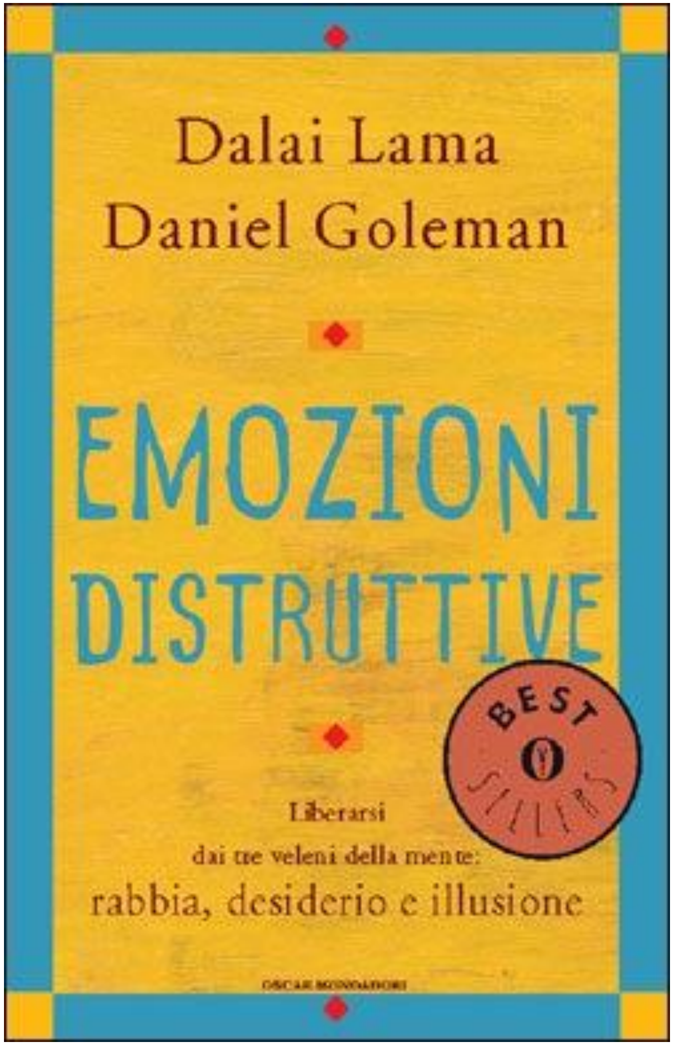
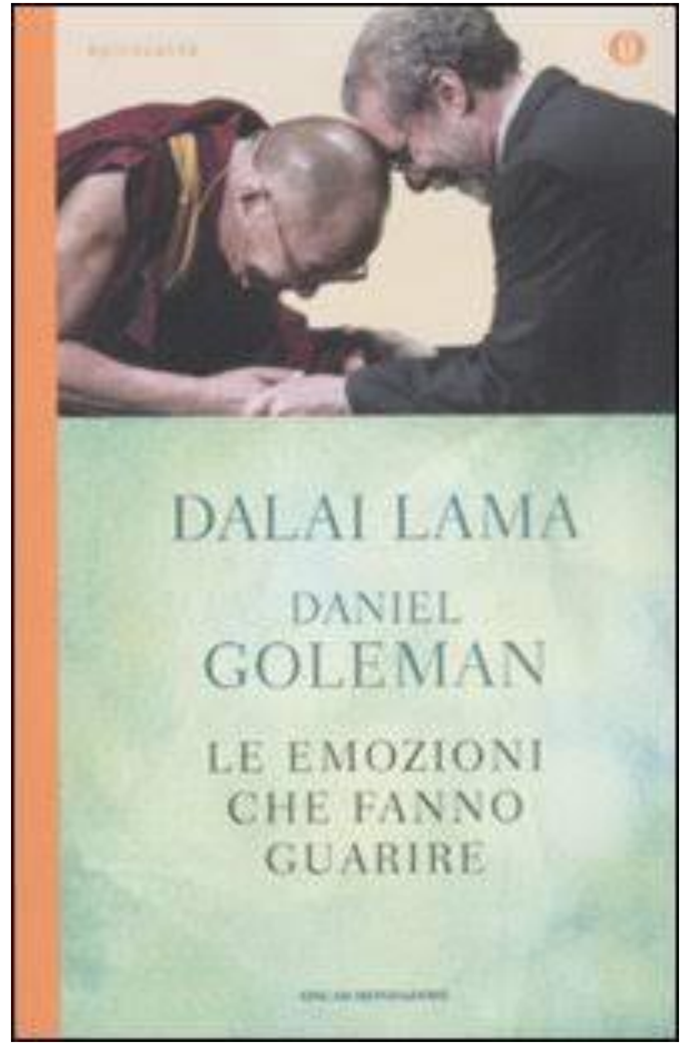
I tre veleni: brama, odio e illusione


Dalai Lama
Daniel Goleman
EMOZIONI DISTRUTTIVE
BEST SELLERS
Liberarsi
dai tre veleni della mente:
rabbia, desiderio e illusione
OSCAR MONDADORI


DALAI LAMA
DANIEL GOLEMAN
LE EMOZIONI CHE FANNO GUARIRE

Meditation and the Startle Response: A Case Study

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Abstract

The effects of two kinds of meditation (open presence and focused) on the facial and physiological aspects of the defensive response to an aversive startle stimulus were studied in a Buddhist monk with approximately 40 years of meditation experience. The participant was exposed to a 115 db, 100 ms acoustic startle stimulus under the two meditation conditions, a distraction condition (to control for cognitive and attentional load) and an unanticipated condition (startle presented without warning or instruction). A completely counterbalanced 24-trial single-subject design was used, with each condition repeated six times. Most aspects of the participant's responses in the unanticipated condition did not differ from those of a comparison group of 12 age-matched male controls. Both kinds of meditation produced physiological and facial responses to the startle that were smaller than in the distraction condition. Within meditation conditions, open presence meditation produced smaller physiological and facial responses than focused meditation. These results from a single highly expert meditator indicate that these two kinds of meditation can differentially alter the magnitude of a primitive defensive response.

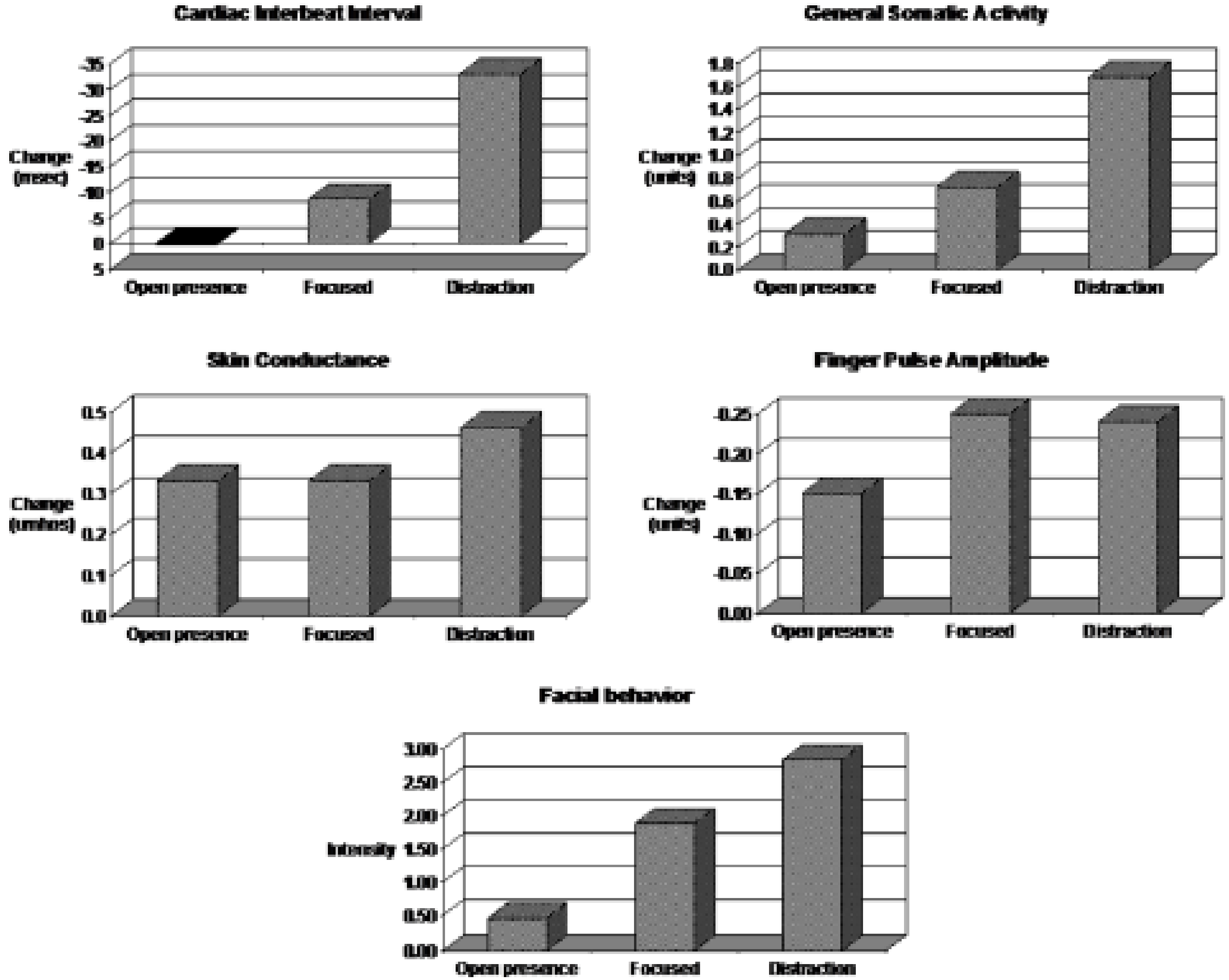
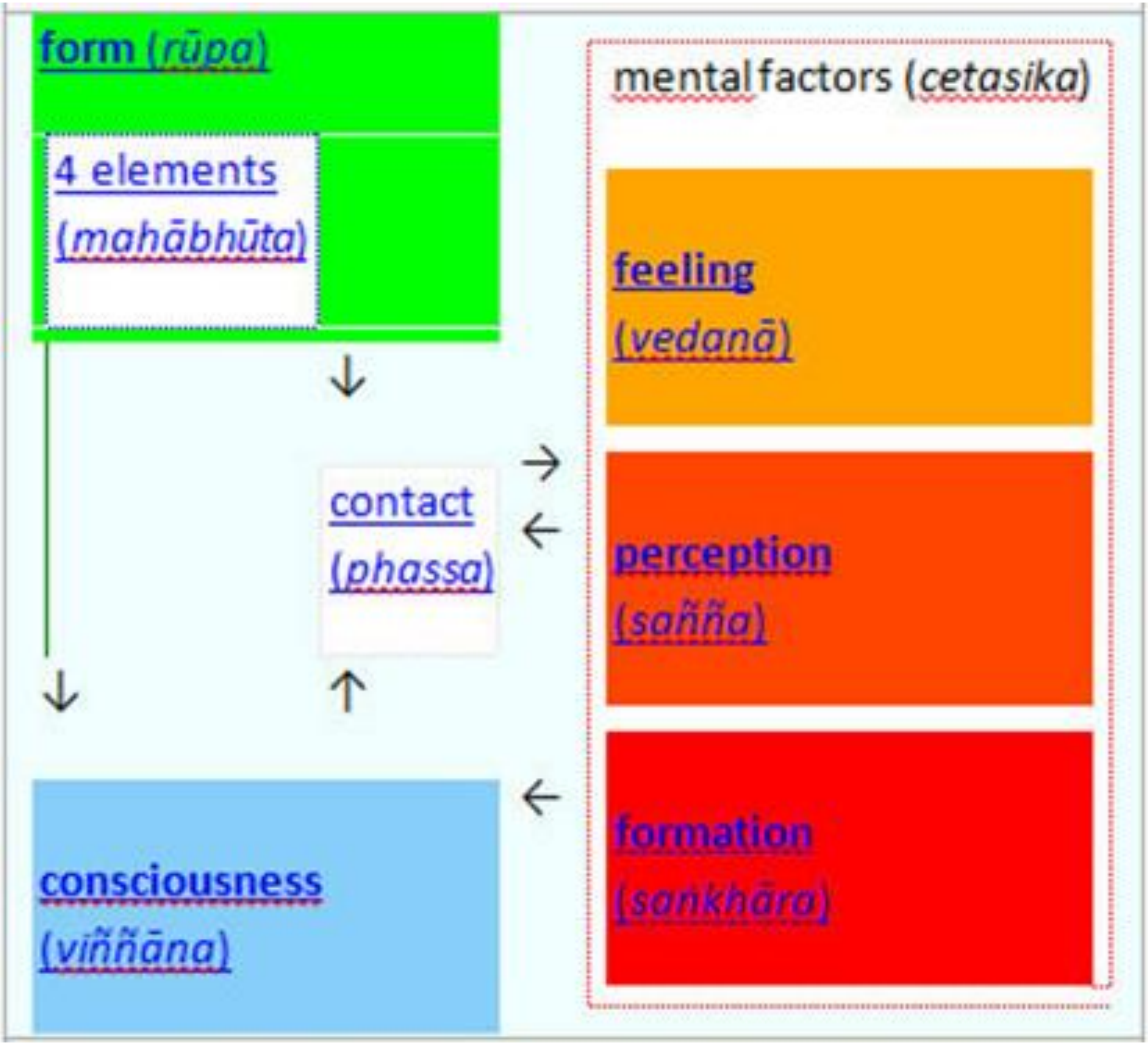
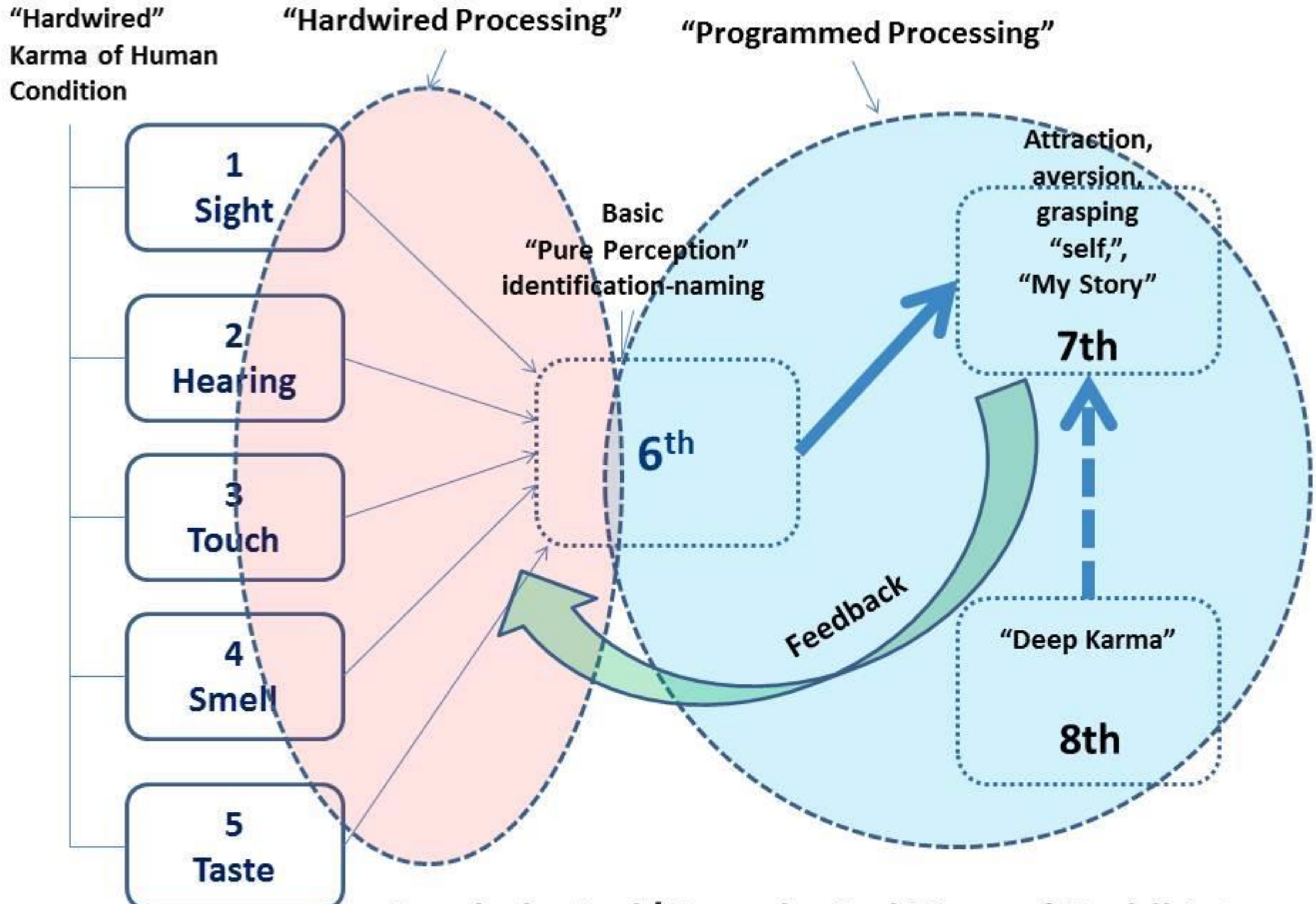


Figure 2.

