Introduction

Figure 1 Different models of the psyche in psychoanalysis (upper) and the brain in current neuroscience (lower) with red dotted lines indicating their insufficient, i.e., contingent connection ("gap of contingency")

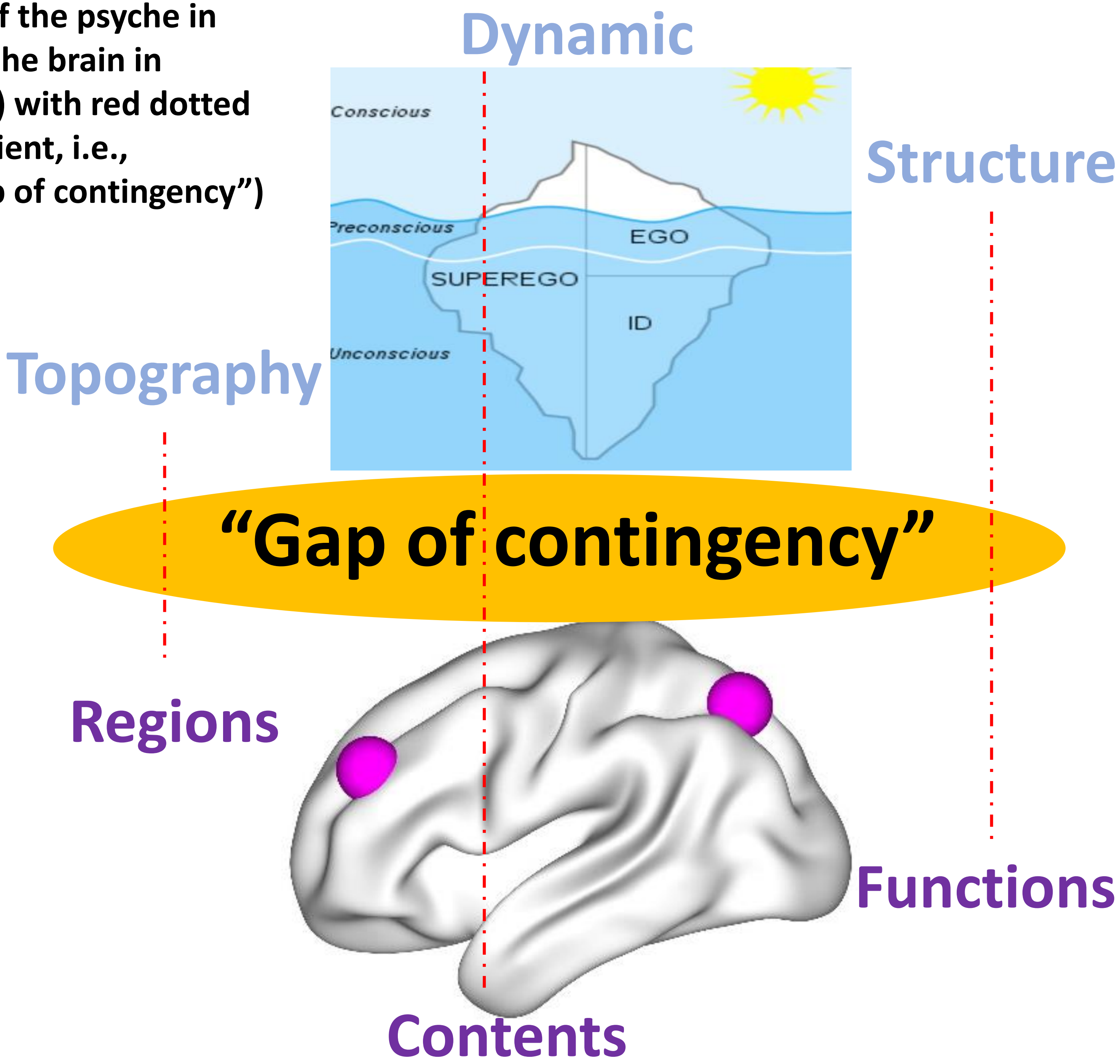
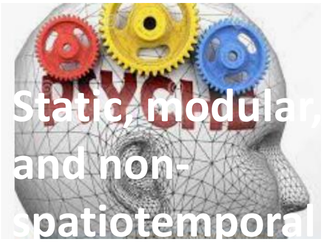
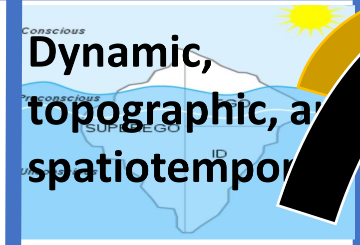
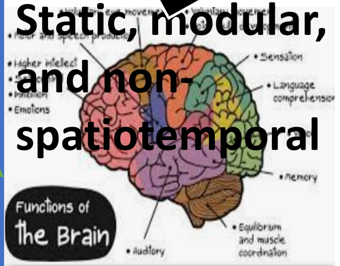
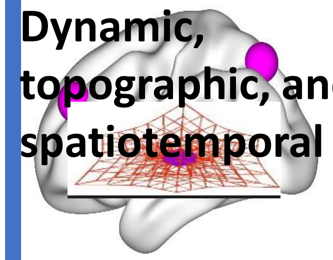


Table 1 Views of psyche and brain in psychology, psychoanalysis, and different forms of neuroscience

	Psychology	Psychoanalysis	Cognitive or Affective Neuroscience	Spatiotemporal Neuroscience
Psyche	 Static, modular, and non-spatiotemporal	 Dynamic, topographic, a spatiotempor		
Brain			 Static, modular, and non-spatiotemporal	 Dynamic, topographic, and spatiotemporal

Arrows indicate the combination of the models of the psyche in Psychology and Psychoanalysis with the model of brain as in Cognitive/Affective Neuroscience (green arrow, black arrow) as well as of Psychoanalysis with Spatiotemporal Neuroscience (orange arrow). Red lines (on the black arrow) indicate the mismatch between the models of psyche (in psychoanalysis) and brain (in Cognitive/Affective Neuroscience)

Figure 2 Shared features as "common currency" (middle) of brain (lower) and psychic apparatus (upper)

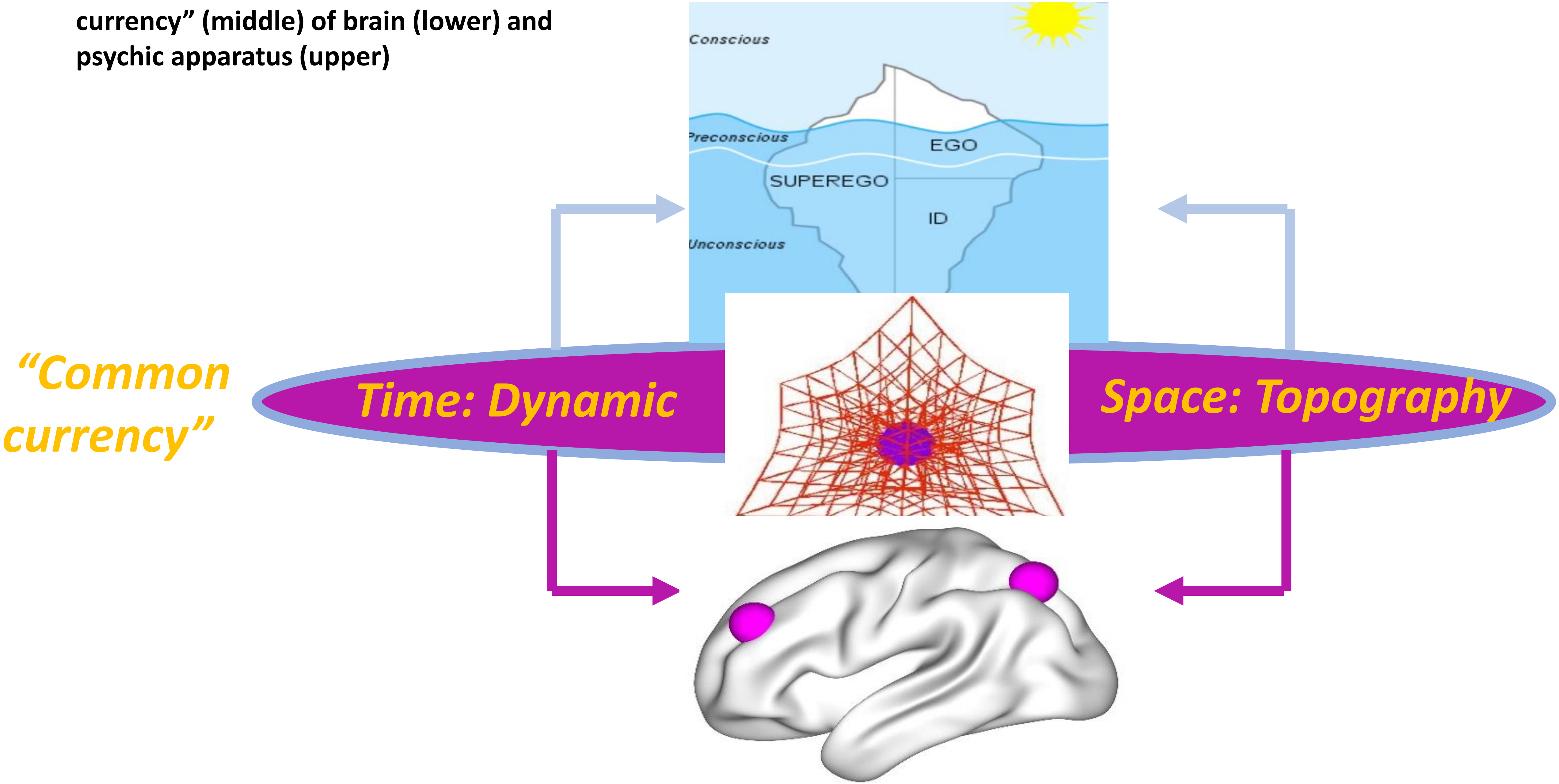
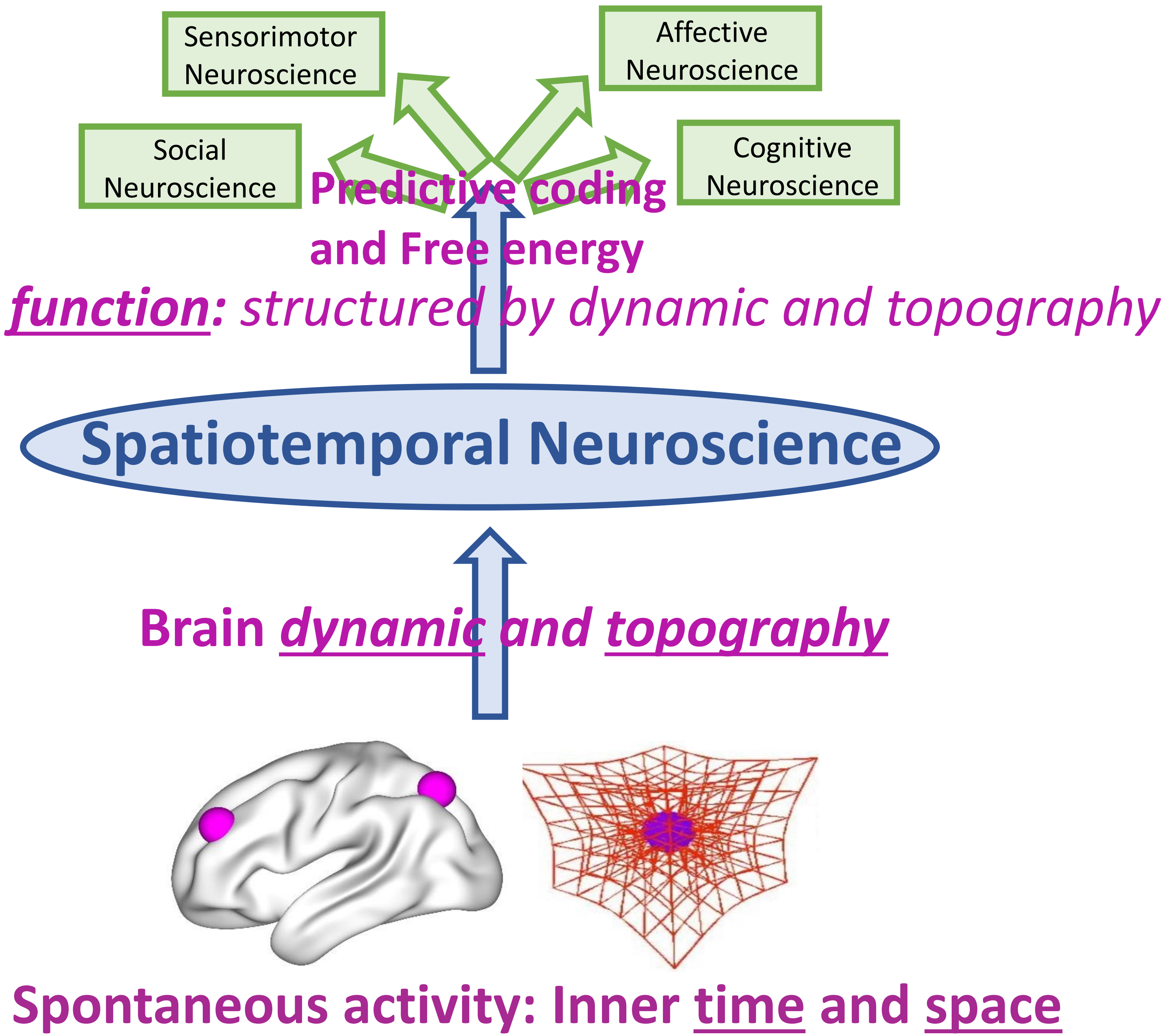