Average physiological and facial behavioral response to unanticipated startle across six replications of open presence meditation, focused meditation, and distraction conditions in MR. All responses are scaled so that greater activation is in the upwards direction

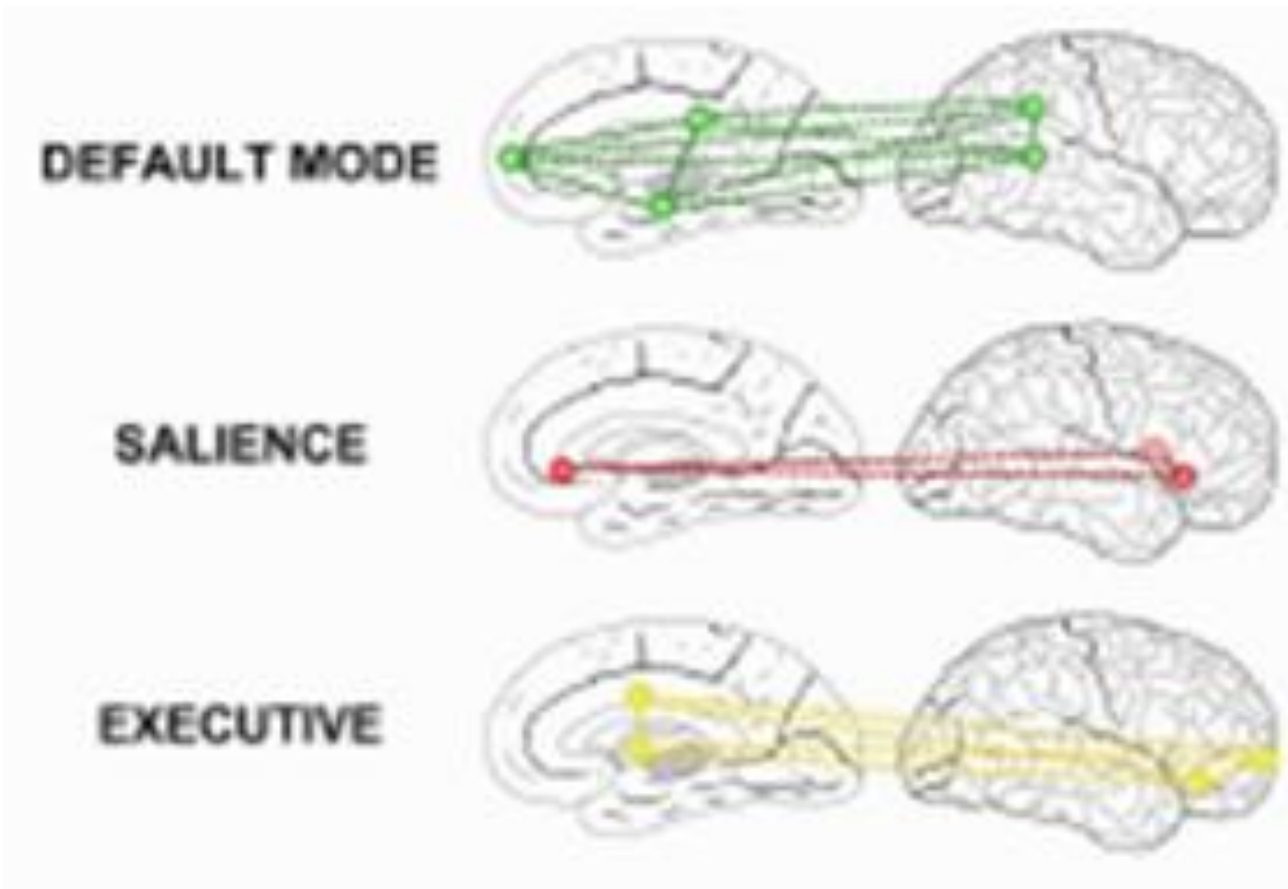


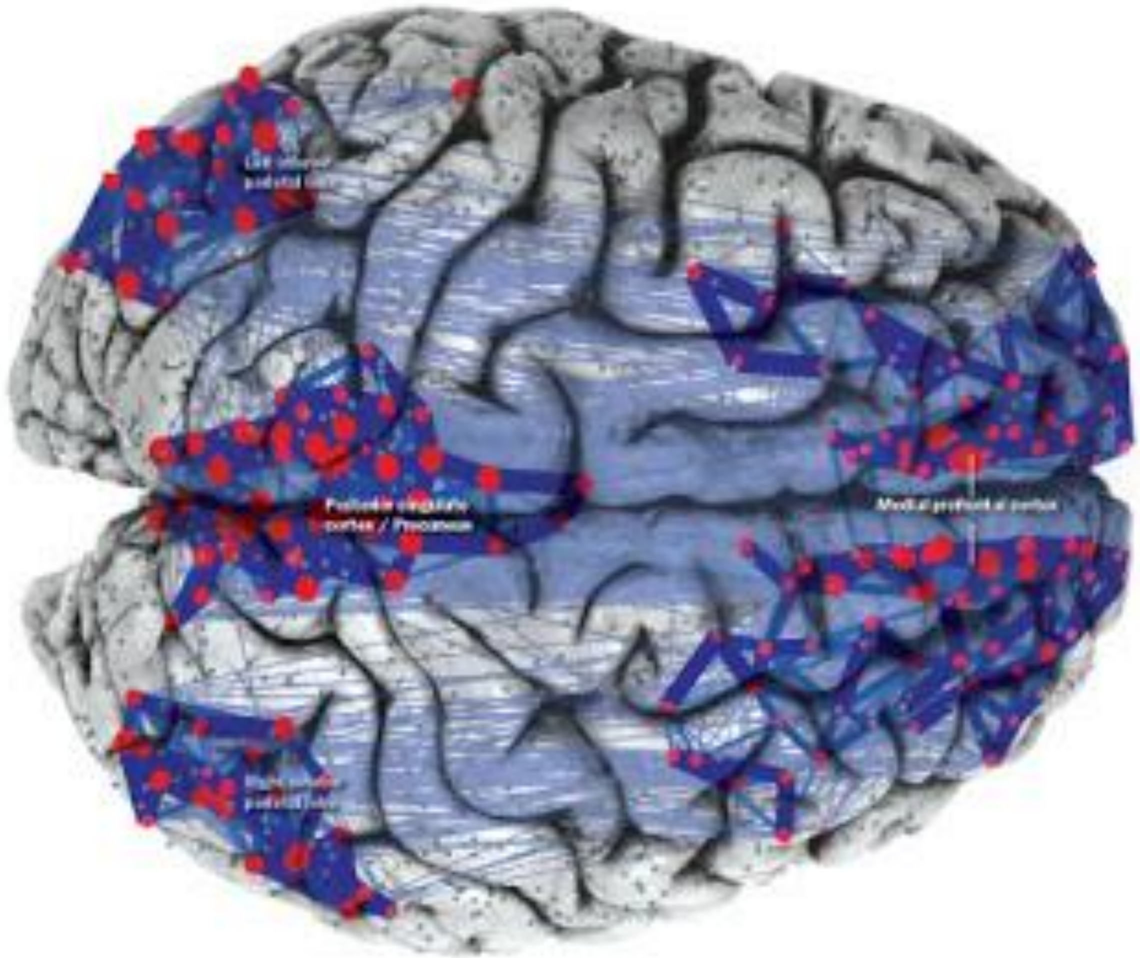
Il modello dei cinque aggregati nella psicologia buddhista (da Thanissaro, 2001)



Psychological/Neurological View of Buddhist Eight Consciousnesses

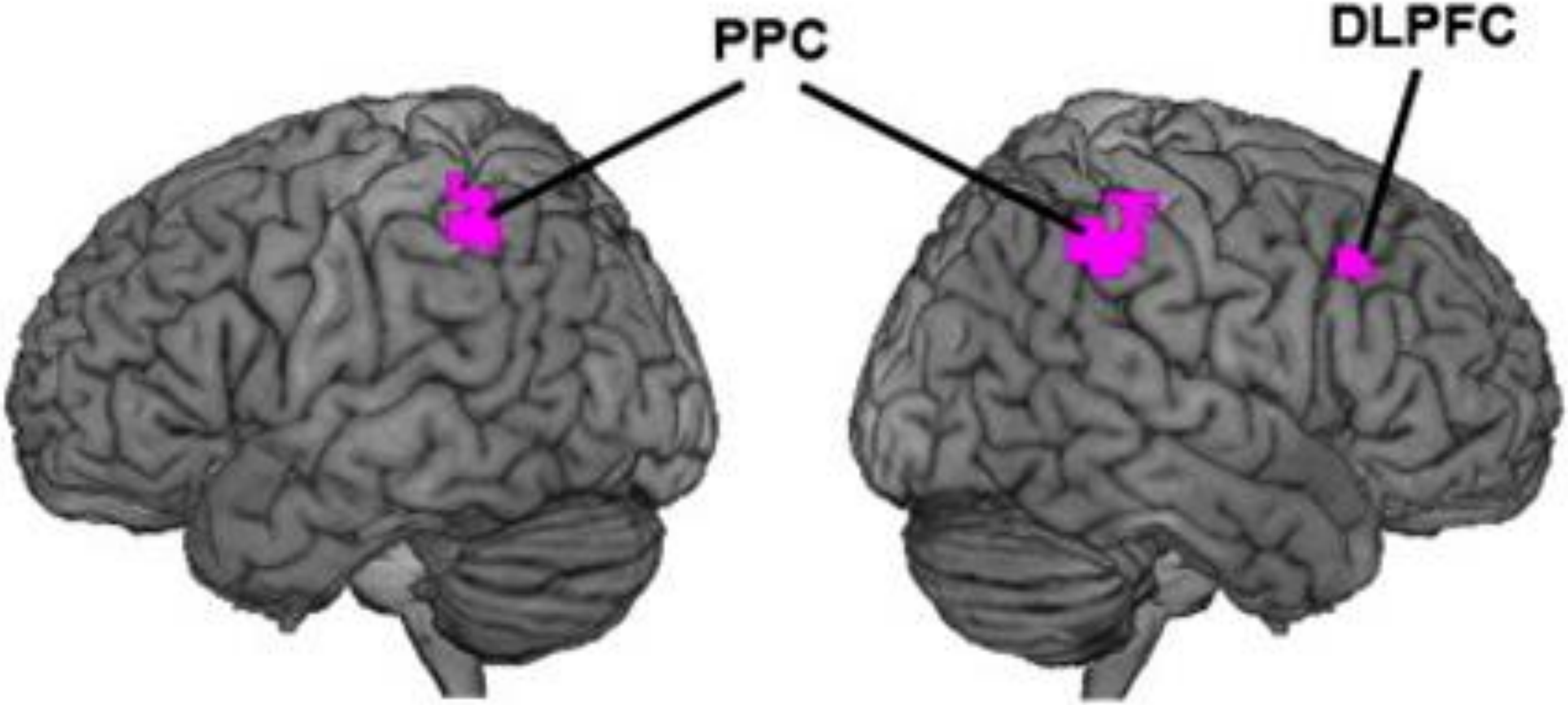
I tre network cerebrali centrali principali - «aggregati cerebrali»

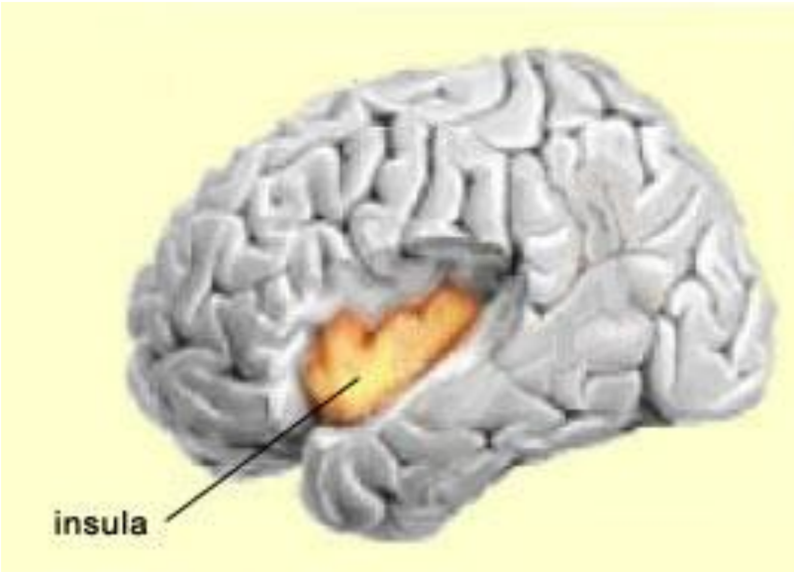


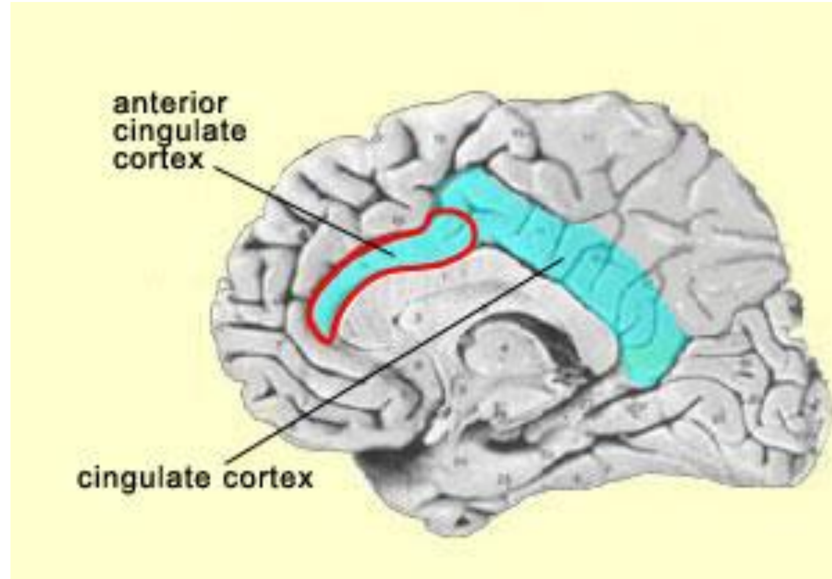


Default Mode Network
rete di regioni cerebrali connessa al mind wandering (divagare della mente)

Executive Network







Salience network: insula anteriore e cingolo anteriore dorsale

A remarkable set of psychological and neuroscientific findings is consistent with Buddha's view that the self as a fixed, separate and permanent entity cannot be found in the mind/brain!

- The default mode network lacking clear boundaries, being an aggregate of a large number of neuronal populations, needing other networks and «external» areas to work, being subject to changes through the lifetime and experiences such as meditation and hypnosis, being partly active and partly inactive during dreams (where self experiences may differ from wakefulness).

- The executive or conscious fronto-parietal network being also composite and needing support from several other networks and areas of the brain, needing coordination with the salience network, and lacking clear boundaries.

- Different aspects of the self, such as the «I» (first-person pre-reflective or minimal self) and «Me» (third-person reflective self), with different areas or networks being associated to the «I» and to the «Me».