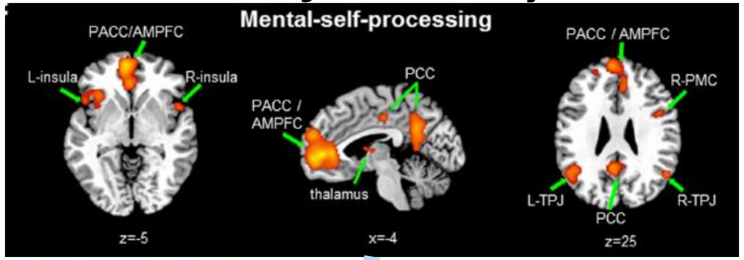
Figure 3 Spatiotemporal Neuroscience – from brain dynamic and topography to brain function



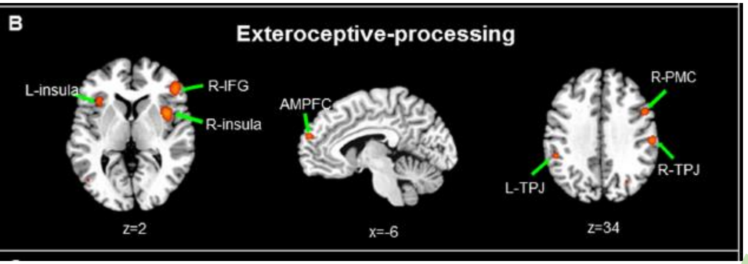
Chapter 1

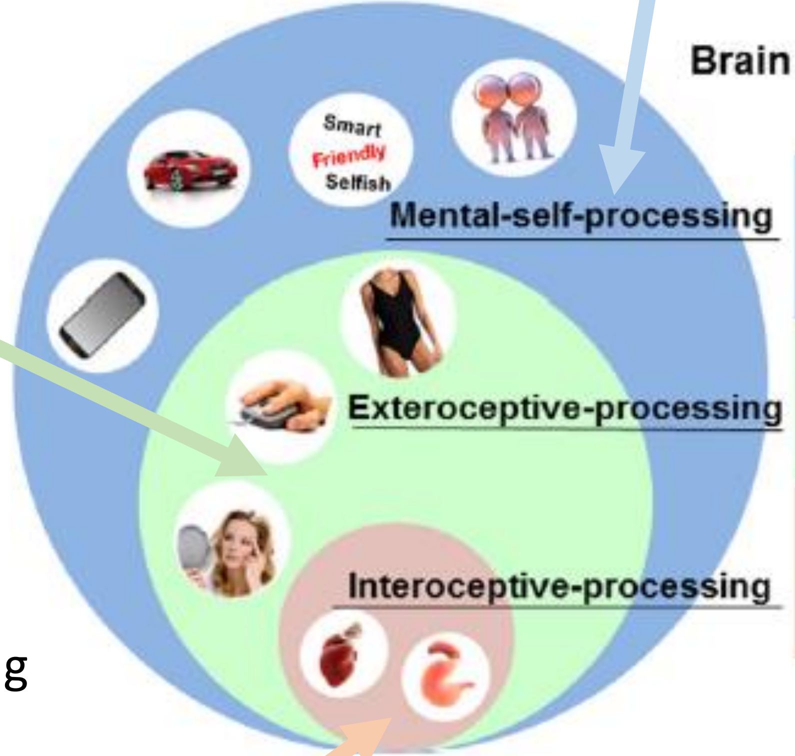
Figure 1a Nested hierarchy of self

Mental self processing
= Self-***referentiality***



Extero-proprioceptive
processing = Self-***predictive***





Brain regions for each level of self-processing

Mental-self-processing	Insula	TPJ	AMPFC	PMC	PACC	PCC
Exteroceptive-processing	Insula	TPJ	AMPFC	PMC		
Interoceptive-processing	Insula					

Interoceptive processing
= Self-***relatedness***

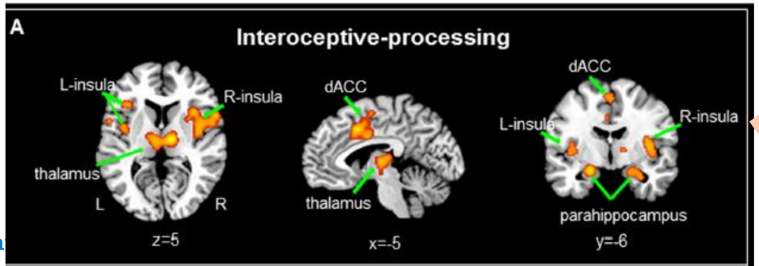


Figure 1b Converging nested hierarchies of self in neuroscience and psychoanalysis

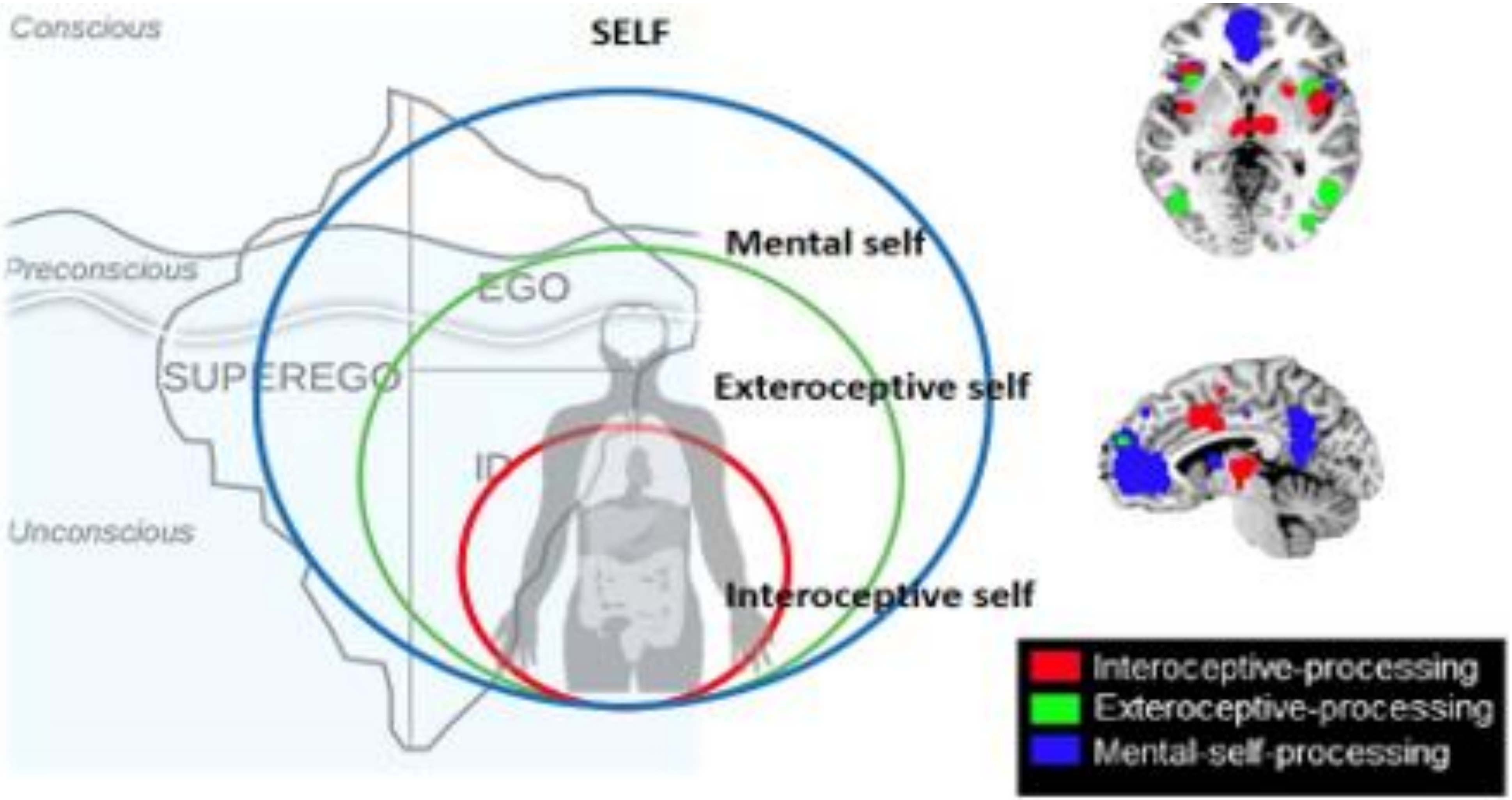
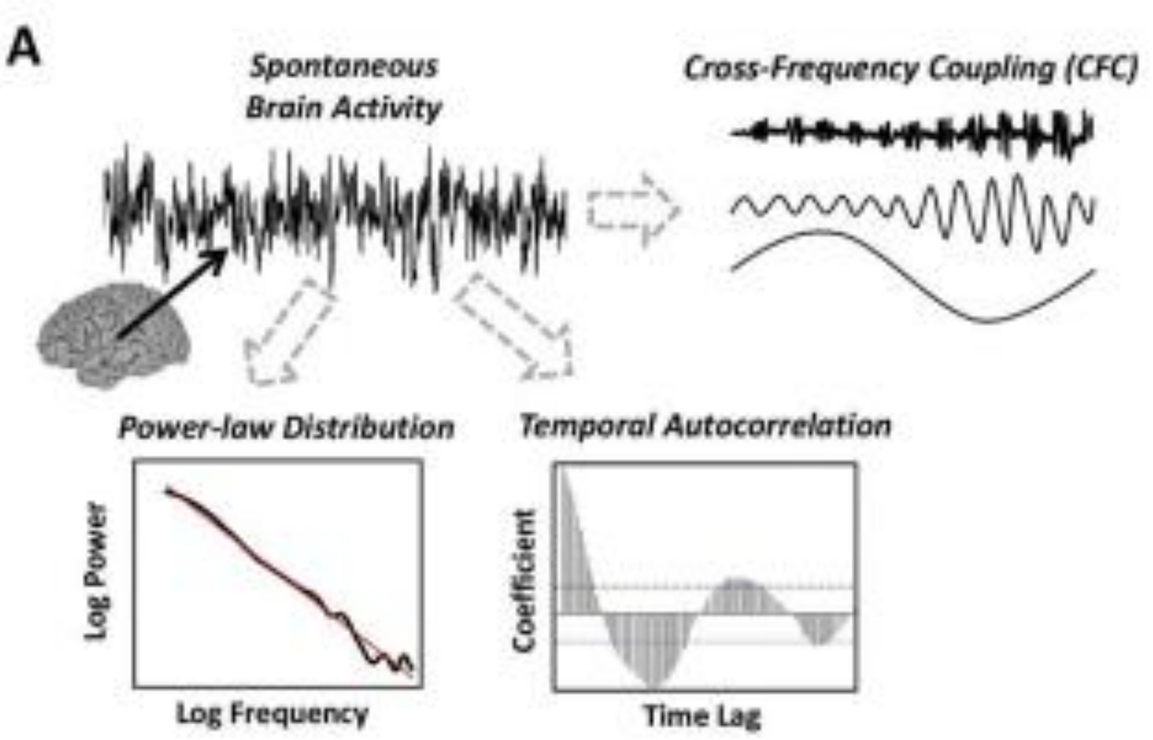


Figure 2a The temporal brain – Temporal nestedness with scale-free activity in the brain (left and upper right) just like the Russian dolls with their spatial nestedness (lower part)