- Ecological self
- Interpersonal self
- Private self
- Extended self
- Self-concept

Modello di Damasio

Interazioni tra livelli del sé nel cervello: Il ruolo integrativo delle cortecce posteromediali

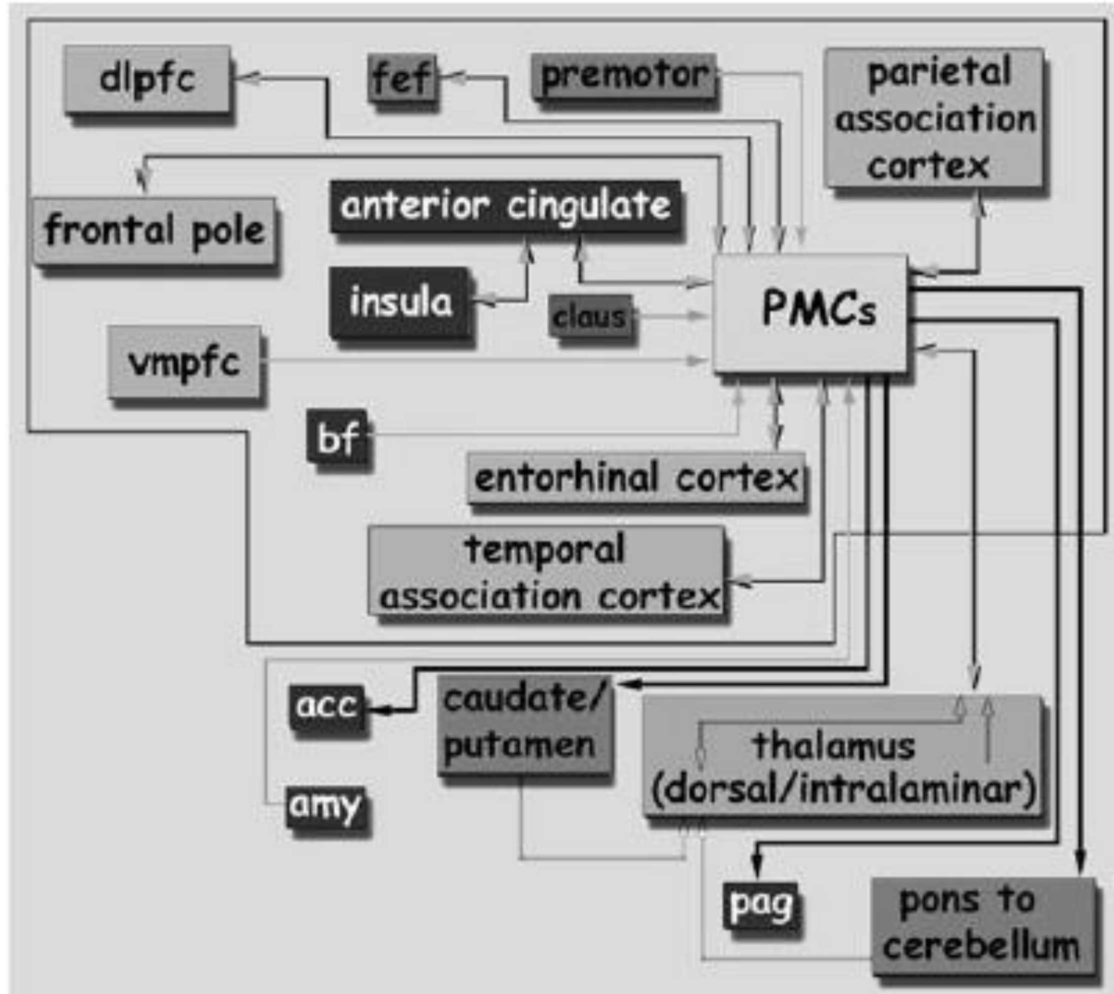


Figure 9.4: The pattern of neural connections to and from the posteromedial cortices (PMCs), as determined in a study conducted in the monkey. Abbreviations: dlpfc = dorsolateral prefrontal cortex; fef = frontal eye fields; vmpfc = ventromedial prefrontal cortex; bf = basal forebrain; claus = claustrum; acc = nucleus accumbens; amy = amygdala; pag = periaqueductal gray.

frontiers in
HUMAN NEUROSCIENCE

ORIGINAL RESEARCH ARTICLE
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A pattern theory of self

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I argue for a pattern theory of self as a useful way to organize an interdisciplinary approach to discussions of what constitutes a self. According to the pattern theory, a self is constituted by a number of characteristic features or aspects that may include minimal embodied, minimal experiential, affective, intersubjective, psychological/cognitive, narrative, extended, and situated aspects. A pattern theory of self helps to clarify various interpretations of self as compatible or commensurable instead of thinking them in opposition, and it helps to show how various aspects of self may be related across certain dimensions. I also suggest that a pattern theory of self can help to adjudicate (or at least map the differences) between the idea that the self correlates to self-referential processing in the cortical midline structures of the brain and other narrower or wider conceptions of self.

Keywords: self, pattern theory, cortical midline structures, first-person perspective

INTRODUCTION: VARIATIONS ON THE SELF

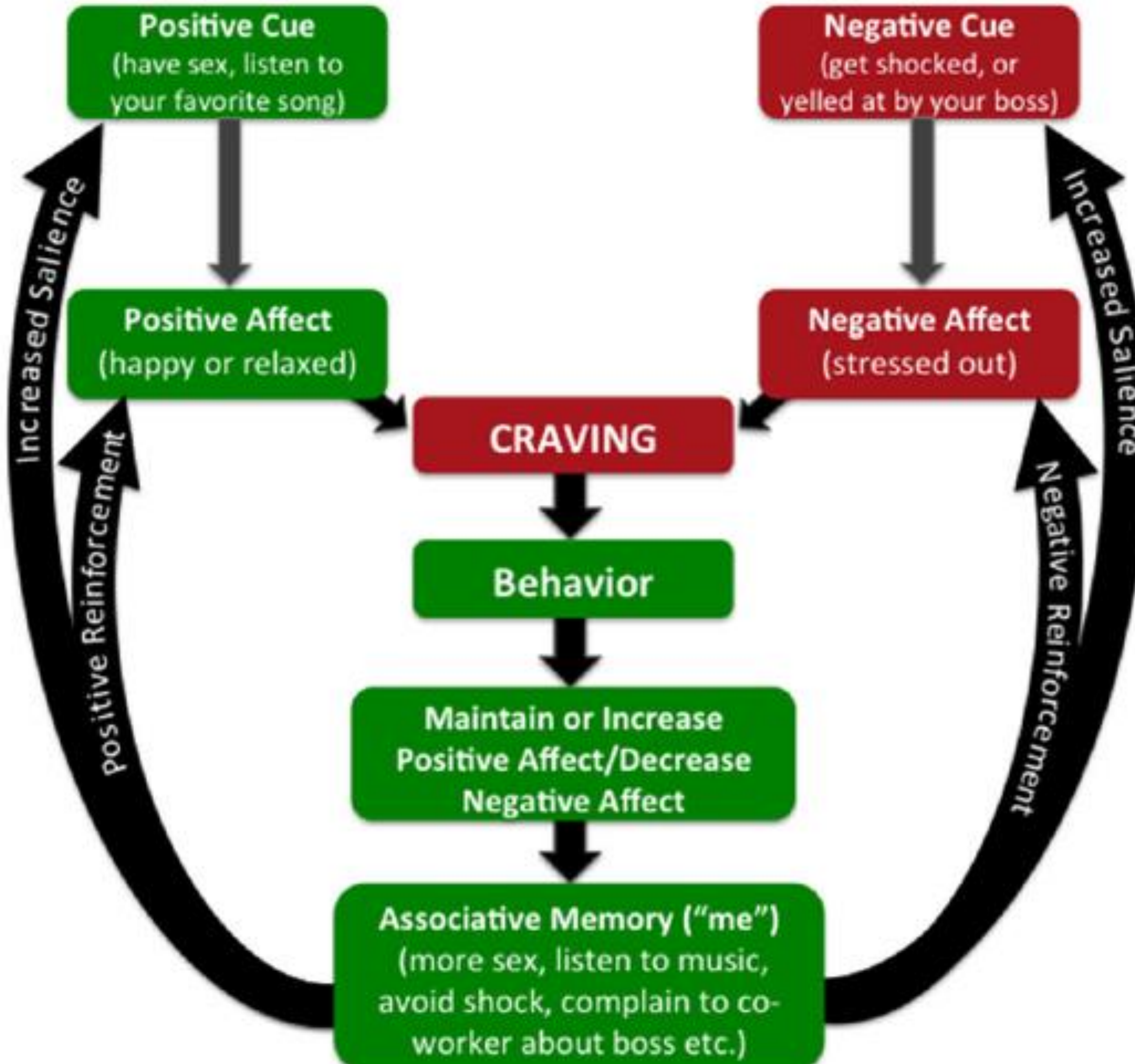
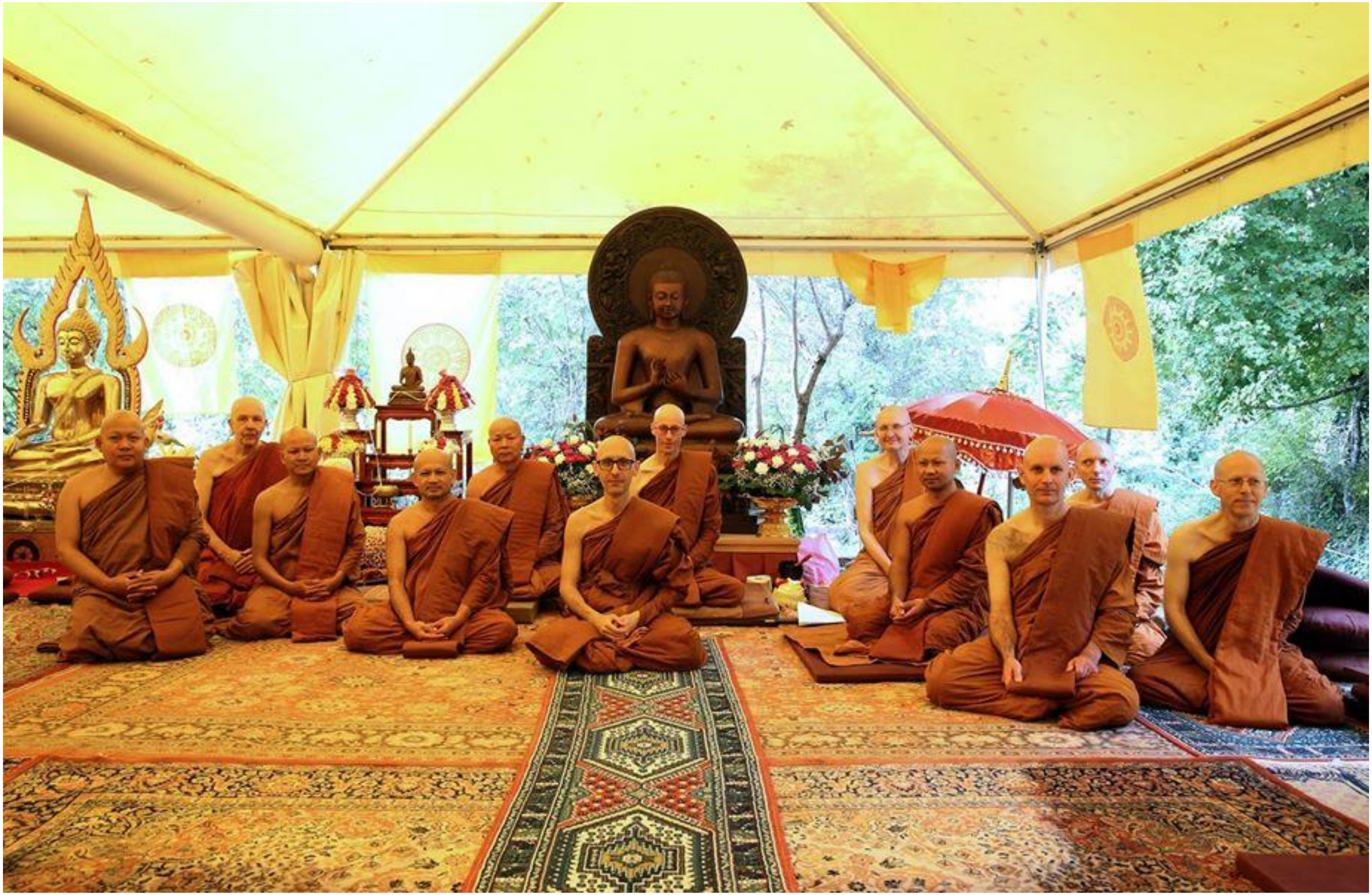


Figure 1. Associative learning "habit loop." Behavior becomes associated with positive (green) and negative (red) affect through positive and negative reinforcement. Adapted, with permission, from Brewer *et al.*[7]



Thai Forest Theravada Buddhist monks in Santacittarama Monastery (Italy)

Thai Forest Theravada Buddhist monks and nuns in Amaravati Monastery (England)

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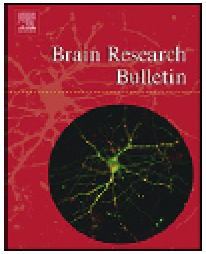

Research report

Neural correlates of focused attention and cognitive monitoring in meditation

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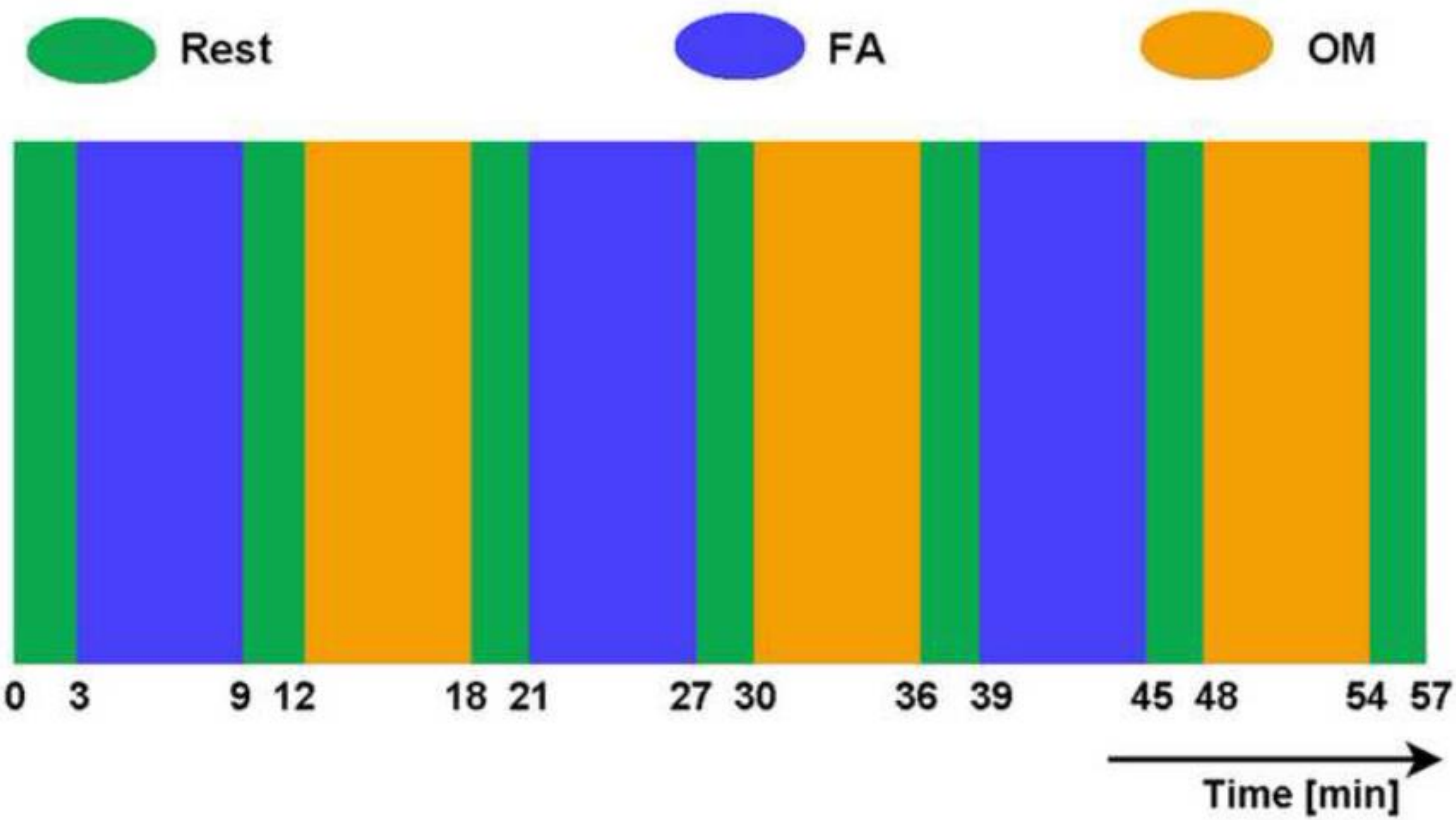
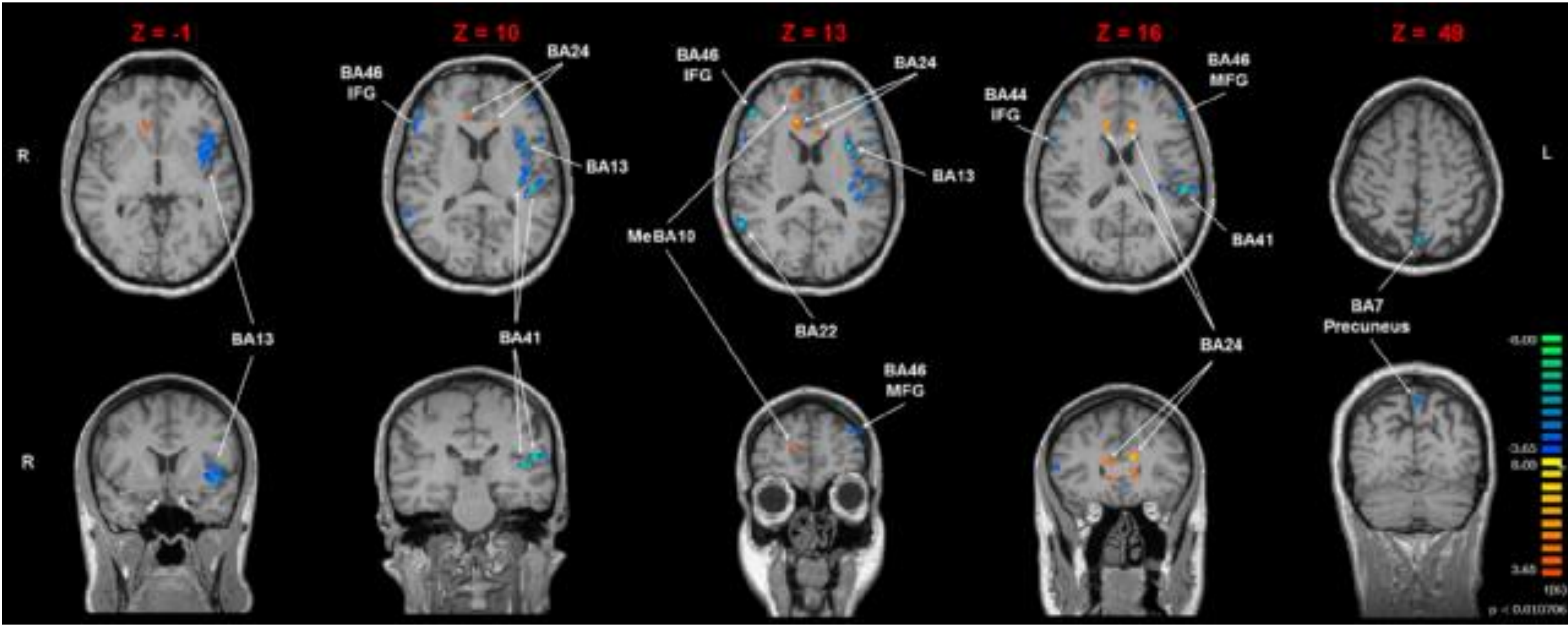
Sequence of conditions in the experiment