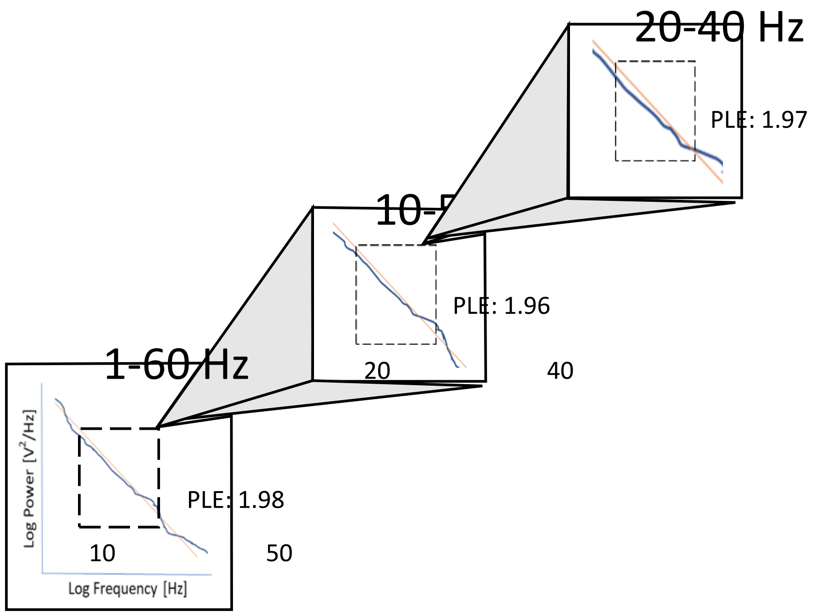
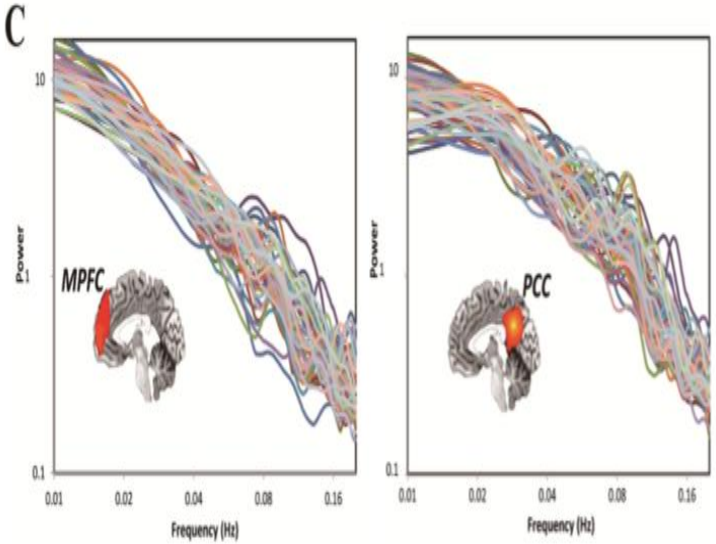
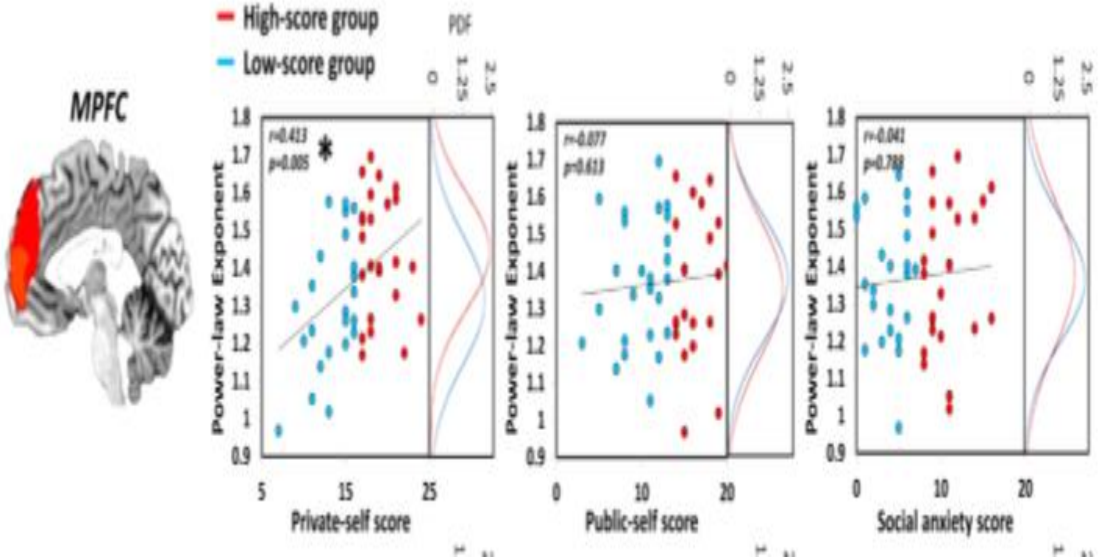


Figure 2b The temporal self – From the brain's scale-free activity with its temporal nestedness to the self in infraslow frequencies of fMRI (upper right/Huang et al., 2016) and faster frequencies of EEG (lower right, Wolff et al., 2019)





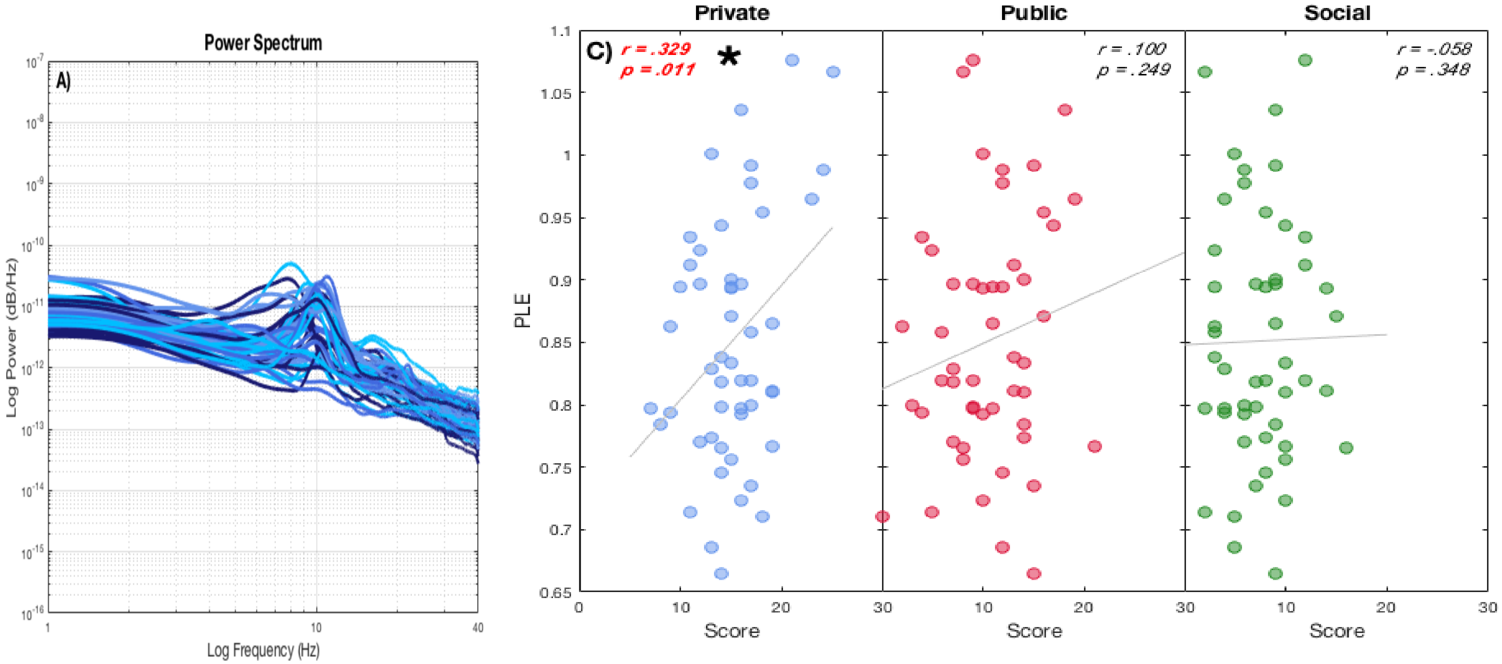


Figure 3a Activation in right insula during empathy correlates with the degree of narcissism (Scalabrini et al. 2017)

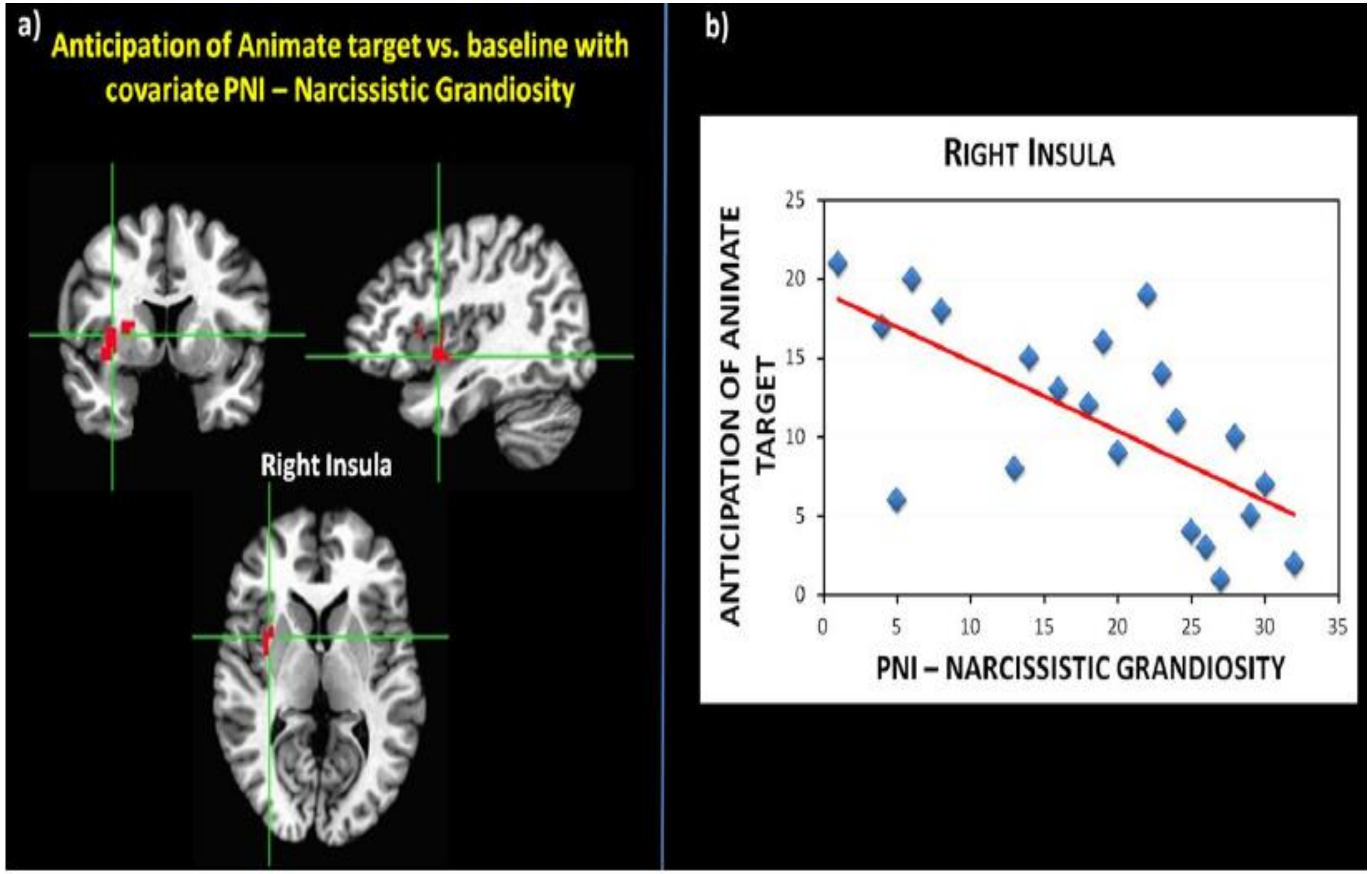
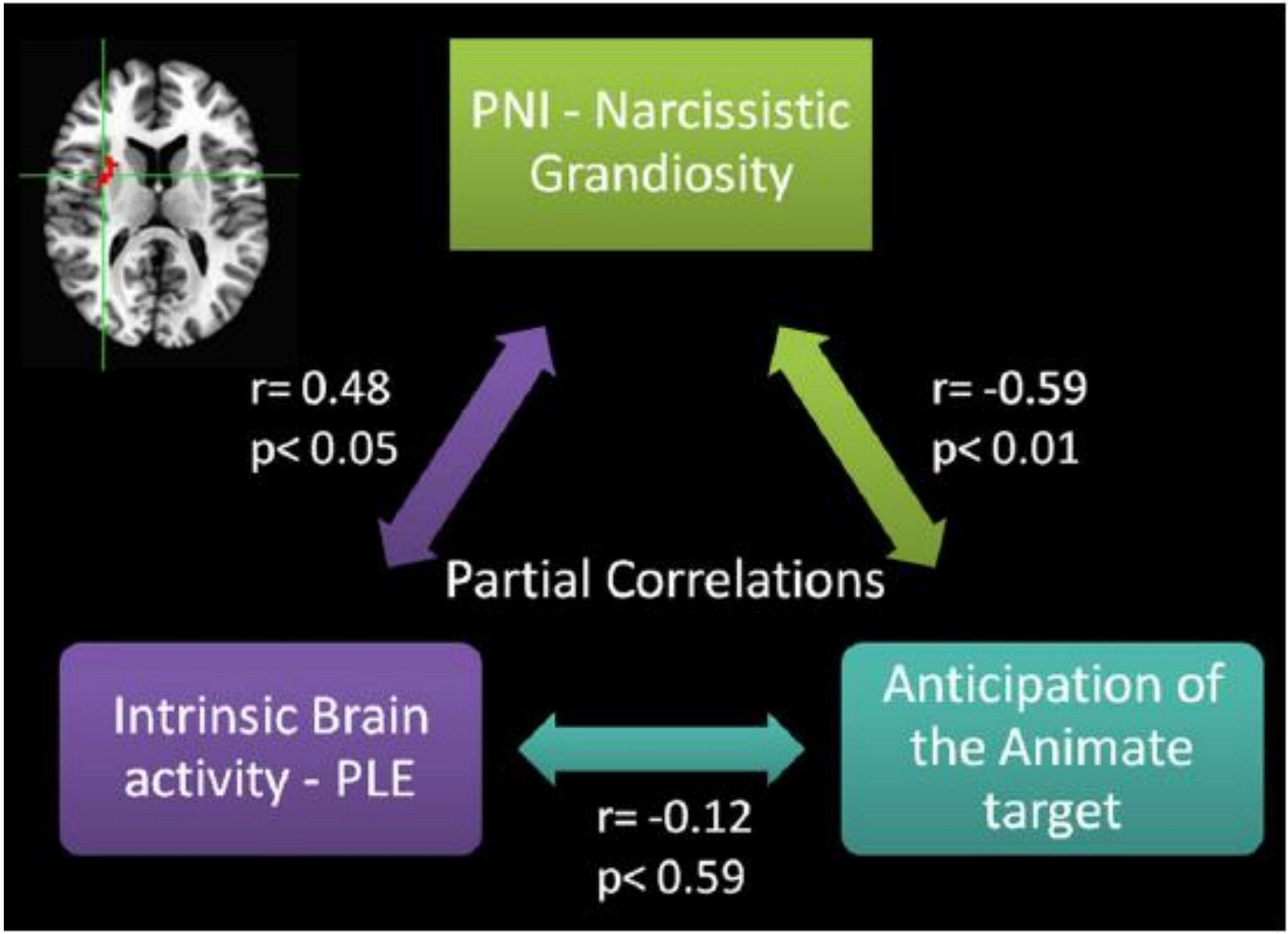
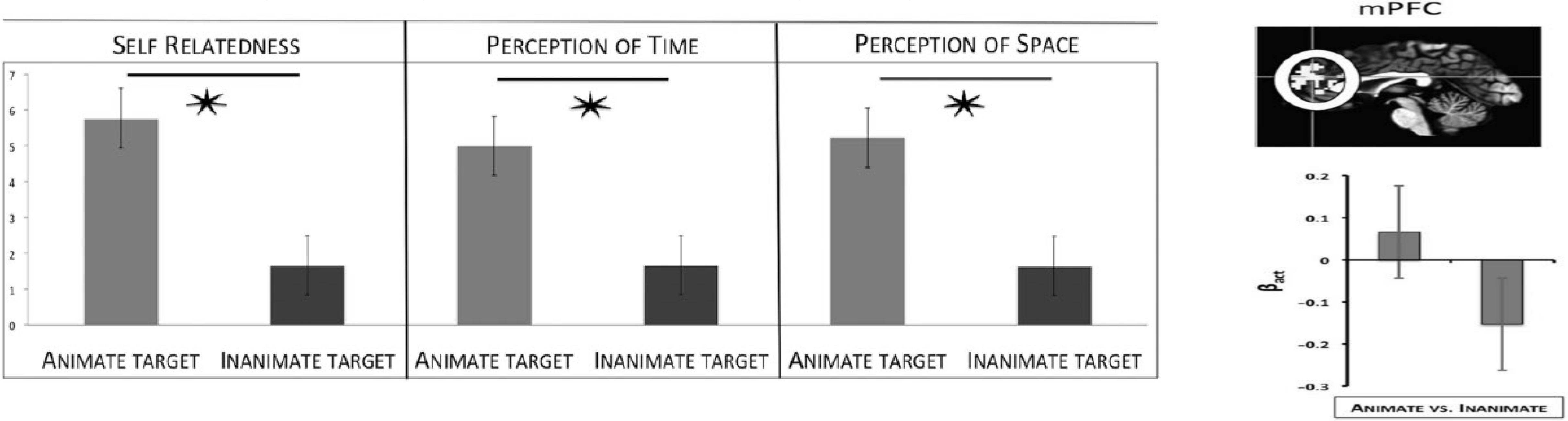


Figure 3b Slow-fast dynamic of the brain's intrinsic activity (power law exponent/PLE) relates to narcissism and neural activity during anticipation of others (Scalabrini et al. 2017)



Chapter 2

Figure 1a Psychological (upper left) and neuronal (upper right) distinction of animate and inanimate environmental contexts and their prediction by the brain's scale-free activity (lower part)



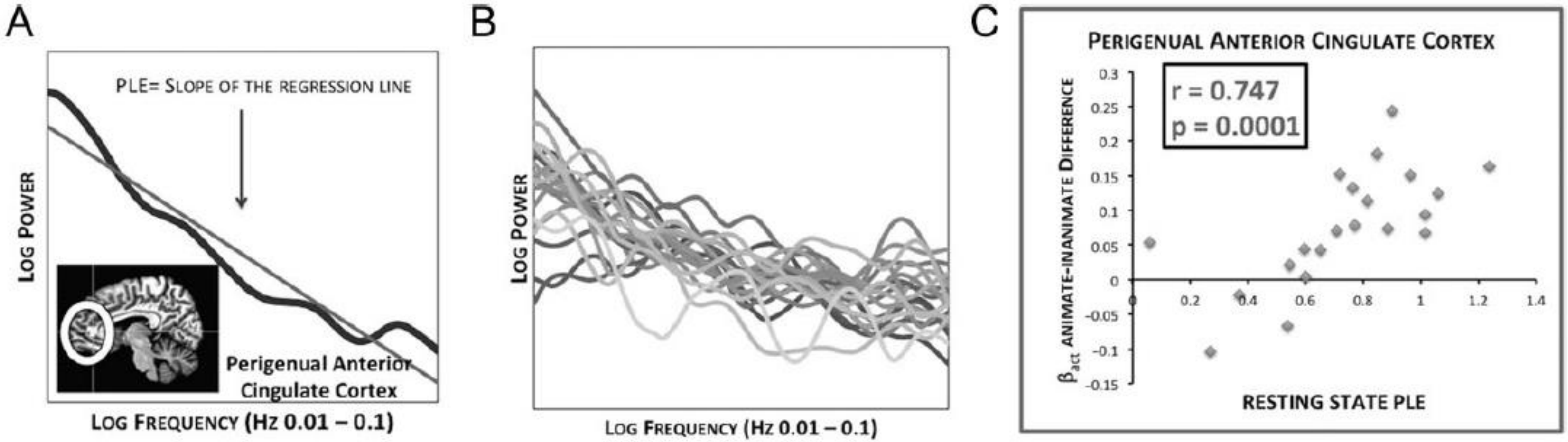


Figure 1b The neuro-ecological and neuro-social basis of attachment

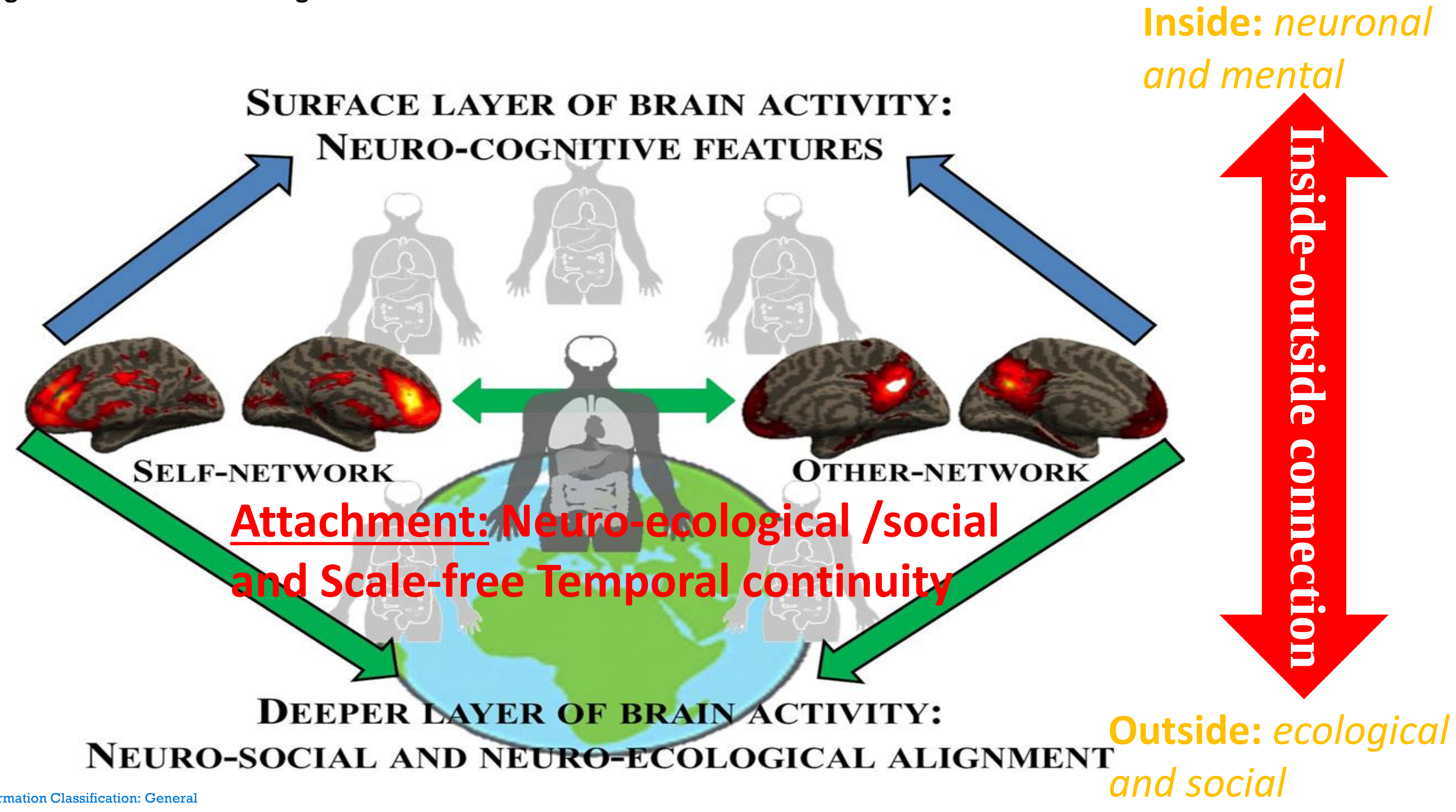


Figure 2a Nested neural hierarchy of self with interoceptive, exteroceptive, and mental layers of self-processing (left and middle) and its relation to the different levels of trauma severity (right orange arrow) and severity of trauma response (right red arrow)