FA: Focused Attention Meditation (Samatha)
OM: Open Monitoring Meditation (Vipassana)



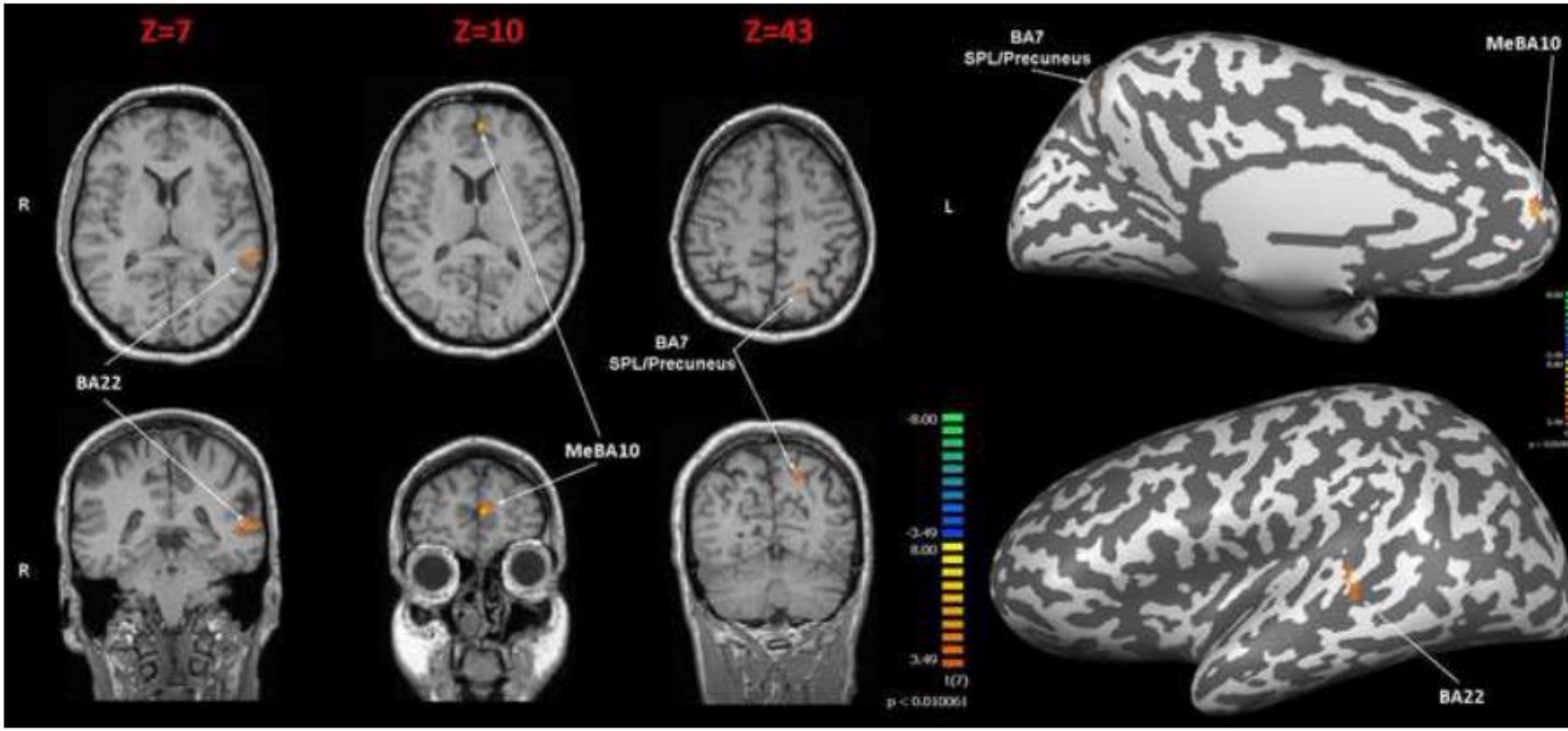
Focused Attention meditation versus Rest



BA7 Precuneus
BA10 Anterior Prefrontal Cortex
BA13 Insula
BA22 Superior Temporal Gyrus

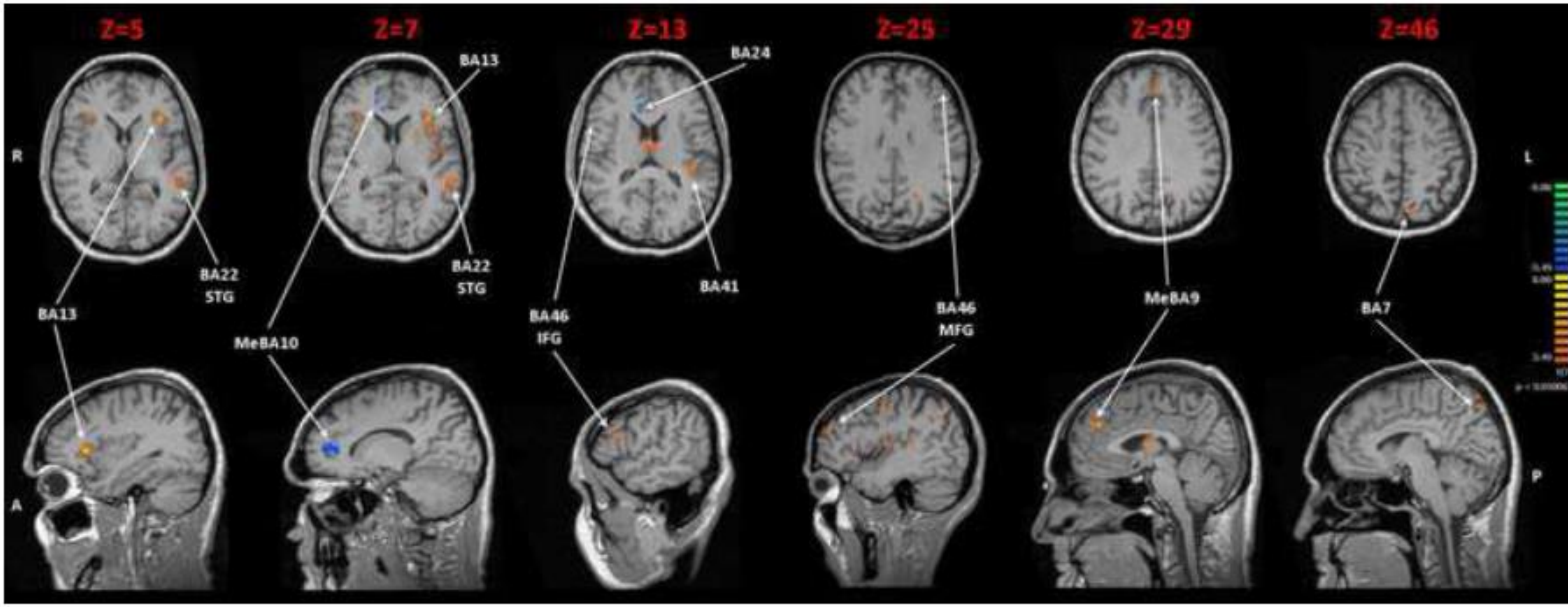
BA24 Anterior Cingulate Cortex
BA41 Auditory Primary Cortex
BA44 Ventrolateral Prefrontal Cortex
BA46 Dorsolateral Prefrontal Cortex

Open Monitoring meditation versus Rest



BA22 Superior Temporal Gyrus
BA7 Superior Parietal Lobule / Precuneus
MeBA10 Medial Anterior Prefrontal Cortex

Open Monitoring meditation versus Focused Attention meditation



BA7 Precuneus
BA10 Anterior Prefrontal Cortex
BA13 Insula
BA24 Anterior Cingulate Cortex

BA46 Inferior Frontal Gyrus
BA41 Auditory Primary Cortex
BA22 Superior Temporal Gyrus
BA9 Dorsolateral Prefrontal Cortex

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Magnetoencephalographic alpha band connectivity reveals differential default mode network interactions during focused attention and open monitoring meditation

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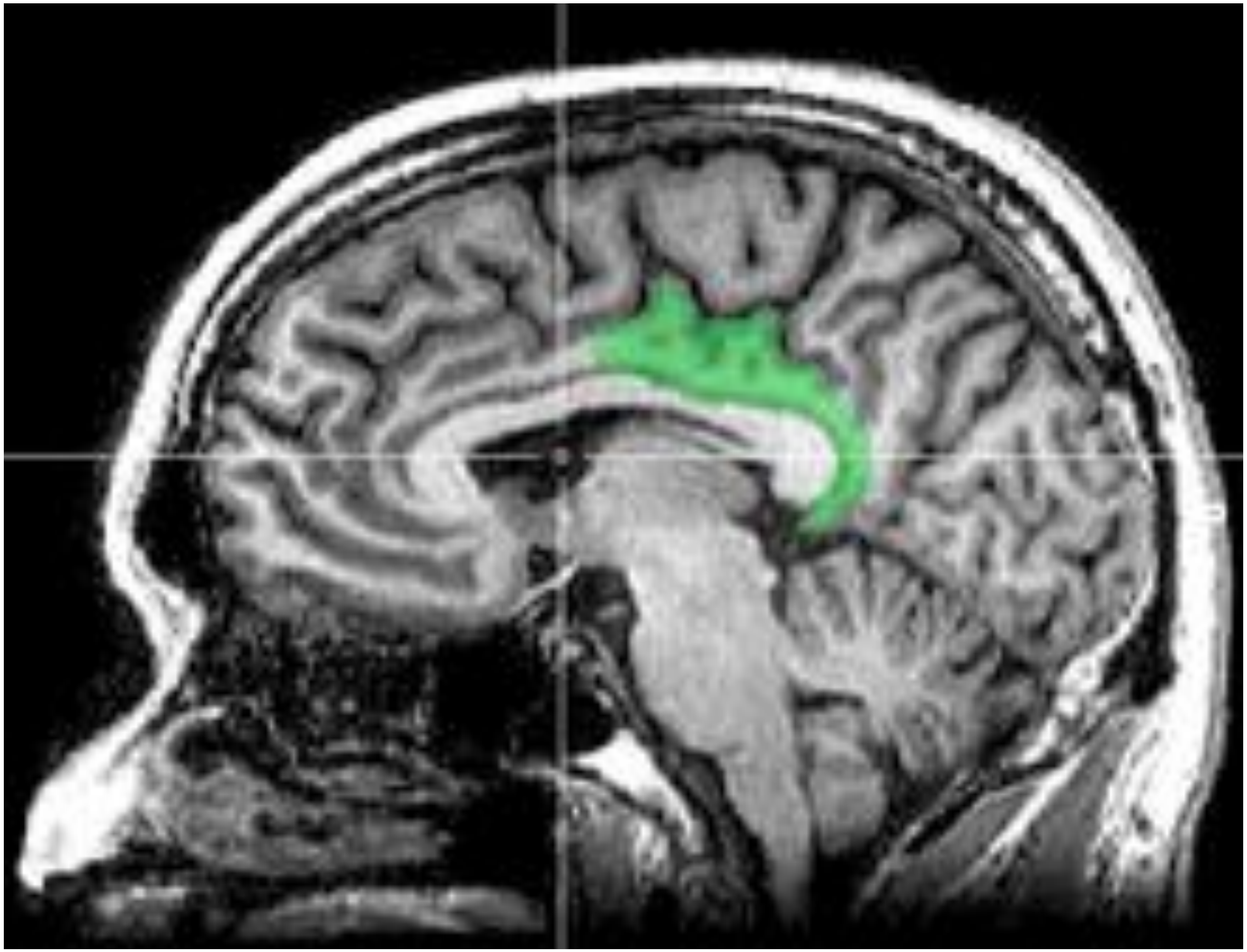
According to several conceptualizations of meditation, the interplay between brain systems associated to self-related processing, attention and executive control is crucial for meditative states and related traits. We used magnetoencephalography (MEG) to investigate such interplay in a highly selected group of "virtuoso" meditators (Theravada Buddhist monks), with long-term training in the two main meditation styles: *focused attention* (FA) and *open monitoring* (OM) meditation. Specifically, we investigated the differences between FA meditation, OM meditation and resting state in the coupling between the posterior cingulate cortex, core node of the Default Mode Network (DMN) implicated in mind wandering and self-related processing, and the whole brain, with a recently developed phase coherence approach. Our findings showed a state dependent coupling of posterior cingulate cortex (PCC) to nodes of the DMN and of the executive control brain network in the alpha frequency band (8–12 Hz), related to different attentional and cognitive control processes in FA and OM meditation, consistently with the putative role of alpha band synchronization in the functional mechanisms for attention and consciousness. The coupling of PCC with left medial prefrontal cortex (lmPFC) and superior frontal gyrus characterized the contrast between the two meditation styles in a way that correlated with meditation expertise. These correlations may be related to a higher mindful observing ability and a reduced identification with ongoing mental activity in more expert meditators. Notably, different styles of meditation and different meditation expertise appeared to modulate the dynamic balance between fronto-parietal (FP) and DMN networks. Our results support the idea that the interplay between the DMN and the FP network in the alpha band is crucial for the transition from resting state to different meditative states.



Posterior cingulate cortex: a key hub of the default mode network

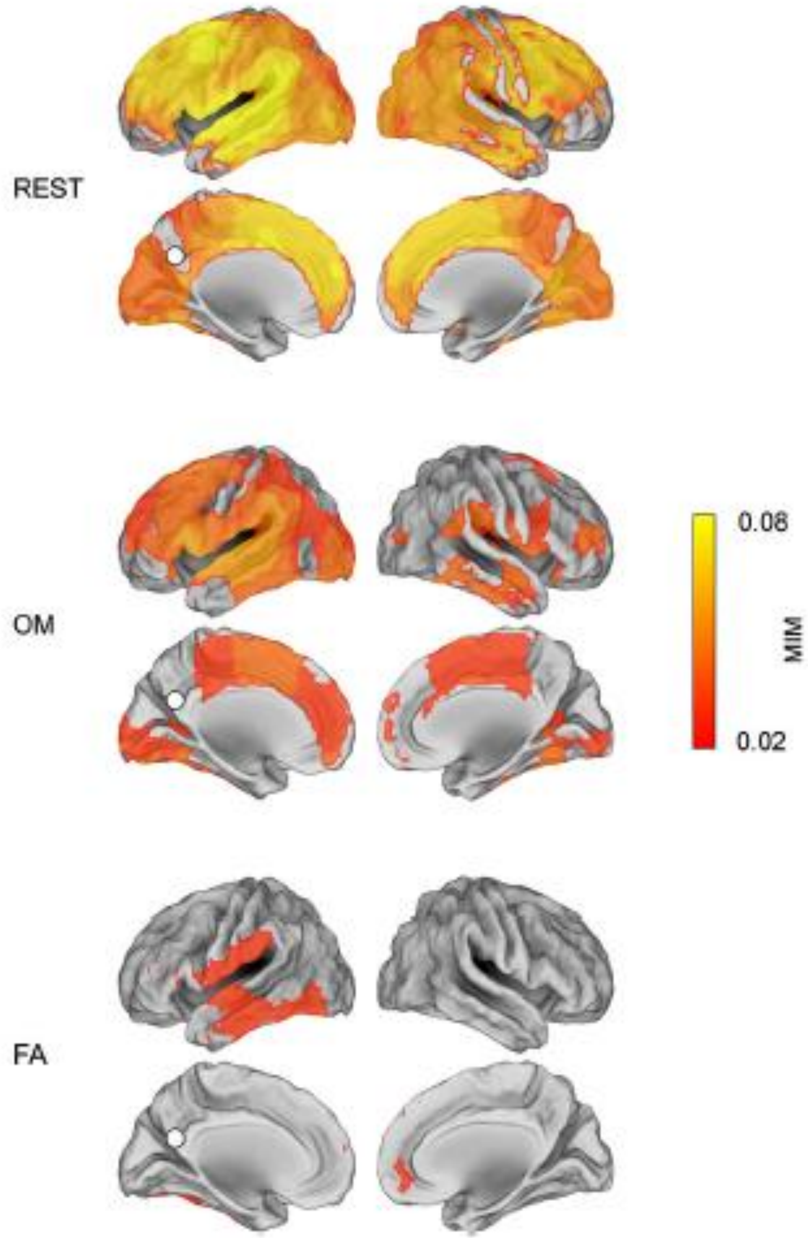


FIGURE 2 | Alpha band MIM connectivity map ($p < 0.01$, Bonferroni corrected value) with respect to the PCC seed in the three conditions: REST, OM meditation, FA meditation.

Table 1 | List of MNI coordinates for the areas most significantly connected to posterior cingulate cortex in the alpha band.

	Hemisphere	*x* (mm)	*y* (mm)	*z* (mm)	ROI
OM	L	−61	−33	−6	*LTC*
	L	−17	30	61	*SFG*
	L	−43	20	49	*MSFG*
	L	−7	0	50	*ACC*
	L	−23	31	48	*dlPFC*
	L	−64	−42	38	*AG*
	R	56	−41	14	*vITG*
FA	L	−26	−97	5	*IOG*
	L	−61	−11	−6	*LTC*
	R	56	−41	−14	*vITG*
	R	61	−22	−6	*LTC*
REST	L	−61	−33	−7	*LTC*
	L	−17	30	61	*SFG*
	L	−43	20	49	*MSFG*
	L	−7	0	50	*ACC*
	L	−64	−42	38	*AG*
	L	−4	46	12	*mPFC*
	R	4	0	47	*ACC*

The Region of Interest (ROI) represent areas whose MIM value is equal or larger than the 75% of the maximum MIM value for each condition. The ROI labelling is as follows: lateral temporal cortex (LTC), superior frontal gyrus (SFG), middle superior frontal (MSFG), ventral inferior parietal sulcus (vIPS), anterior cingulate cortex (ACC), dorsolateral prefrontal cortex (dlPFC), angular gyrus (AG), ventral inferior temporal gyrus (vITG), inferior occipital gyrus (IOG), left medial prefrontal cortex (lmPFC).

Table 2 | List of ROIs significantly differently connected to posterior cingulate cortex in the alpha band in the contrast between conditions.

	Hemisphere	*x* (mm)	*y* (mm)	*z* (mm)	ROI	Connectivity to PCC
FA-REST	L	−17	30	61	*SFG*	REST > FA
	L	−43	18	43	*MSFG*	REST > FA
	L	−61	−33	−6	*LTC*	REST > FA
	L	−7	0	50	*ACC*	REST > FA
	R	21	8	69	*SFG*	REST > FA
	R	10	0	51	*ACC*	REST > FA
OM-REST	L	−22	−58	67	*IPS*	REST > OM
OM-FA	L	−4	46	12	*mPFC*	OM > FA
	L	−28	−4	69	*SFG*	OM > FA
	L	−23	31	48	*dlPFC*	OM > FA
	L	−1	−2	44	*ACC*	OM > FA
	L	−58	−37	42	*IPL*	OM > FA
	R	2	0	46	*ACC*	OM > FA

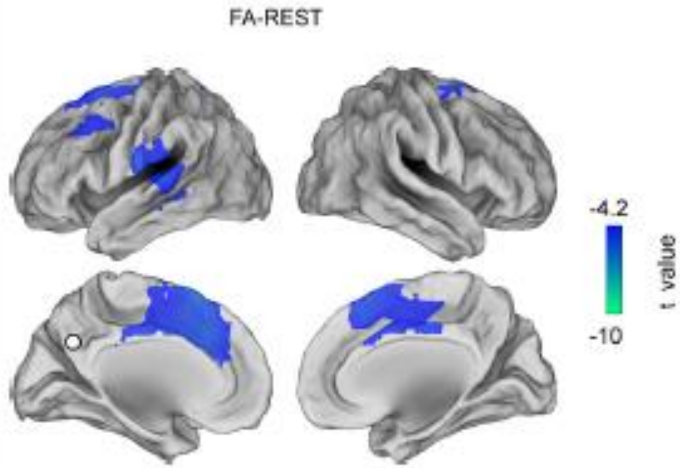


FIGURE 3 | T map for the contrast FA meditation vs. REST obtained in the alpha band ($p < 0.01$, FDR corrected value).

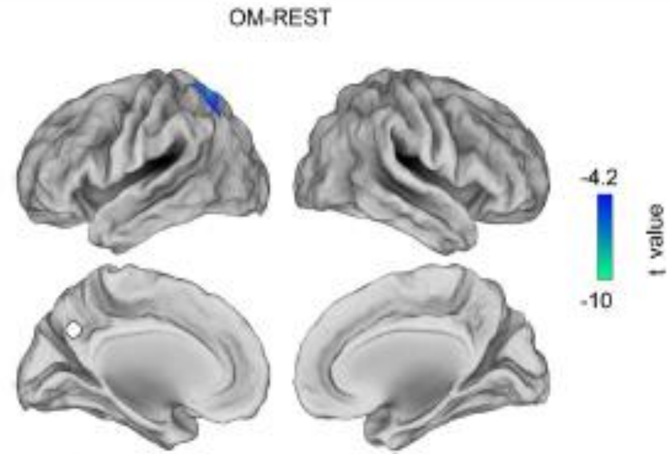


FIGURE 4 | T map for the contrast OM meditation vs. REST obtained in the alpha band ($p < 0.01$, FDR corrected value).

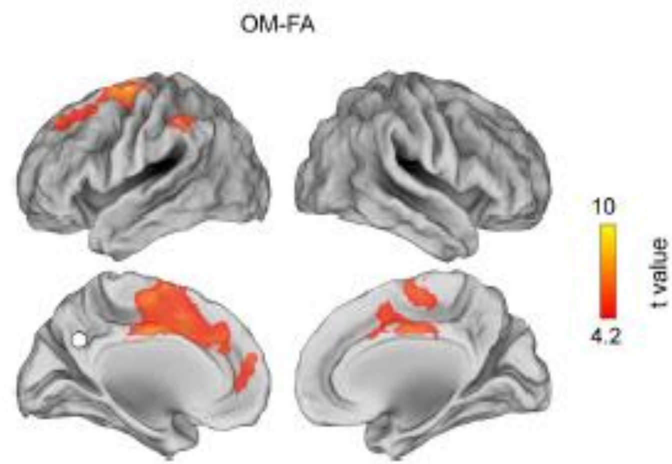


FIGURE 5 | T map for the contrast OM meditation vs. FA meditation in the alpha band ($p < 0.01$, corrected value).

Magnetoencephalographic (MEG) study
of oscillatory coupling within and between:

Default Mode Network (DMN)
Executive Network (EN)
Salience Network (SN)

in Focused Attention (FA) meditation
and Open Monitoring (OM) meditation

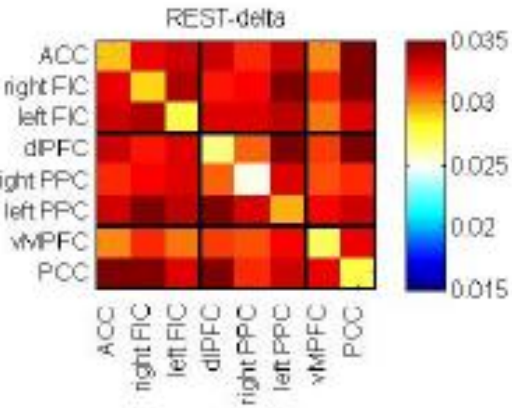
Raffone et al., in preparation

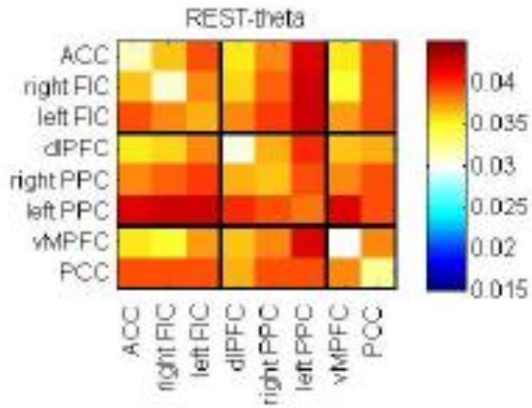
Table S1. Coordinates of SN, CEN, and DMN regions from ICA-derived clusters of the auditory event segmentation task

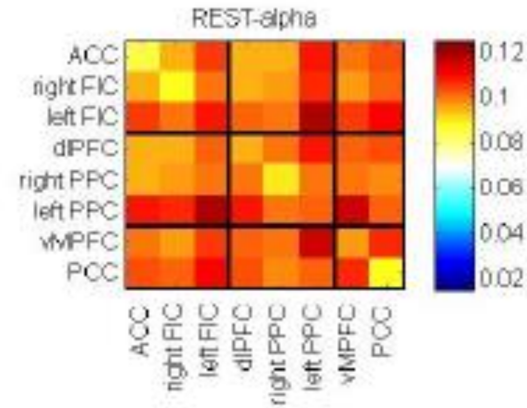
Regions	R/L	BA	Peak-MNI cords, mm	Z-Score
Fronto-insular Cortex (FIC)	R	47	37 25 −4	4.98
	L	47	−32 24 −6	4.58
Anterior Cingulate Cortex (ACC)	R/L	24/32	4 30 30	5.80
Dorsolateral Prefrontal Cortex (DLPFC)	R	9	45 16 45	5.14
Posterior Parietal Cortex (PPC)	R	40	54 −50 50	6.18
	L	40	−38 −53 45	4.90
Ventromedial Prefrontal Cortex (VMPFC)	R/L	11	−2 36 −10	4.92
Posterior Cingulate Cortex (PCC)	R/L	23/30	−7–43 33	6.36

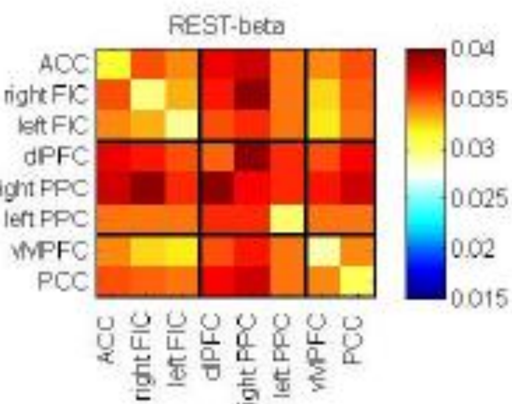
Abbreviations: BA, brodmann area; R/L, right or left.

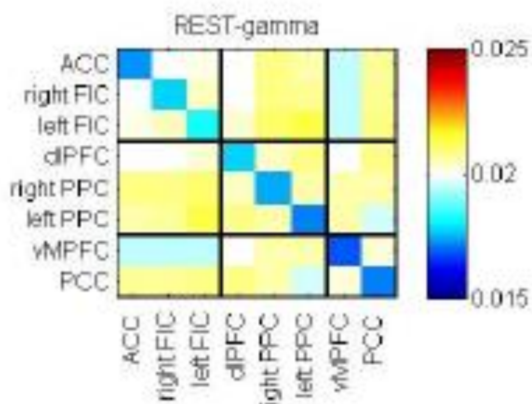
Media tra i soggetti (gruppo dei monaci) della Phase Coherence tra i nodi delle reti Salience, Central Executive e Default nella condizione REST