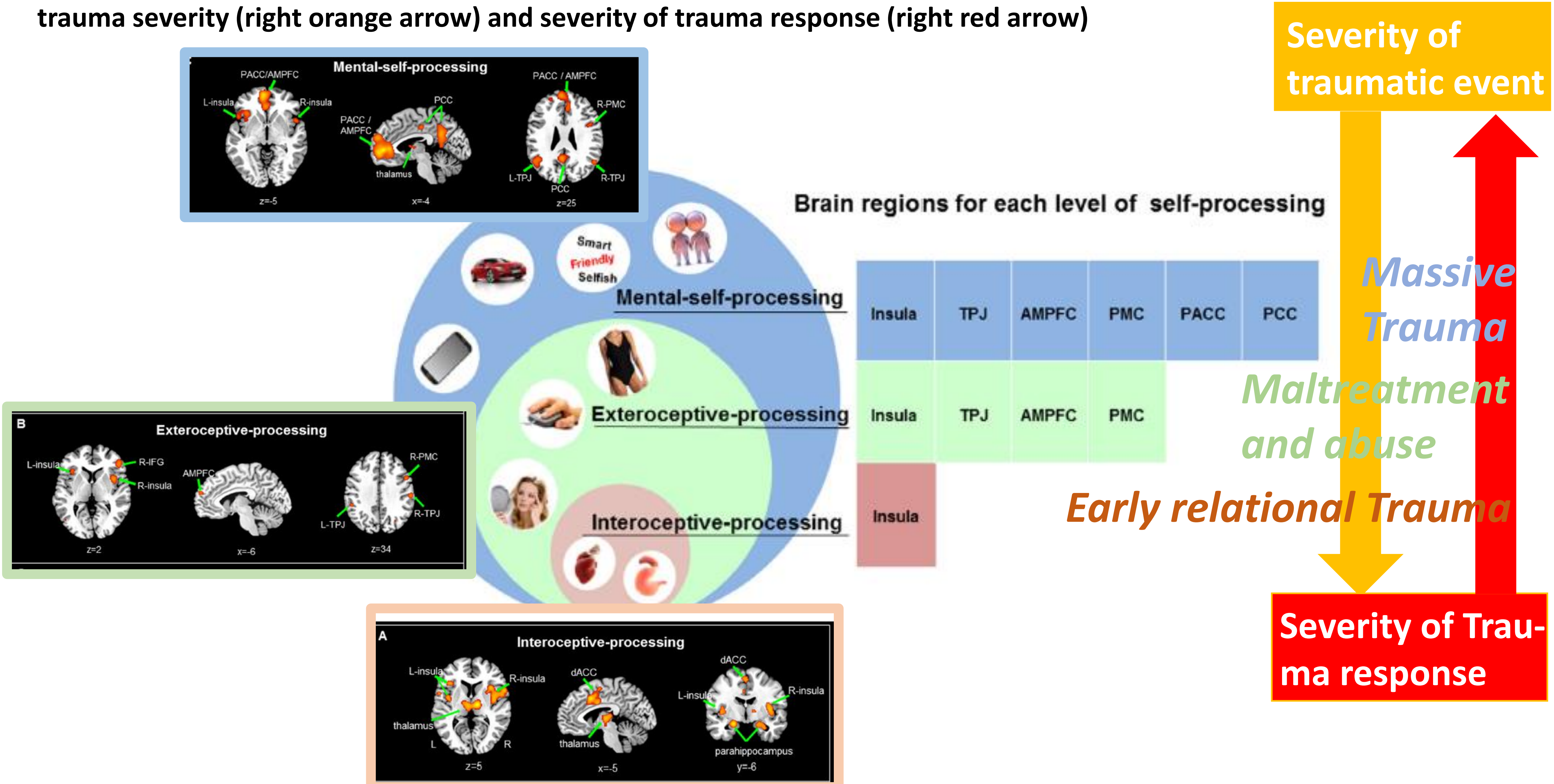
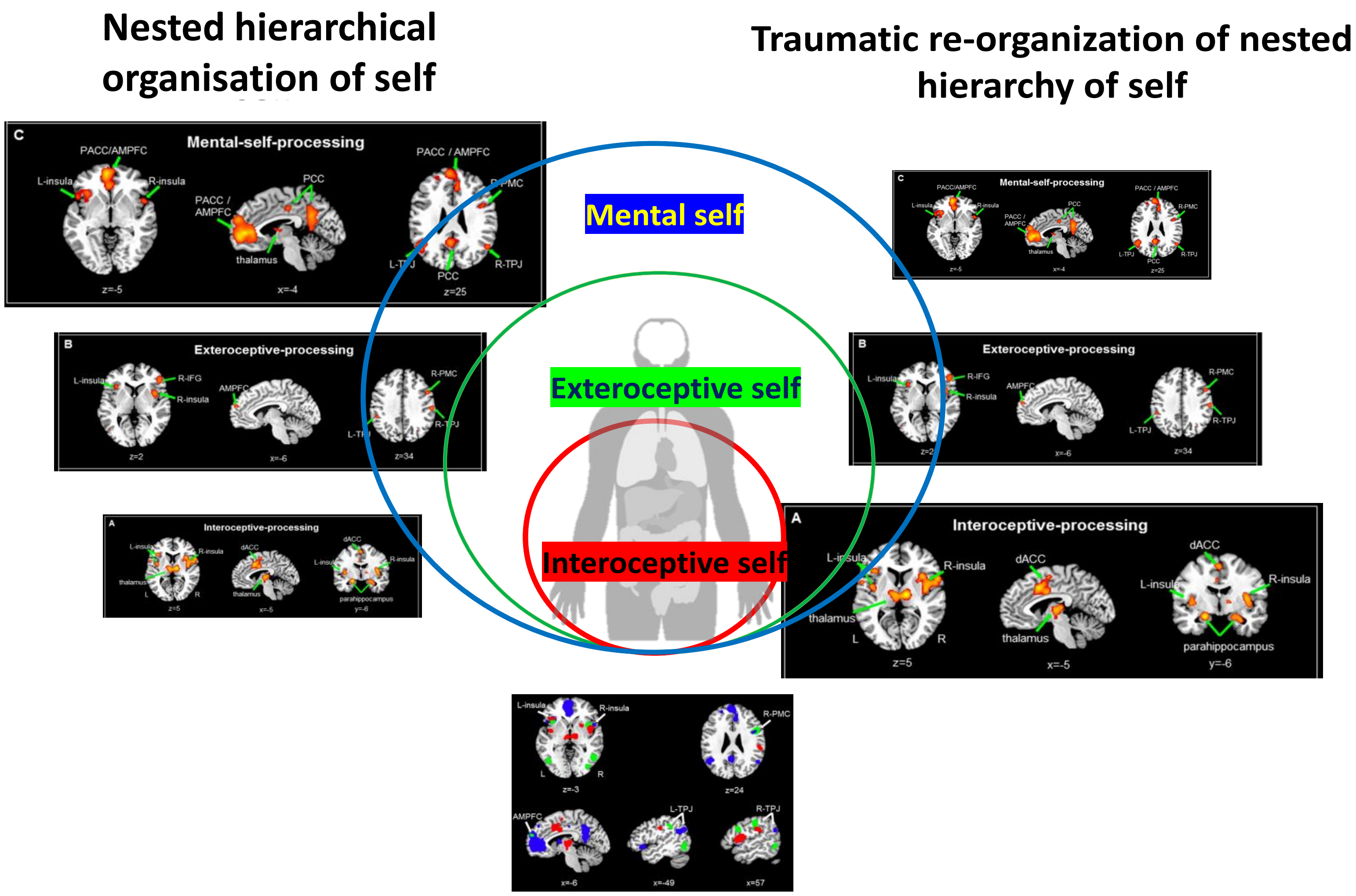


Figure 2b Nested hierarchy of self and its re-organization in trauma



Chapter 3

Figure 1 Hierarchy of early immature (left) and later more mature (right) defense mechanisms

Defence mechanism	Function
Idealisation	Attributing perfect qualities to others as a way of avoiding anxiety or negative feelings, such as contempt, envy, or anger
Psychotic introjection	Internalising aspects of a significant person as a way of dealing with the loss of that person and/or the differentiation between subject and object. Introjection leads to an internalised representation experienced as "other" ("in toto internalisation")
Projection	Perceiving and reacting to unacceptable inner impulses and their derivatives as though they were outside the self. Results in a distorted perception of reality (e.g. delusion)
Projective identification	Both an intrapsychic defence mechanism and an interpersonal mode of communication and interaction. Behaving in such a way that subtle interpersonal pressure is placed on another person to take on characteristics of an aspect of the self or an internal object that is projected into that person. The person who is the target of that projection then begins to behave, think, and feel in keeping what has been projected
Splitting	Compartmentalising experiences of self and other. When the individual is confronted with the contradictions in behaviour, thought, or affect, he or she reacts with denial or indifference. Contrary to repression incompatible contents are in principle conscious or subconscious
Denial	Avoiding awareness of aspects of external reality that are difficult to face by disregarding sensory data. The individual avoids to perceive aspects that may be conflictuous or traumatising
Dissociation	Disrupting one's sense of continuity in the areas of identity, memory, consciousness, or perception as a way of retaining an illusion of psychological control in the face of helplessness and loss of control. Contrary to splitting, dissociation may involve alteration of memory of events because of the disconnection of the self from the event
Acting out	Enacting an unconscious wish or fantasy impulsively as a way of avoiding painful affect. Through this unconscious actualisation of the past in the present, the origin and the repetitive character of the enactment are unrecognised
Somatisation	Converting emotional pain or other affect states into physical symptoms and focussing one's attention on somatic (rather than intrapsychic) concerns. Somatisation involves different functional modes: somatisation by means of "histrionic" identification (conversion), somatisation as an emotional correlate (in somato-psychosomatic processes), and projective somatisation (externalisation of unbearable affects and pains into one's own body (hypochondria)
Regression	Returning to an earlier phase of development or psychic functioning to avoid the conflicts, pains, and tensions associated with one's present level of development or actual situation
Autism	Returning to one's inner world, often connected with schizoid fantasies, to avoid anxiety in interpersonal situations

Defence mechanism	Function
Intellectualisation	Using excessive and abstract ideation to avoid difficult feelings
Rationalisation	Justification of unacceptable attitudes, beliefs, or behaviours to make the tolerable to oneself
Isolation of affect	Separating an idea from its associated affect state to avoid emotional turmoil
Undoing	Attempting to negate sexual, aggressive, or shameful implications from a previous comment or behaviour by elaborating, clarifying, or doing the opposite
Reaction formation	Transforming an unacceptable wish or impulse into its opposite. This is often a permanent and habitual process which gets along with the development of respective character traits
Displacement	Shifting feelings associated with one idea or object to another that resembles the original in some way
	Shifting aggressive feelings which originally were directed to another person against one's own self (autoaggression)
Identification	Internalising the qualities of another person by becoming like the person
	This is an essential process in the development of a person, by which intrapsychic structures emerge (mature forms of internalisation). Identification may be used as a defence (e.g. identification with the aggressor or development of conversion as a defence against psychic pain after loss and separation)
Introjection	Internalising aspects of a significant person as a way of dealing with the loss of that person and/or the anxieties resulting from separation and the differentiation between subject and object. Introjection leads to an internalised representation of the object ("in-toto- internalisation"), whereas identification is experienced as part of the self ("selective internalisation")
Repression	Essential psychic process which is connected with the development of the unconscious
	Expelling unacceptable ideas or impulses or blocking them from entering consciousness (amnesia, scotomising certain contents). The above-described defence mechanisms serve repression in a wider sense, i.e. blocking them from entering consciousness
Sublimation	Transforming socially objectionable or internally unacceptable aims into socially acceptable ones. This is a controversial term, especially because of Freud's assumption that cultural achievements necessarily presuppose to give up drive wishes

Figure 2a Pierre Janet's view of dissociation as lack of integration of contents into consciousness

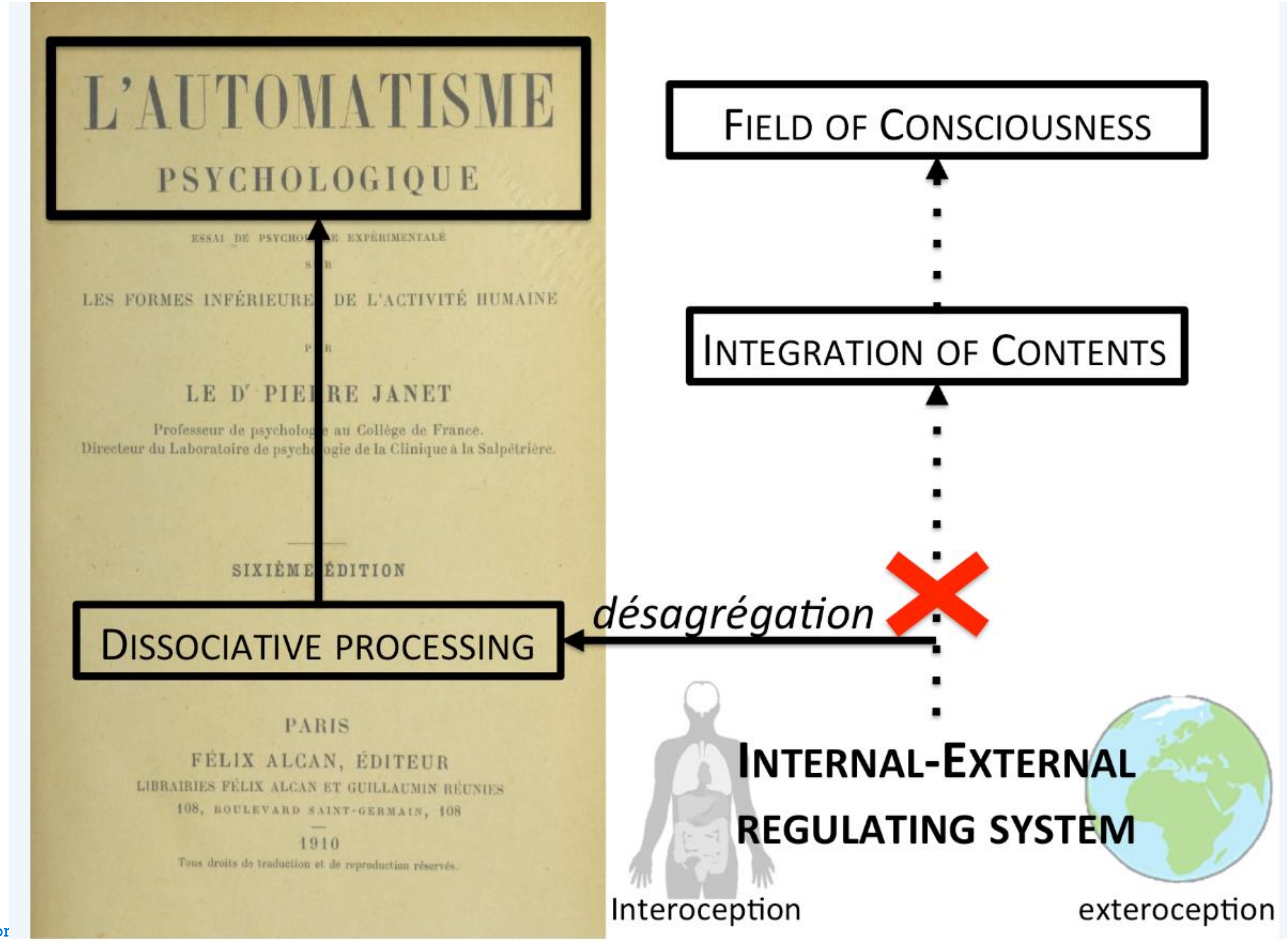
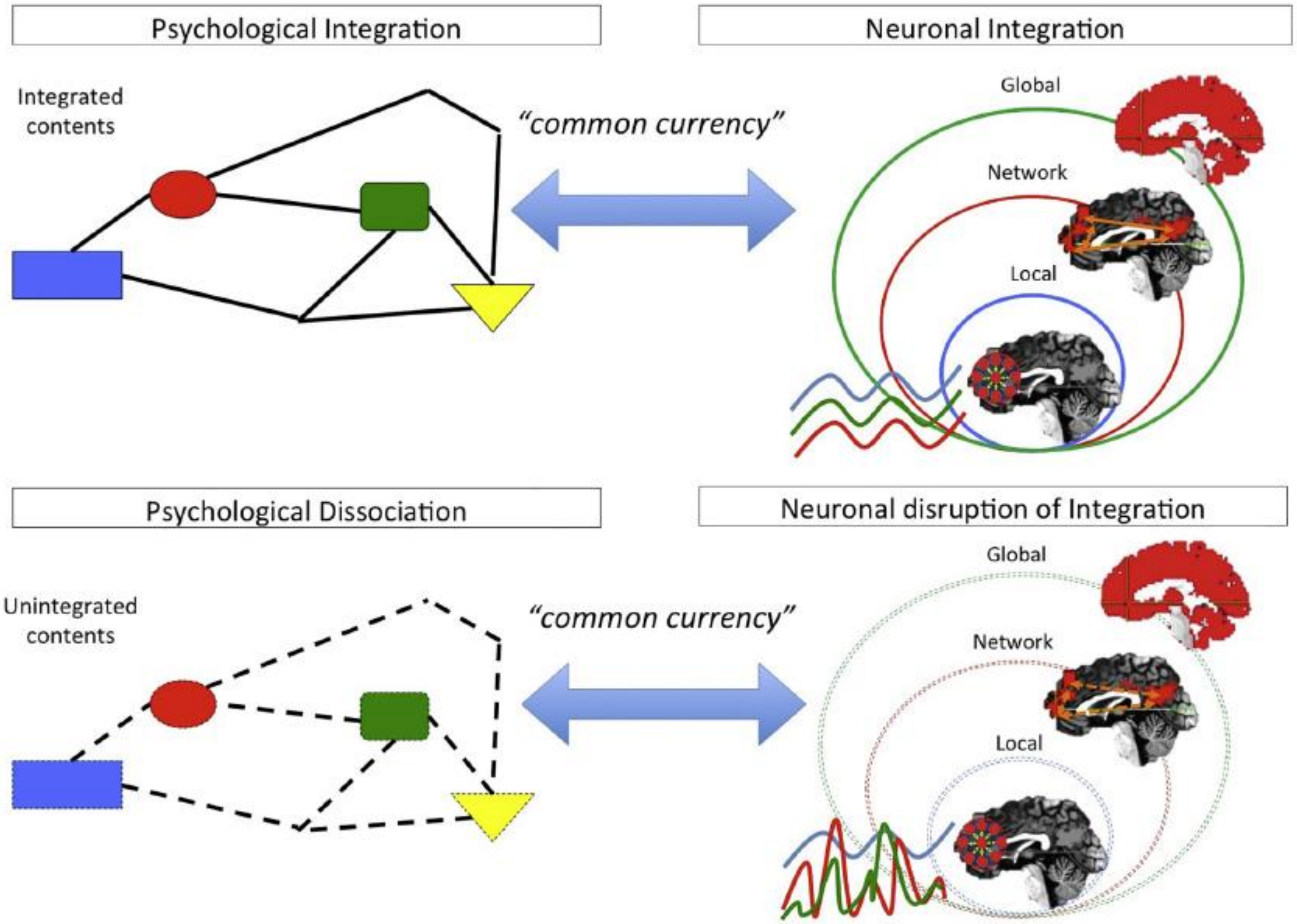
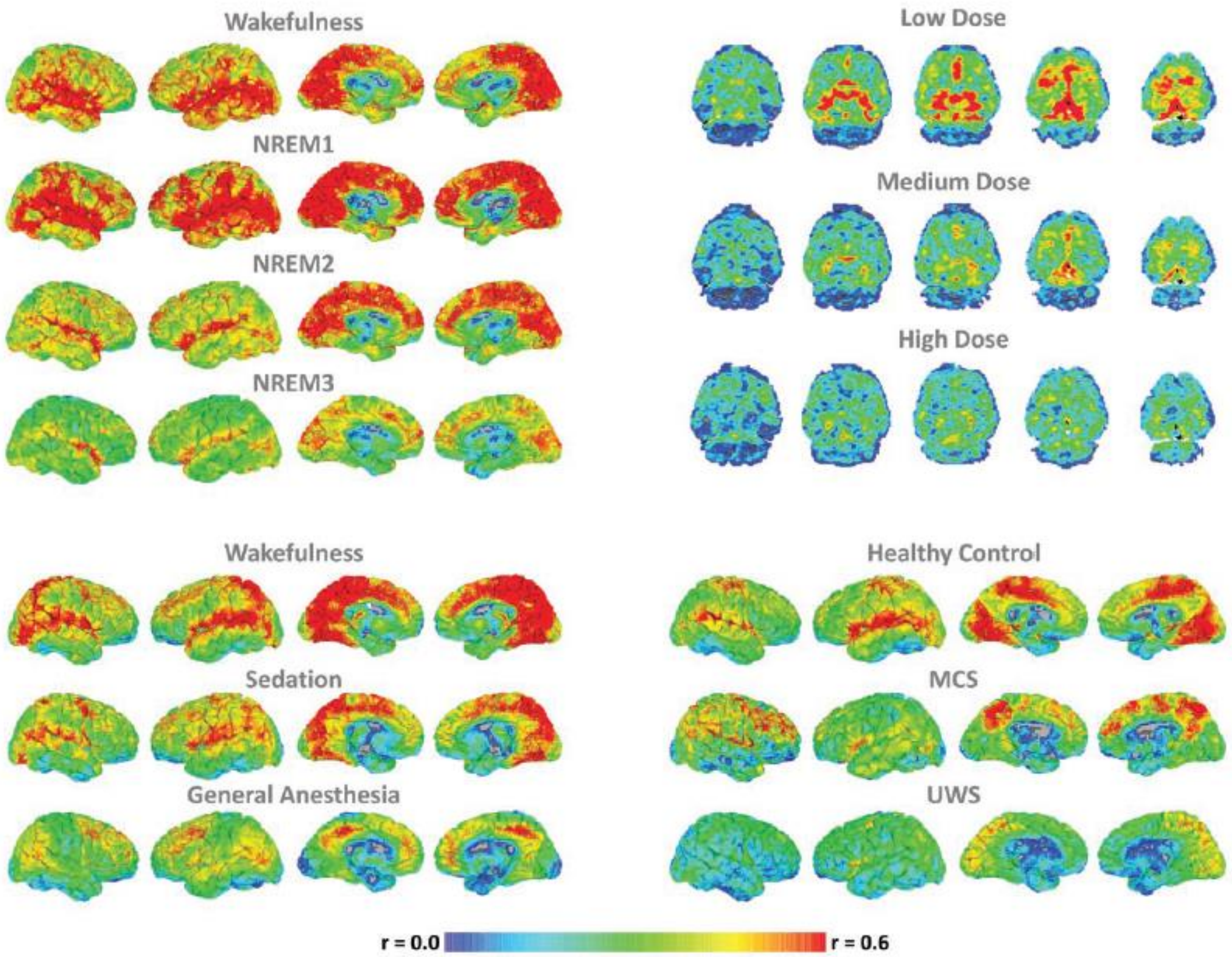


Figure 2b Integration (upper) and dissociation (lower) are shared by psychological (left) and neuronal (right) levels as their "common currency"



Chapter 4



Wakefulness
NREM1
NREM2
NREM3
Low Dose
Medium Dose
High Dose
Wakefulness
Sedation
General Anesthesia
Healthy Control
MCS
UWS
r = 0.0
r = 0.6

Fig. 1a. Average whole-brain global signal correlation maps at the group level. (*Top left*) Human subjects in different stages of sleep. (*Bottom left*) Human subjects receiving propofol infusion. (*Top right*) Rats receiving different doses of propofol. (*Bottom right*) Human subjects of healthy controls, patients with minimally conscious state (MCS), and unresponsive wakefulness syndrome (UWS). Of note, the distinctions in the images of the healthy controls during wakefulness may be due to the fact that different scanners or data acquisition parameters can affect the absolute value of the measurement.

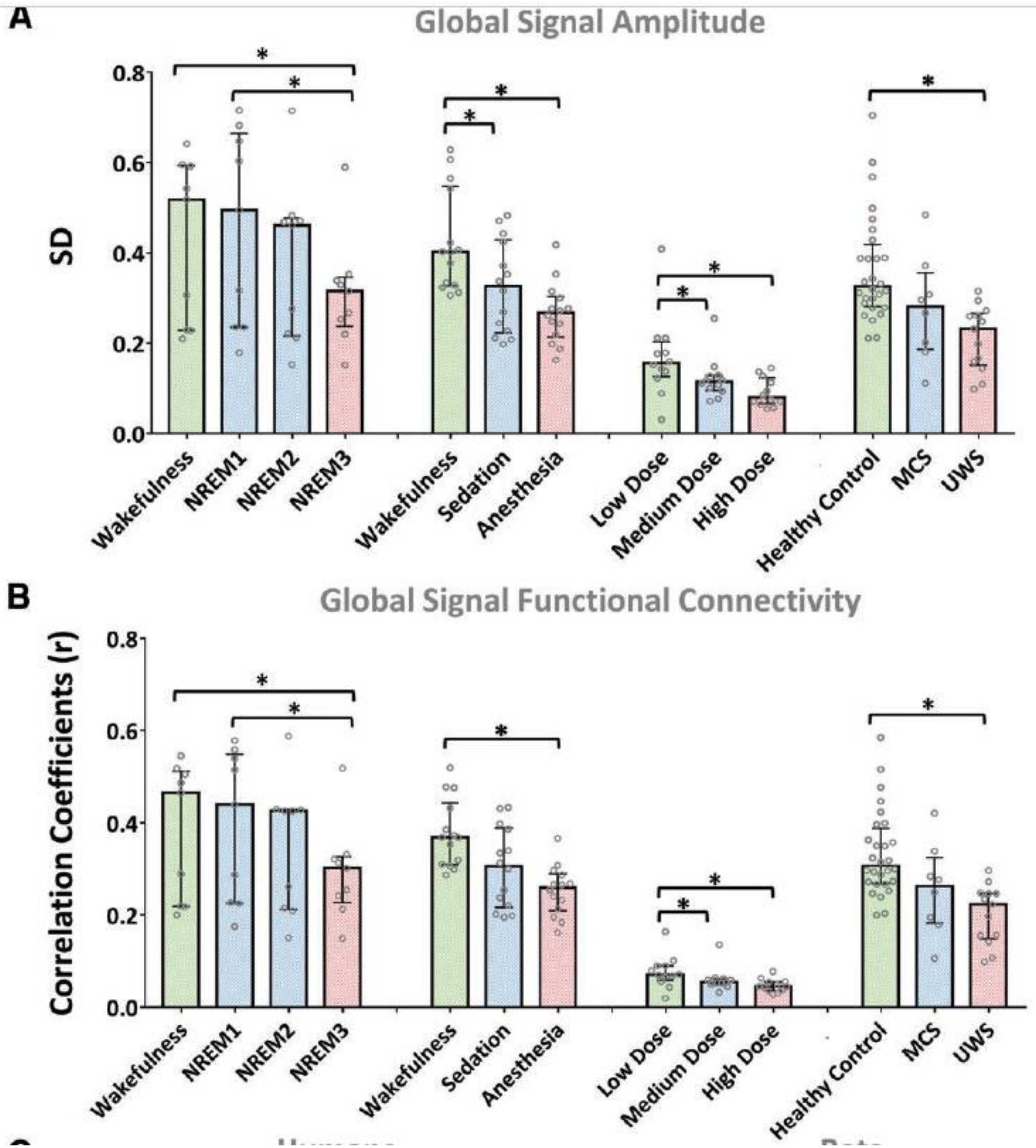

A
Global Signal Amplitude
SD
Wakefulness
NREM1
NREM2
NREM3
Wakefulness
Sedation
Anesthesia
Low Dose
Medium Dose
High Dose
Healthy Control
MCS
UWS
B
Global Signal Functional Connectivity
Correlation Coefficients (r)
Wakefulness
NREM1
NREM2
NREM3
Wakefulness
Sedation
Anesthesia
Low Dose
Medium Dose
High Dose
Healthy Control
MCS
UWS

Fig. 1b. Global signal amplitude and global signal functional connectivity in disorders of consciousness.