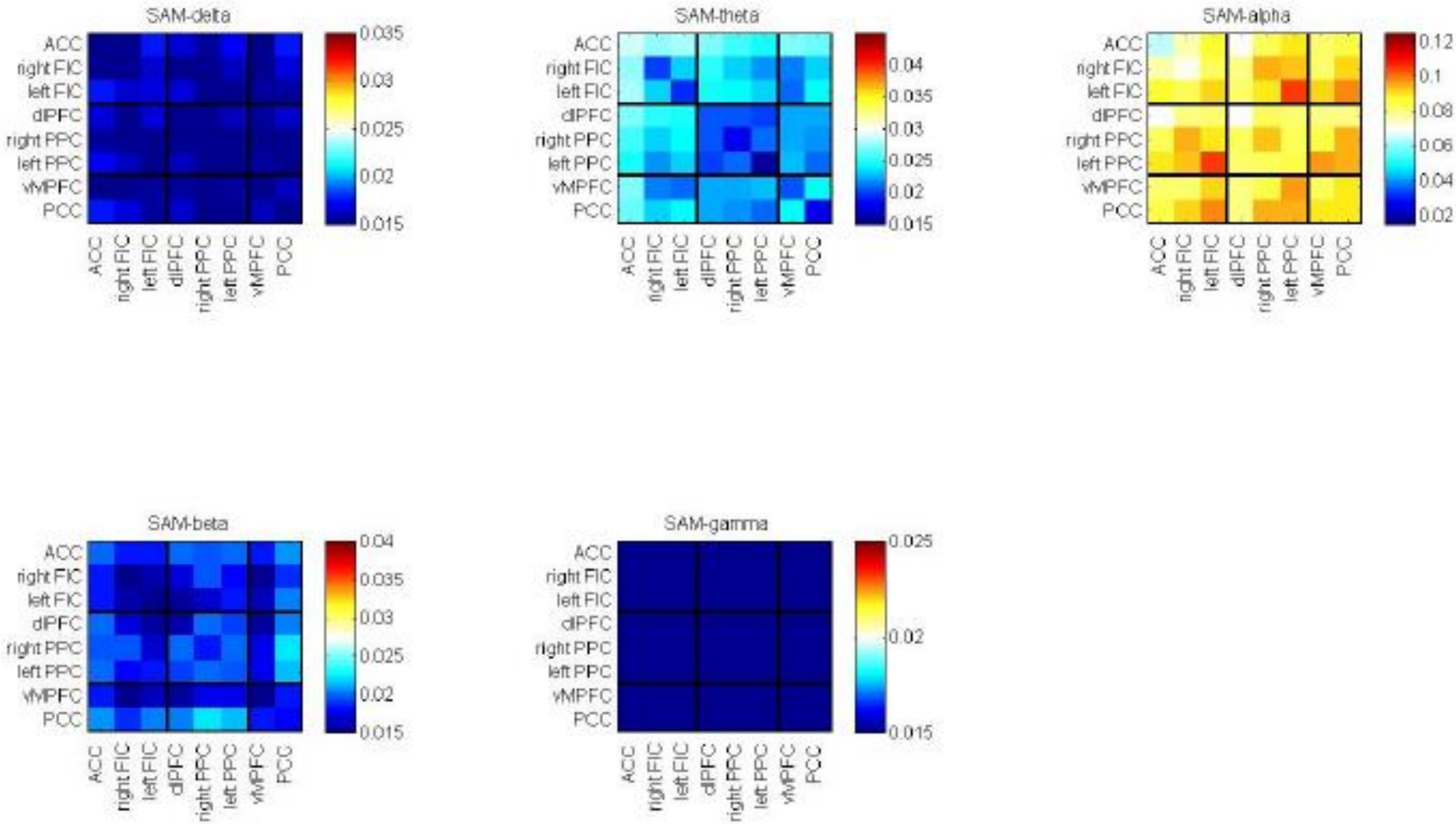




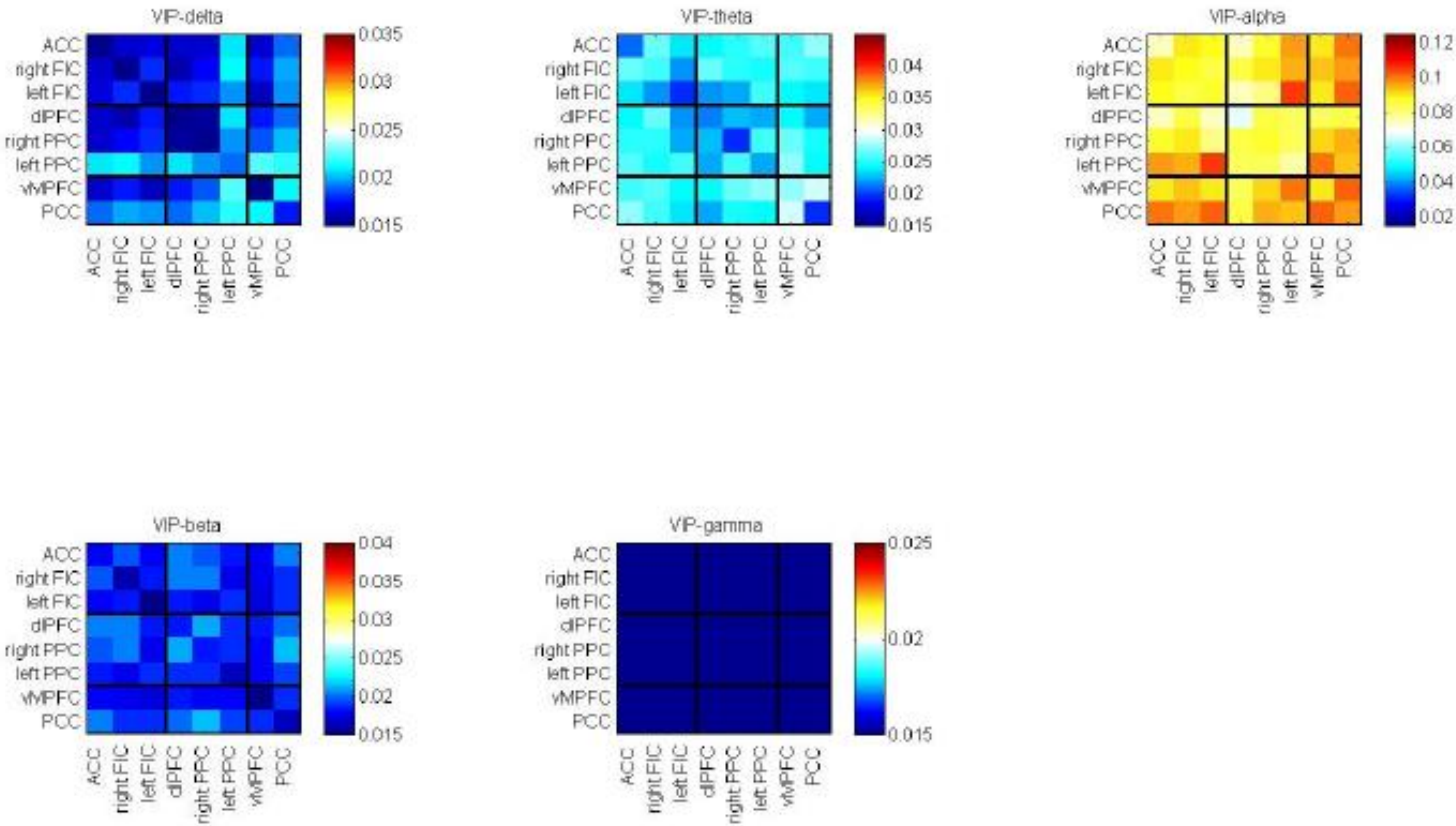


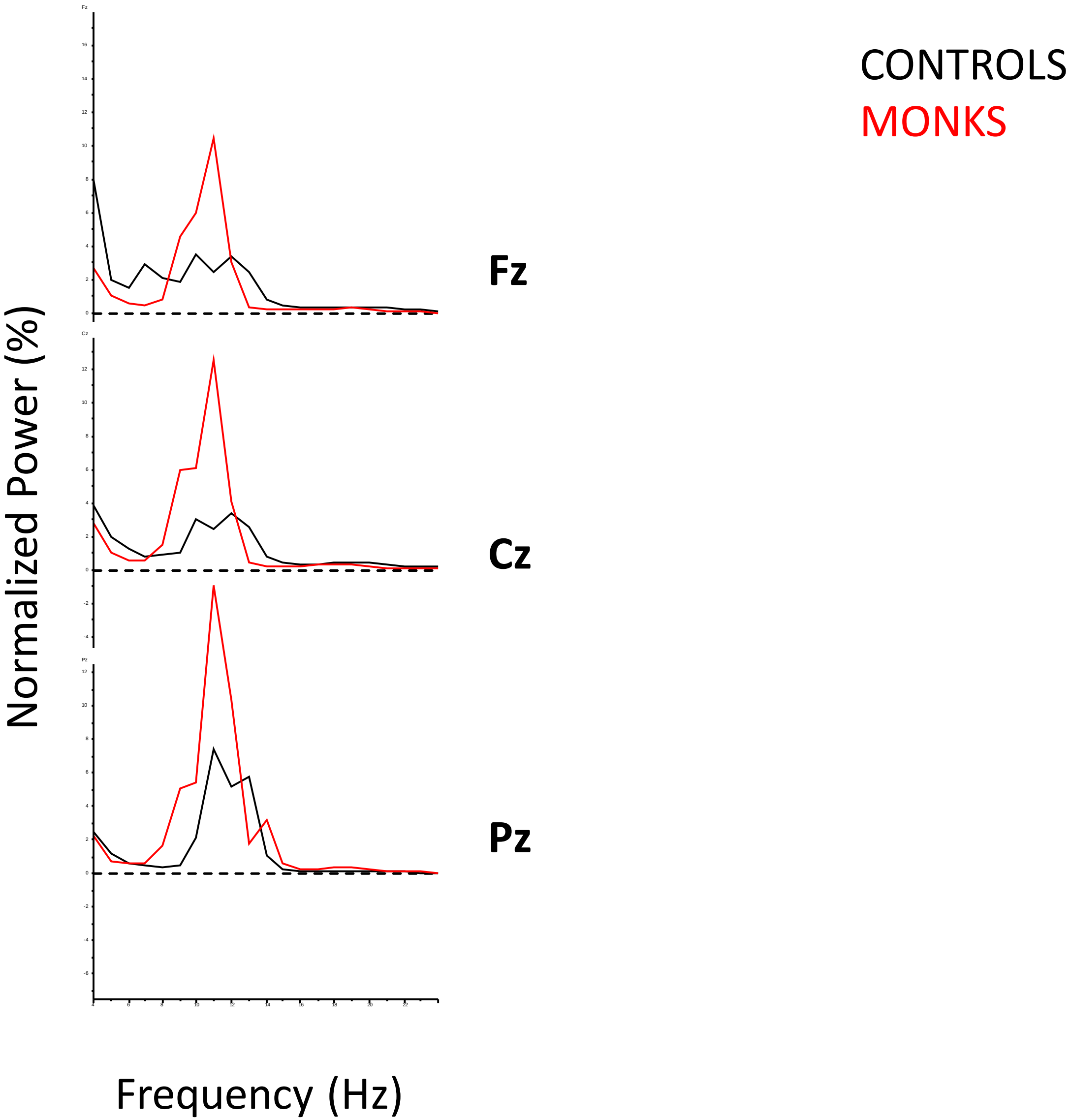


Media tra i soggetti (gruppo dei monaci) della Phase Coherence tra i nodi delle reti Salience, Central Executive e Default nella condizione FA



Media tra i soggetti (gruppo dei monaci) della Phase Coherence tra i nodi delle reti Salience, Central Executive e Default nella condizione OM





CONTROLS
MONKS
Fz
Cz
Pz
Normalized Power (%)
Frequency (Hz)

Toward a brain theory of meditation

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Abstract

The rapidly progressing science of meditation has led to insights about the neural correlates of focused attention meditation (FAM), open monitoring meditation (OMM), compassion meditation (CM) and loving kindness meditation (LKM), in terms of states and traits. However, a unified theoretical understanding of the brain mechanisms involved in meditation-related functions, including mindfulness, is lacking. After reviewing the main forms of meditation and their relationships, the major brain networks and brain states, as well as influential theoretical views of consciousness, we outline a Brain Theory of Meditation (BTM). BTM takes the lead from considerations about the roles of the major brain networks, i.e., the central executive, salience and default mode networks, and their interplay, in meditation, and from an essential energetic limitation of the human brain, such that only up to 1% of the neurons in the cortex can be concurrently activated. The development of the theory is also guided by our neuroscientific studies with the outstanding participation of Theravada Buddhist monks, with other relevant findings in literature. BTM suggests mechanisms for the different forms of meditation, with the down-regulation of brain network activities in FAM, the gating and tuning of network coupling in OMM, and state-related up-regulation effects in CM and LKM. The theory also advances a leftward asymmetry in top-down regulation, and an enhanced inter-hemispheric integration, in meditation states and traits, also with implications for a theoretical understanding of conscious access. Meditation thus provides a *meta-function* for an efficient brain/mind regulation, and a flexible allocation of highly limited and often constrained (e.g., by negative emotion and mind wandering) brain activity resources, which can be related to *mindfulness*. Finally, a series of experimental predictions is derived from the theory.

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The Cost of Cortical Computation

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Summary

Electrophysiological recordings show that individual neurons in cortex are strongly activated when engaged in appropriate tasks, but they tell us little about how many neurons might be engaged by a task, which is important to know if we are to understand how cortex encodes information. For human cortex, I estimate the cost of individual spikes, then, from the known energy consumption of cortex, I establish how many neurons can be active concurrently. The cost of a single spike is high, and this severely limits, possibly to fewer than 1%, the number of neurons that can be substantially active concurrently. The high cost of spikes requires the brain not only to use representational codes that rely on very few active neurons, but also to allocate its energy resources flexibly among cortical regions according to task demand. The latter constraint explains the investment in local control of hemodynamics, exploited by functional magnetic resonance imaging, and the need for mechanisms of selective attention.

rat neocortex. Neurons in human neocortex are larger than those in rat and receive and make more synapses, but they are not otherwise known to differ in their basic structure or organization [5]. Thus, with appropriate scaling of parameters for the larger neurons, Attwell and Laughlin's analysis can be used to estimate the energy consumed by a pyramidal neuron in human neocortex.

In different mammals, the number of neurons under a unit area of cortical surface is relatively constant (~100,000/mm^2), except in primate striate cortex, where it may be twice as high [6]. Increasing brain size brings an increase in cortical thickness and a proportionately lower density of neurons [5, 6] without an increase in cell body size, which remains approximately constant at 15 μm diameter [7]. The volume of axons and dendrites increases with cortical thickness. This reflects an increase in the lengths of dendrites and axons without an increase in diameter [5]. Table 1 summarizes relevant statistics for human cortex.

Postsynaptic Potentials

Individual synapses are assumed to be the same in rat and human neurons, so the energy costs associated with transmitter uptake and release will be the same, as will the current flow through receptor channels. Given (from Table 1) 7×10^8 synapses per mm^3 of cortex, and 40,000 neurons/mm^3, the average neuron will make 17,500 synaptic contacts. If we use this number, and assume a 50% failure rate [8, 9], the cost of EPSPs arising from a single spike will be 1.2×10^9 ATP mole-

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Shifting brain asymmetry: the link between meditation and structural lateralization

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Previous studies have revealed an increased fractional anisotropy and greater thickness in the anterior parts of the corpus callosum in meditation practitioners compared with control subjects. Altered callosal features may be associated with an altered inter-hemispheric integration and the degree of brain asymmetry may also be shifted in meditation practitioners. Therefore, we investigated differences in gray matter asymmetry as well as correlations between gray matter asymmetry and years of meditation practice in 50 long-term meditators and 50 controls. We detected a decreased rightward asymmetry in the precuneus in meditators compared with controls. In addition, we observed that a stronger leftward asymmetry near the posterior intraparietal sulcus was positively associated with the number of meditation practice years. In a further exploratory analysis, we observed that a stronger rightward asymmetry in the pregenual cingulate cortex was negatively associated with the number of practice years. The group difference within the precuneus, as well as the positive correlations with meditation years in the pregenual cingulate cortex, suggests an adaptation of the default mode network in meditators. The positive correlation between meditation practice years and asymmetry near the posterior intraparietal sulcus may suggest that meditation is accompanied by changes in attention processing.

Research project funded by *BIAL Foundation*, Portugal

Title: *Aware Mind-Brain*: bridging insights on the mechanisms and neural substrates of human awareness and meditation

Project proposer and coordinator:
Dr. Antonino Raffone
Department of Psychology
Sapienza University of Rome

Project duration: 30 months

Funded budget: 135,000 euros

Start date: November 1st, 2015

Mindfulness and Pain

Cerebral Cortex November 2012;22:2692–2702
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Advance Access publication December 15, 2011

Pain Attenuation through Mindfulness is Associated with Decreased Cognitive Control and Increased Sensory Processing in the Brain

Tim Gard[1,2], Britta K. Hölzel[1,2], Alexander T. Sack[3], Hannes Hempel[2], Sara W. Lazar[1], Dieter Vaitl[2,4] and Ulrich Ott[2,4]

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A non-elaborative mental stance and decoupling of executive and pain-related cortices predicts low pain sensitivity in Zen meditators

Joshua A. Grant[a,b,c,e], Jérôme Courtemanche[c,d], Pierre Rainville[b,c,e]

Ann. N.Y. Ac
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Issue: *Advances in Meditation Research*

Mindfulness meditation–based pain relief: a mechanistic account

Fadel Zeidan[1] and David R. Vago[2]

Original Investigation

Effect of Mindfulness-Based Stress Reduction vs Cognitive Behavioral Therapy or Usual Care on Back Pain and Functional Limitations in Adults With Chronic Low Back Pain

A Randomized Clinical Trial

Daniel C. Cherkin, PhD; Karen J. Sherman, PhD; Benjamin H. Balderson, PhD; Andrea J. Cook, PhD; Melissa L. Anderson, MS; Rene J. Hawkes, BS; Kelly E. Hansen, BS; Judith A. Turner, PhD

Mindfulness Meditation for Chronic Pain: Systematic Review and Meta-analysis

Lara Hilton, MPH[1] · Susanne Hempel, PhD[1] · Brett A. Ewing, MS[1] ·
Eric Apaydin, MPP[1] · Lea Xenakis, MPA[1] · Sydne Newberry, PhD[1] ·
Ben Colaiaco, MA[1] · Alicia Ruelaz Maher, MD[1] · Roberta M. Shanman, MS[1] ·
Melony E. Sorbero, PhD[1] · Margaret A. Maglione, MPP[1]

Modulation of pain experiences and their electrophysiological correlates by meditation states and expertise

Valentina Nicolardi[1], Vasil Kolev[2], Juliana Yordanova[2] , Federica Mauro[1], Peter Malinowski[3], Salvatore M. Aglioti[1], Antonino Raffone[1]

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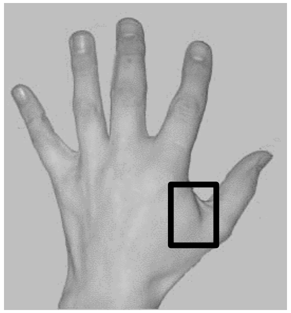
[3]*School of Natural Sciences and Psychology, Liverpool John Moores University, United Kingdom.*

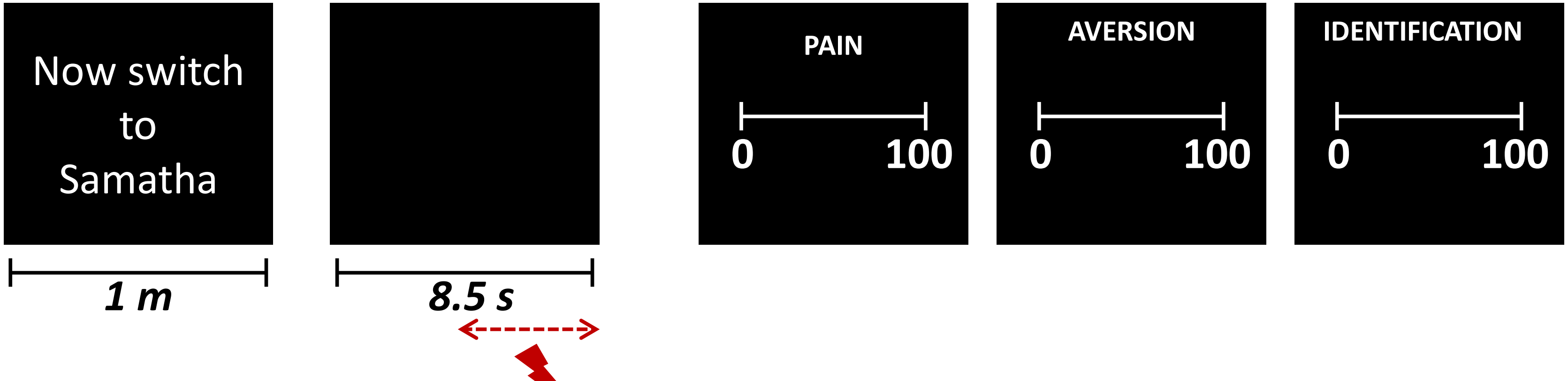
In preparation.

Methods

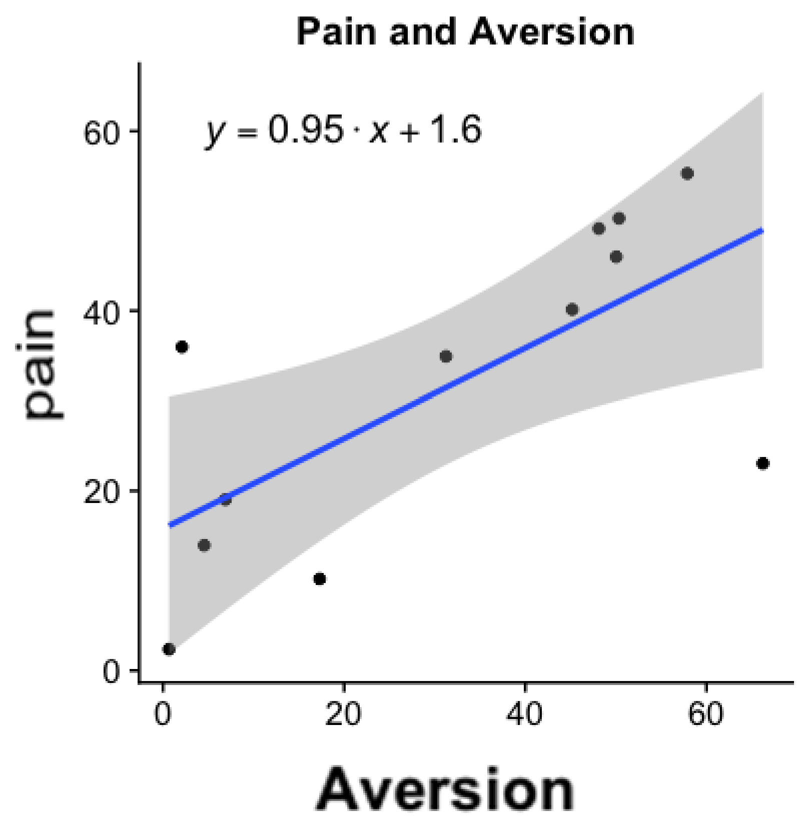


PROCEDURE

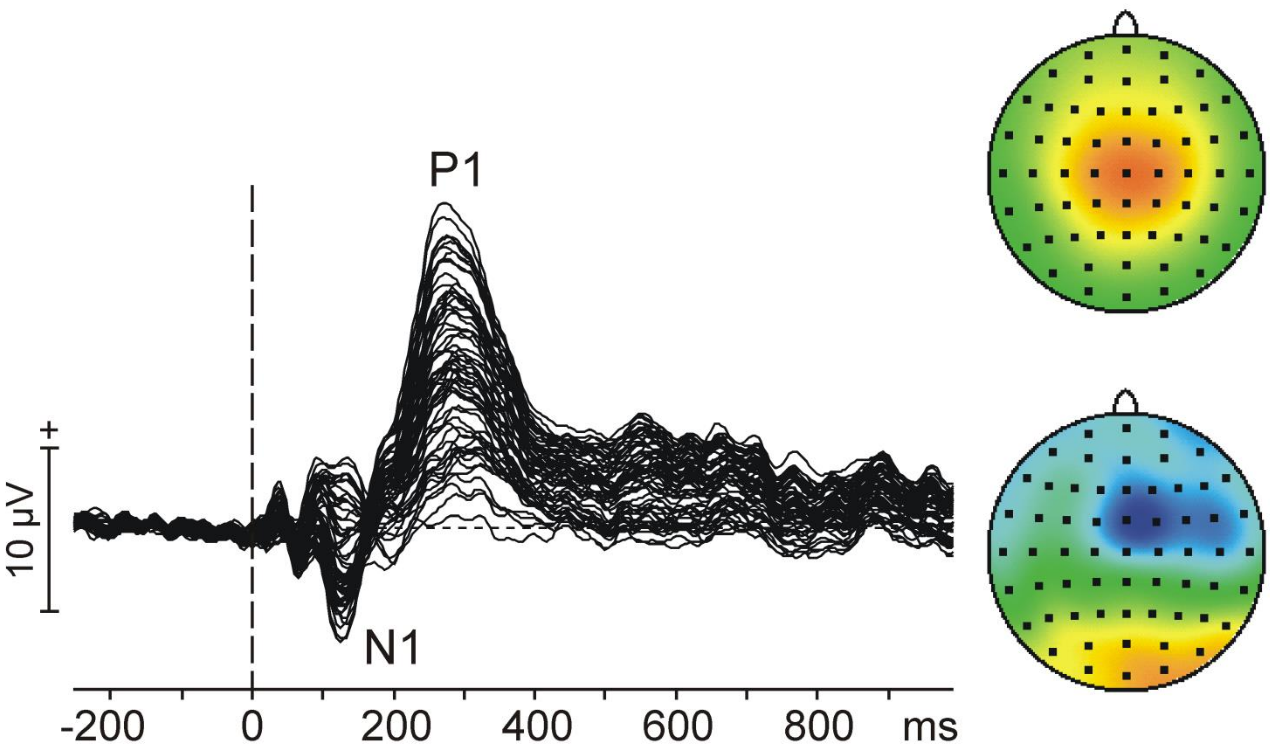
Threshold → Calibration → Task



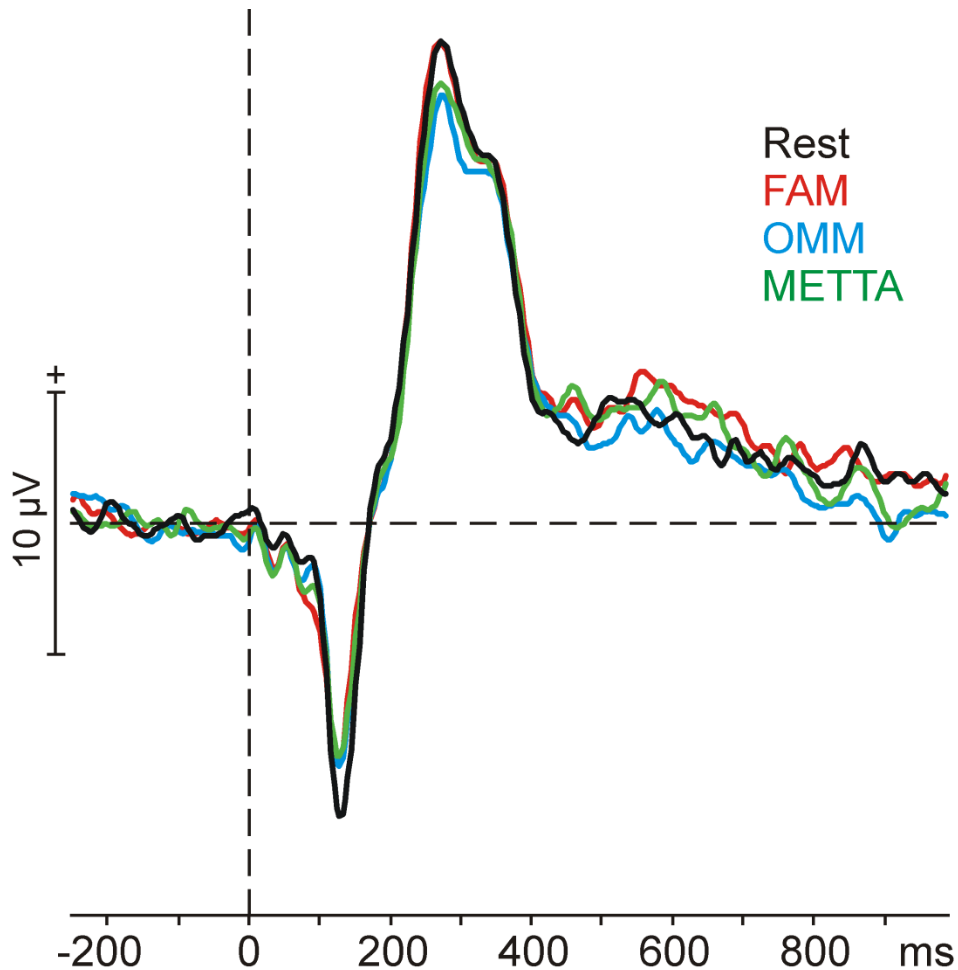
Aversion predicts pain



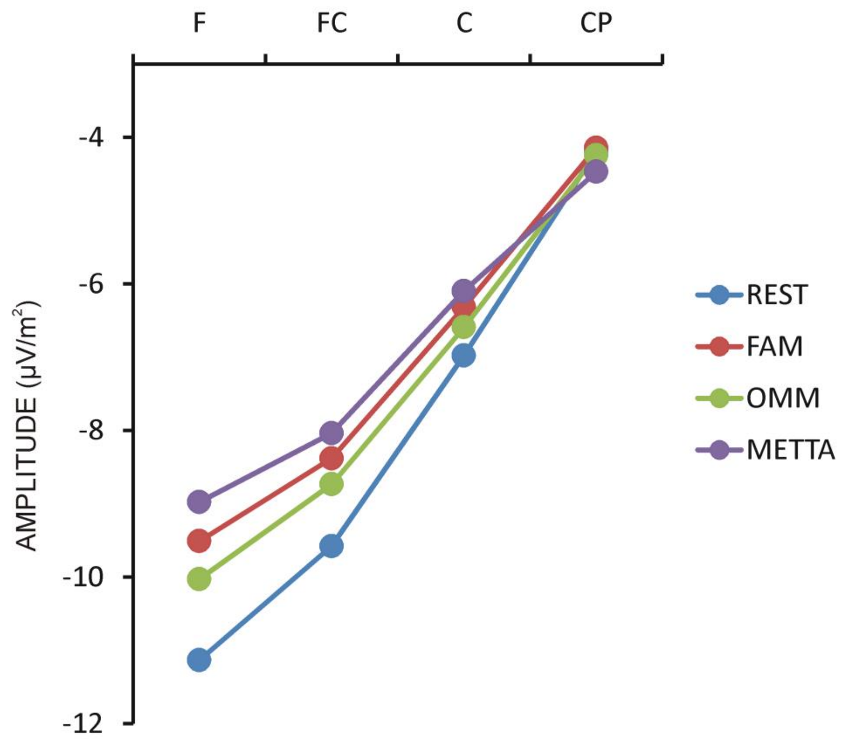
Pain ERPs



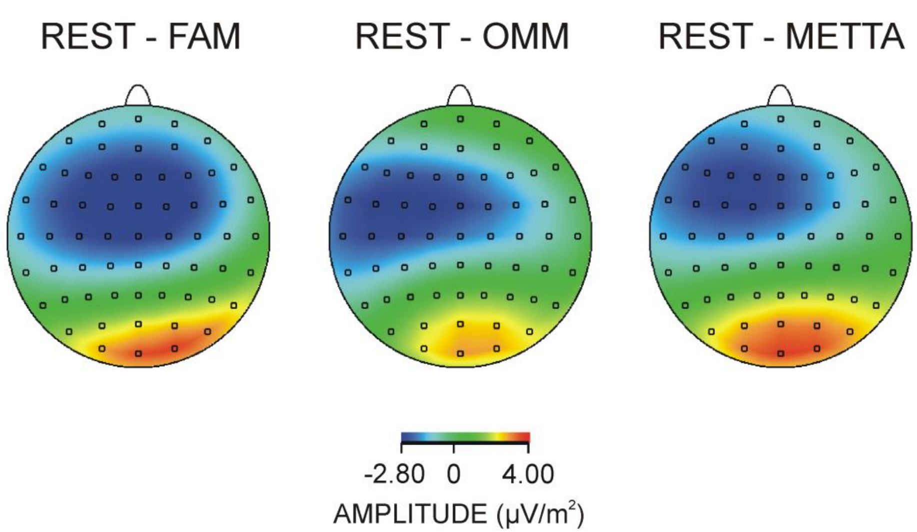
Pain ERPs



Pain ERPs



F
FC
C
CP
-4
-6
-8
-10
-12
AMPLITUDE (µV/m²)
REST
FAM
OMM
METTA



REST - FAM
REST - OMM
REST - METTA
-2.80
0
4.00
AMPLITUDE (µV/m²)

Modulation of emotion experiences and their electrophysiological correlates by meditation states and expertise

Federica Mauro[1], Vasil Kolev[2], Juliana Yordanova[2] , Valentina Nicolardi[1], Peter Malinowski[3], & Antonino Raffone[1]

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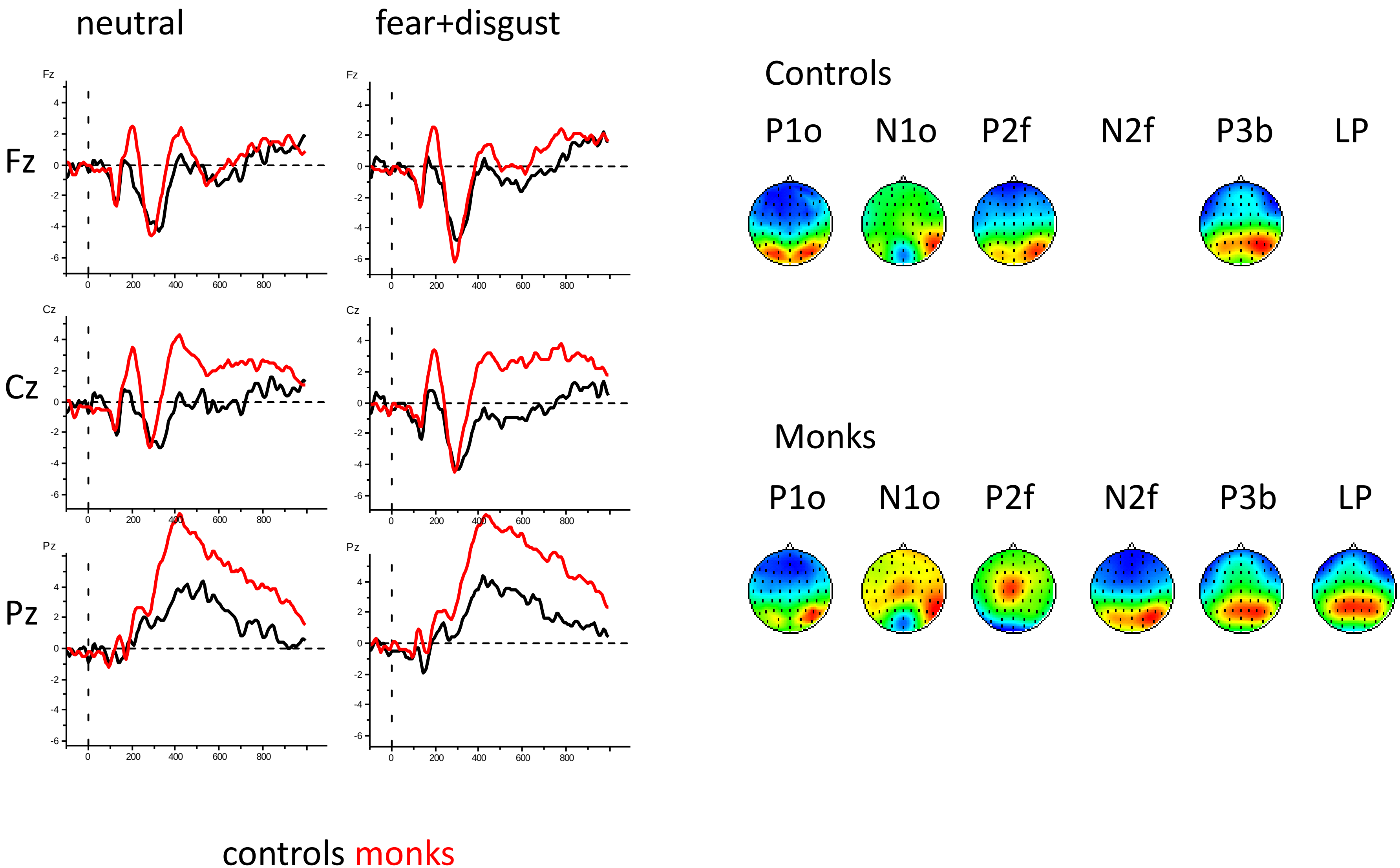
[3]School of Natural Sciences and Psychology, Liverpool John Moores University, United Kingdom.