(*A*) Global signal amplitude as measured by the SD of the global signal time series.

(*B*) Global signal functional connectivity as measured by the average correlation coefficient between the global signal and the signal of each voxel in gray matter. Human natural sleep dataset (n = 9) includes wakefulness and three sleep stages (NREM1, NREM2, and NREM3). Human propofol anesthesia dataset (n = 14) includes wakefulness, sedation, and general anesthesia. Rat propofol anesthesia dataset (male, n = 12) includes low, medium, and high dose. Dataset of disorders of consciousness includes healthy controls (n = 28), patients with minimally conscious state (MCS; n = 8), and unresponsive wakefulness syndrome (UWS; n = 13). *Significance at $\alpha = 0.05$ (corrected). *Bar graph* shows 1st quartile, median, and 3rd quartile.

Figure 2 Cathexis and the Dual layer model of global brain dynamic and topography

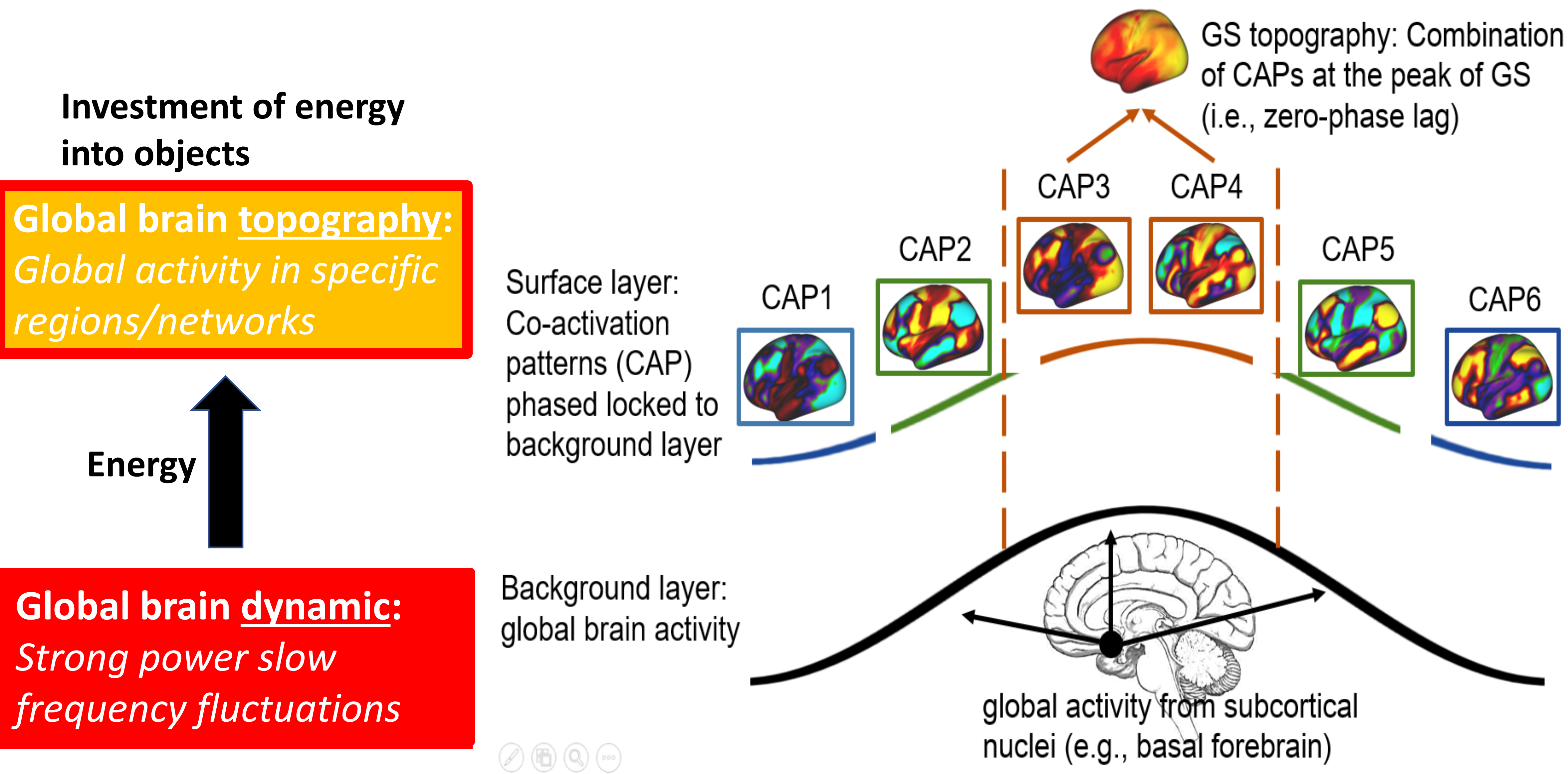


Figure 2: Dual-layer model (DLM) of GS. The DLM of GS suggests that GS is a constellation of neural activities at both a more spatially extended global background layer and a more spatially restricted surface layer featuring co-activation pattern of different networks. The background layer is the global brain activity which, in part, may stem from subcortical sources (e.g., basal forebrain), and provide temporal structure, through its fluctuations, in governing the spatial-topographical organization of the instantaneous brain networks/ co-activation patterns (CAPs) at the surface layer.

Figure 3 From global brain dynamic and topography (lower) over deep temporal and spatial models (middle) to free energy as exchange between environment (upper)

Free energy minimization of brain + environment

↑ **Investment of energy into objects**

"Deep temporal and spatial model"

↑ **Energy**

Global brain dynamic and topography

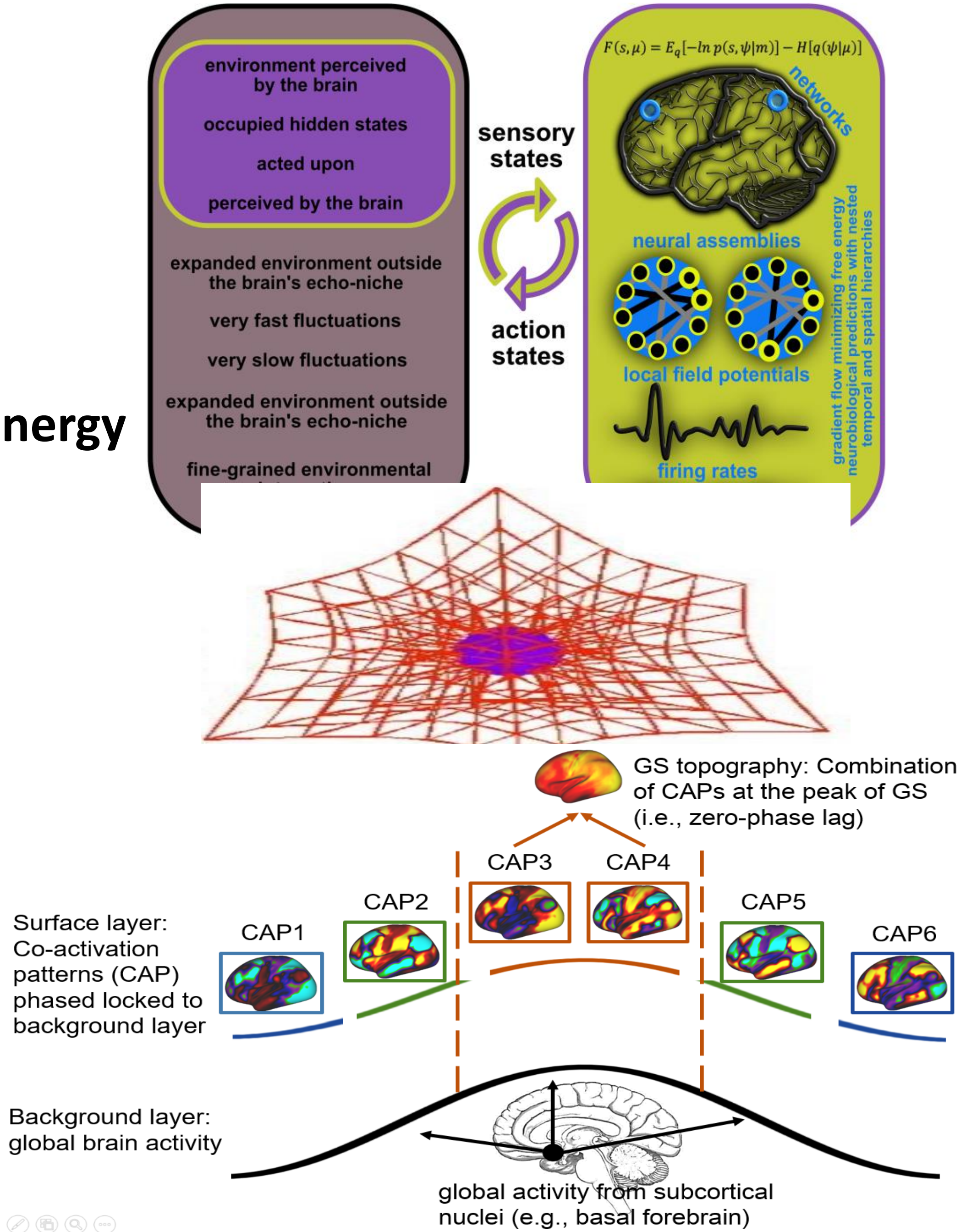
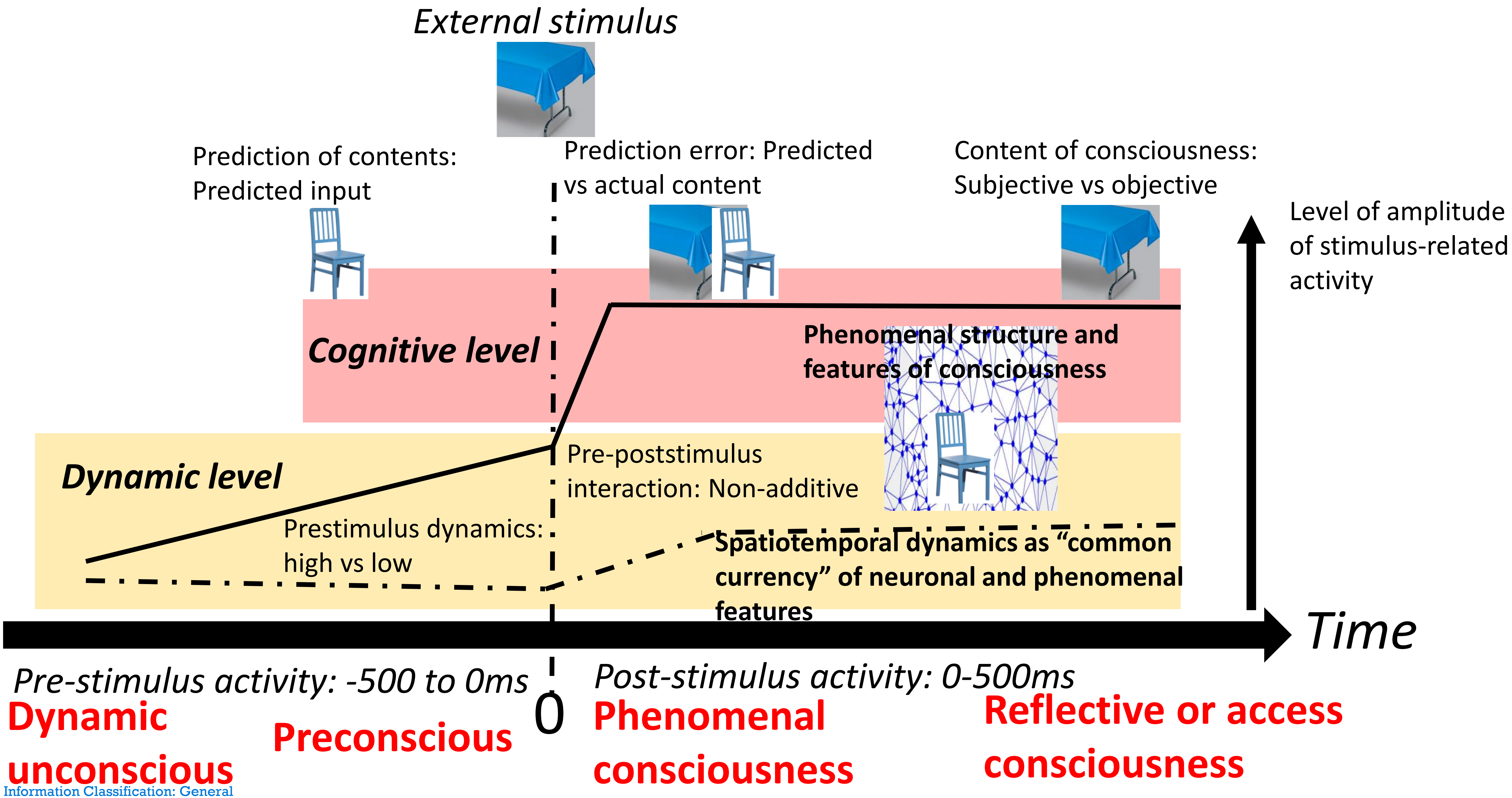


Figure 3

By minimizing free energy, brain and environment align as seen with the maximization of the joint distribution of the brain’s sensory states (s) and hidden states of the environment (ψ) while simultaneously ensuring that the representation of the environment in the brain is maximally entropic (entropy term). Currently the theory has considered neurobiological implementations of this gradient flow – resulting in testable imaging and electrophysiological predictions. With augmentation the goal may be to facilitate extended environmental states (lower left purple panel) that are not readily accommodated in neural states currently but could be accommodated in an artificial agent with extended ’sensory’ inputs.