In preparation.

The two dimensions of sensation colouring according to affective neuroscience

ERPs REST



neutral
fear+disgust
Fz
Cz
Pz
0
200
400
600
800
Controls
Monks
P1o
N1o
P2f
N2f
P3b
LP
controls monks

Patterns of oscillatory brain rhythms and coherence related to focused attention, open monitoring and loving kindness meditation in Buddhist monks

Vasil Kolev[1], Juliana Yordanova[1], Federica Mauro[2], Valentina Nicolardi[2], Peter Malinowski[3], & Antonino Raffone[2]

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In preparation.

Title:

Insights on meditation expertise and brain network neuroplasticity by fMRI functional connectivity and multivariate pattern analysis

Abbreviated title:

Meditation expertise predicted using brain networks

Authors:

Roberto Guidotti[1,2], Cosimo Del Gratta[1,2], Mauro Gianni Perrucci[1,2], Gian Luca Romani[1,2] , Antonino Raffone[3]

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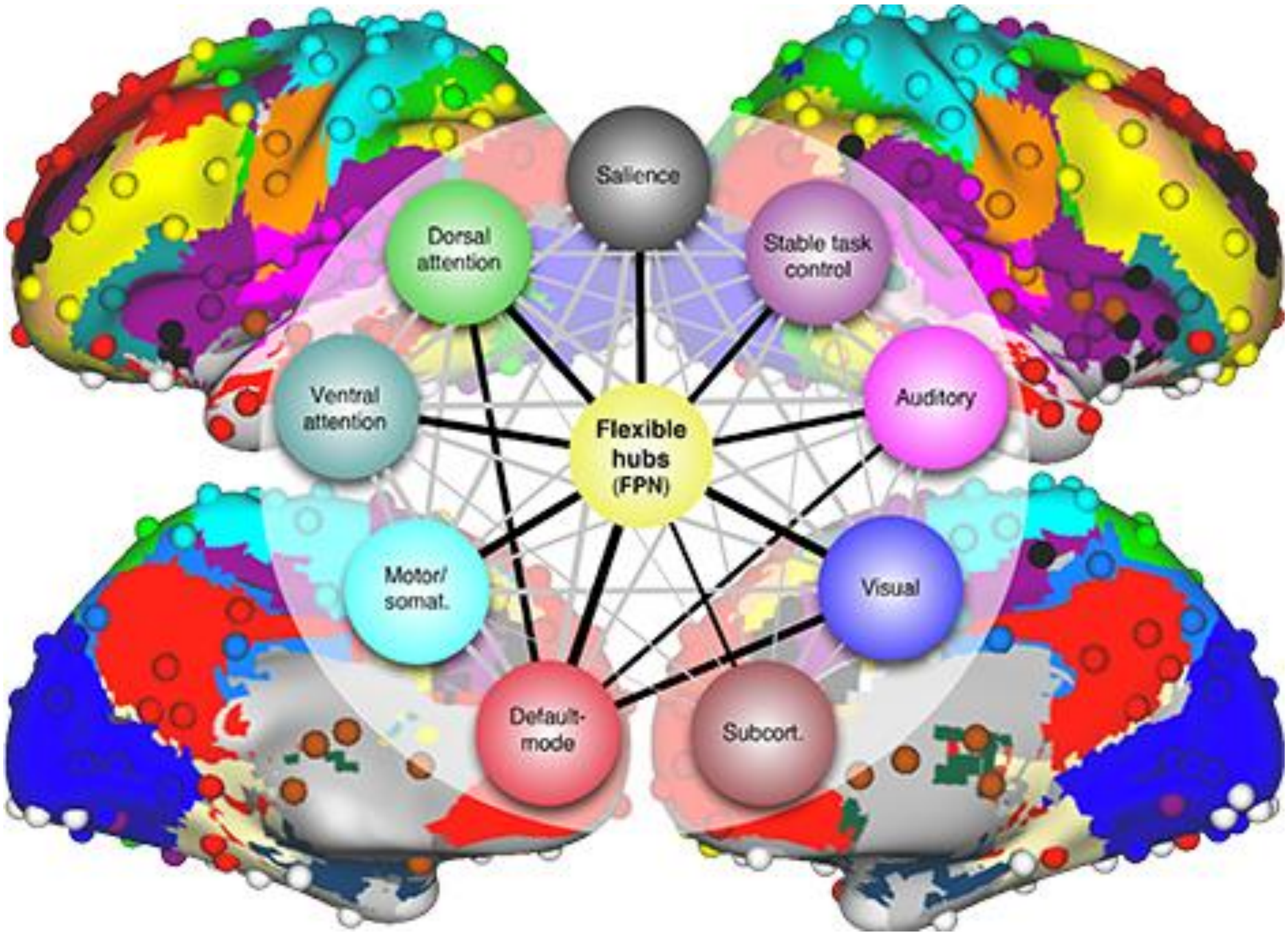
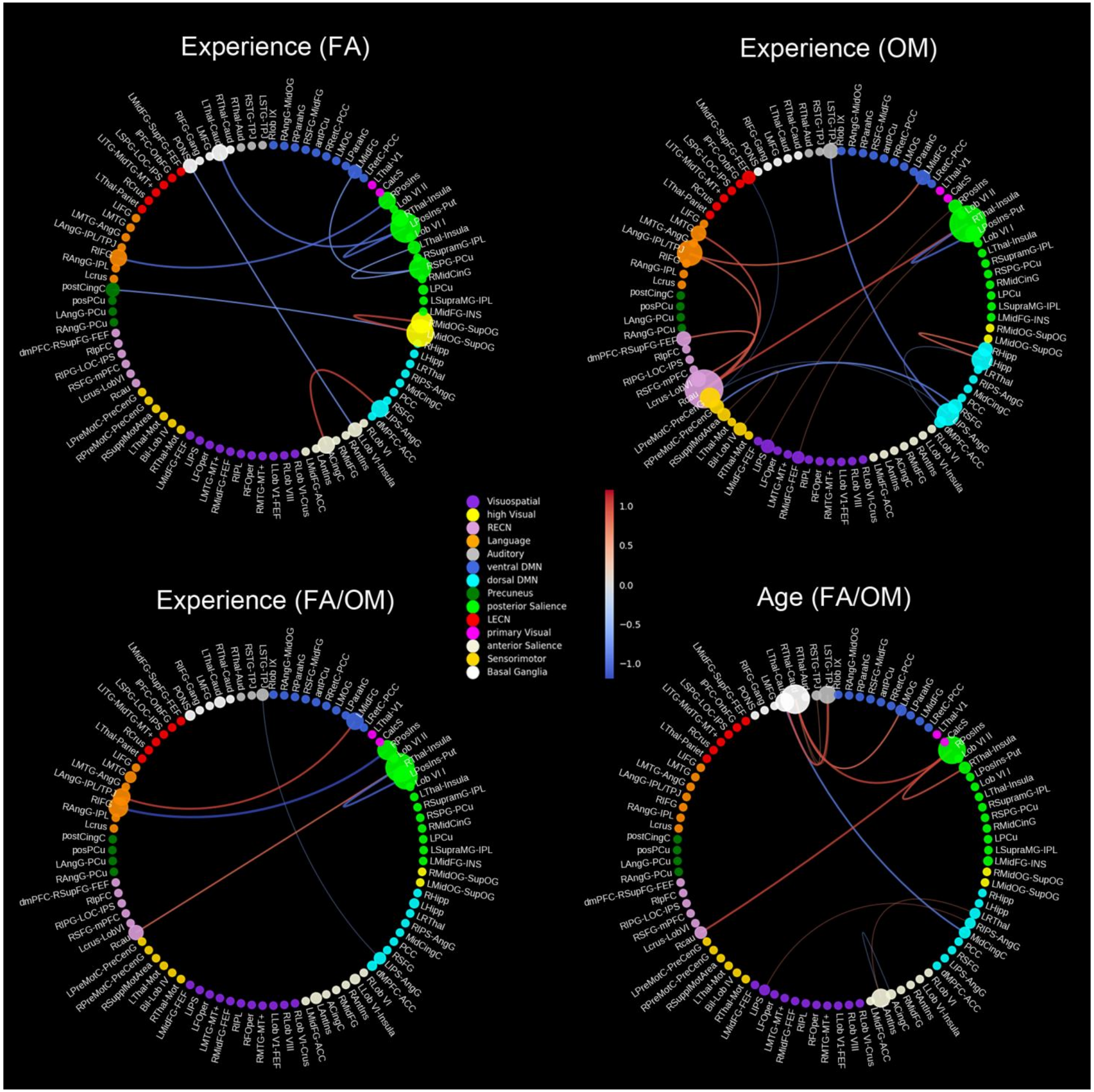
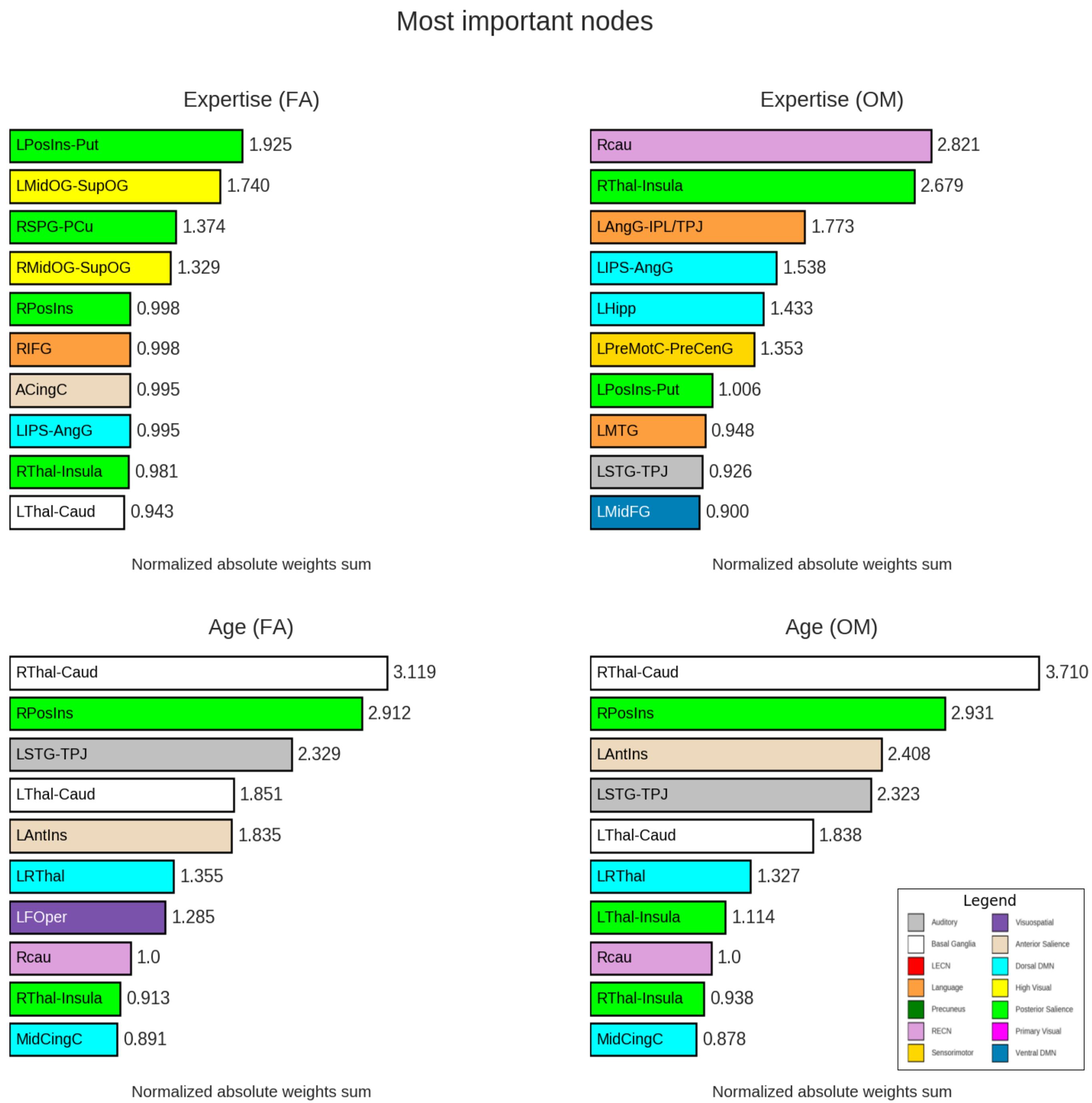


A set of brain networks and the involved neuronal populations across regions

By Dr. Michael W. Cole, Washington University in St. Louis


Experience (FA)
Experience (OM)
Experience (FA/OM)
Age (FA/OM)
Visuospatial
high Visual
RECN
Language
Auditory
ventral DMN
dorsal DMN
Precuneus
posterior Salience
LECN
primary Visual
anterior Salience
Sensorimotor
Basal Ganglia
1.0
0.5
0.0
−0.5
−1.0


Most important nodes
Expertise (FA)
LPosIns-Put 1.925
LMidOG-SupOG 1.740
RSPG-PCu 1.374
RMidOG-SupOG 1.329
RPosIns 0.998
RIFG 0.998
ACingC 0.995
LIPS-AngG 0.995
RThal-Insula 0.981
LThal-Caud 0.943
Normalized absolute weights sum
Expertise (OM)
Rcau 2.821
RThal-Insula 2.679
LAngG-IPL/TPJ 1.773
LIPS-AngG 1.538
LHipp 1.433
LPreMotC-PreCenG 1.353
LPosIns-Put 1.006
LMTG 0.948
LSTG-TPJ 0.926
LMidFG 0.900
Normalized absolute weights sum
Age (FA)
RThal-Caud 3.119
RPosIns 2.912
LSTG-TPJ 2.329
LThal-Caud 1.851
LAntIns 1.835
LRThal 1.355
LFOper 1.285
Rcau 1.0
RThal-Insula 0.913
MidCingC 0.891
Normalized absolute weights sum
Age (OM)
RThal-Caud 3.710
RPosIns 2.931
LAntIns 2.408
LSTG-TPJ 2.323
LThal-Caud 1.838
LRThal 1.327
LThal-Insula 1.114
Rcau 1.0
RThal-Insula 0.938
MidCingC 0.878
Normalized absolute weights sum
Legend
Auditory
Visuospatial
Basal Ganglia
Anterior Salience
LECN
Dorsal DMN
Language
High Visual
Precuneus
Posterior Salience
RECN
Primary Visual
Sensorimotor
Ventral DMN


compassion it.

Grazie per l’attenzione