Chapter 5

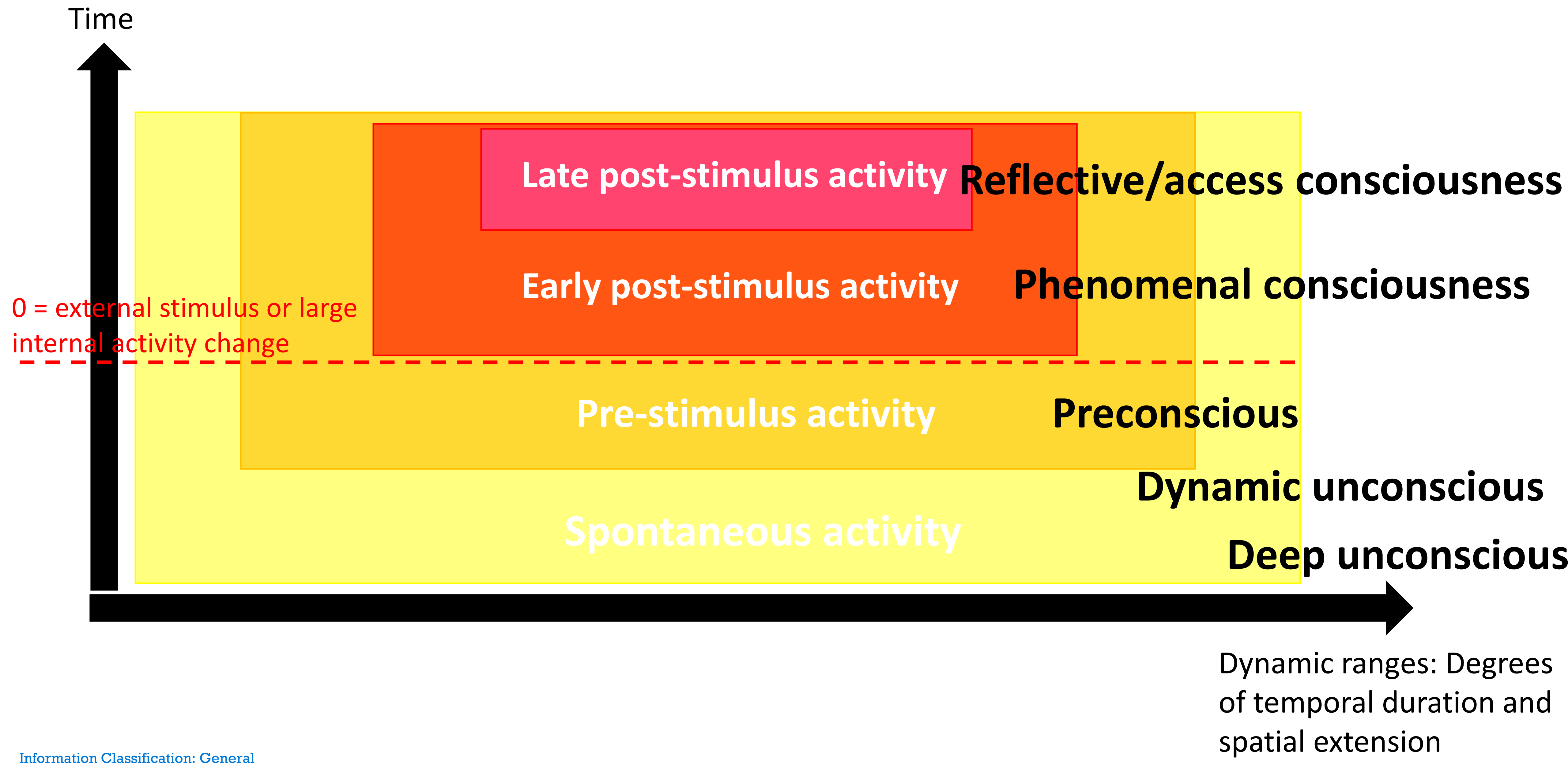
Figure 1 Pre-poststimulus interaction – Dynamic (lower level) and cognitive (upper level) characterization



Caption Figure 2

The figure shows two levels of the interaction of prestimulus and post-stimulus activity.
Upper level: The cognitive level operates more at the surface and can be characterized by prediction of specific contents (like a chair) in the prestimulus period (upper left). That predicted content is compared with the actual content (a table in our example) resulting in the prediction error. The prediction error, in turn, determines the content of consciousness, i.e., its subjective (chair) or objective (table) nature (upper right).
Lower level: The dynamic level operates on a deeper level and shaped by the continuously ongoing activity as manifest in prestimulus activity. The continuous and the dotted line stand for two different levels of prestimulus activity dynamics, high and low. Prestimulus activity is determined by its spatiotemporal dynamics which interacts in a non-additive (rather than additive) way with the external stimulus. The spatiotemporal dynamics provides a certain structure, a spatiotemporal structure, that is manifest in the structure and organisation of phenomenal consciousness within which the content (chair) is integrated and embedded. The spatiotemporal structure provides the shared feature or “common currency” (Northoff et al. 2019) of neuronal and phenomenal features.
Lowest level: The arrow depicts the time, prestimulus period is about -500 to 0ms while the post-stimulus is about 0-500ms. Depending on the time course relative to the external stimulus, one can distinguish dynamic unconscious, preconscious, and phenomenal and reflective/access consciousness (in red).

Figure 2a Temporo-spatial nestedness of the different aspects of neural activity and their relation to unconscious and conscious



Caption Figure 2a

The figure shows how different forms of neural activity are contained and nested within each other in temporo-spatial dynamical terms.
The spontaneous activity shows the largest spatial extension and strongest slow frequencies. Both are reduced with less spatial extension and less slow frequencies in the prestimulus activity. Both spatial extension and range of slow frequencies are further reduced in early stimulus-induced activity and even more so in late stimulus-induced activity.
Due to these temporo-spatial differences, the different forms of neural activity are associated with different dimensions of consciousness including form (spontaneous activity), state/level (prestimulus activity) and content (pre- and post-stimulus).
Finally, prestimulus period itself remains unconscious, early stimulus-induced activity is related to phenomenal consciousness while late stimulus-induced activity is featured by access consciousness. The different dimensions (form, state/level, content) and types or forms (unconscious, phenomenal consciousness, access consciousness) are thus characterized in temporo-spatial dynamical terms.

Figure 2b Different neural conditions of consciousness

"Normal" state/level of consciousness

Neural correlates of consciousness (NCC): Degree of **amplitude in stimulus-related activity** in different regions of the brain (prefrontal, posterior)

Neural prerequisites of consciousness (preNCC): Neuronal variability in **pre-stimulus activity** *and* ***trial-to-trial variability*** *in post-stimulus activity*

Neural predispositions of consciousness (NPC): Infraslow, slow, and fast frequency fluctuations with their **temporo-spatial dynamics and structure in resting state activity**

MCS +

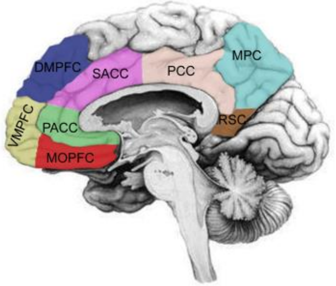
MCS -

UWS/VS

PVS

Coma

"Zero" level of consciousness



Caption Figure 2b

The figure shows the three different kinds of conditions of consciousness (see also Northoff and Heiss 2015) and how they are related to different states/levels of consciousness and its different clinical conditions (arrow on the right).

From bottom to top:

The neural predisposition of consciousness (NPC) refer to the necessary non-sufficient neural conditions of consciousness that are constituted by the resting state activity and its temporo-spatial dynamics including the scale-freeness of slow and fast frequencies. Loss of the NPC leads to coma, persistent vegetative state (PVS) and unresponsive wakefulness state (UWS)/vegetative state (VS).

The neural prerequisites of consciousness (preNCC) describe the enabling neural conditions related to prestimulus activity and its impact on trial-to-trial variability in post-stimulus activity. Loss of the preNCC leads to the minus and plus forms of minimally conscious state (MCS -, MCS +).

Finally, there are the neural correlates of consciousness (NCC) that refer to the sufficient neural conditions of consciousness which are supposed to be mediated by stimulus-related activity in different regions. Presence of the NCC leads to the "normal" conscious state.

Figure 3a Non-conscious, dynamic unconscious, preconscious and conscious

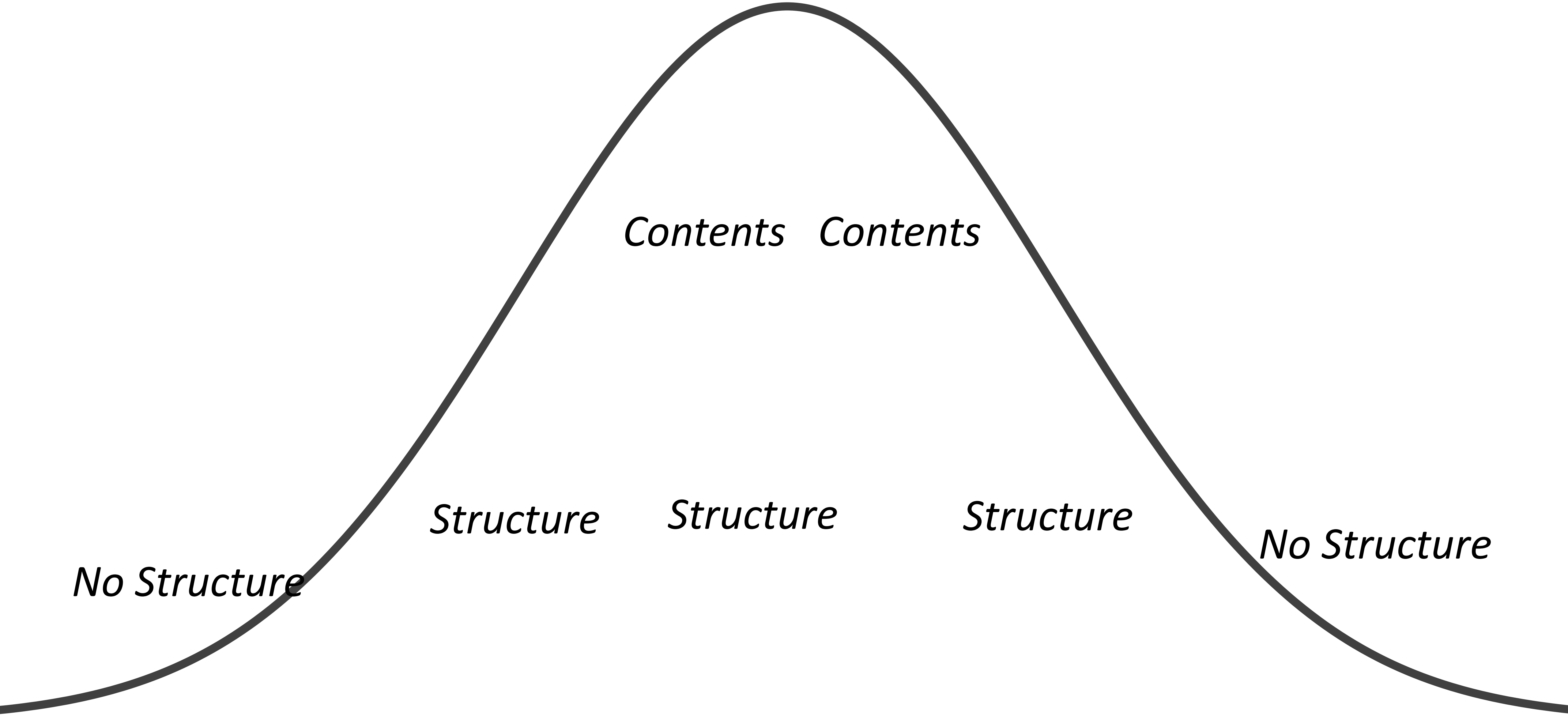
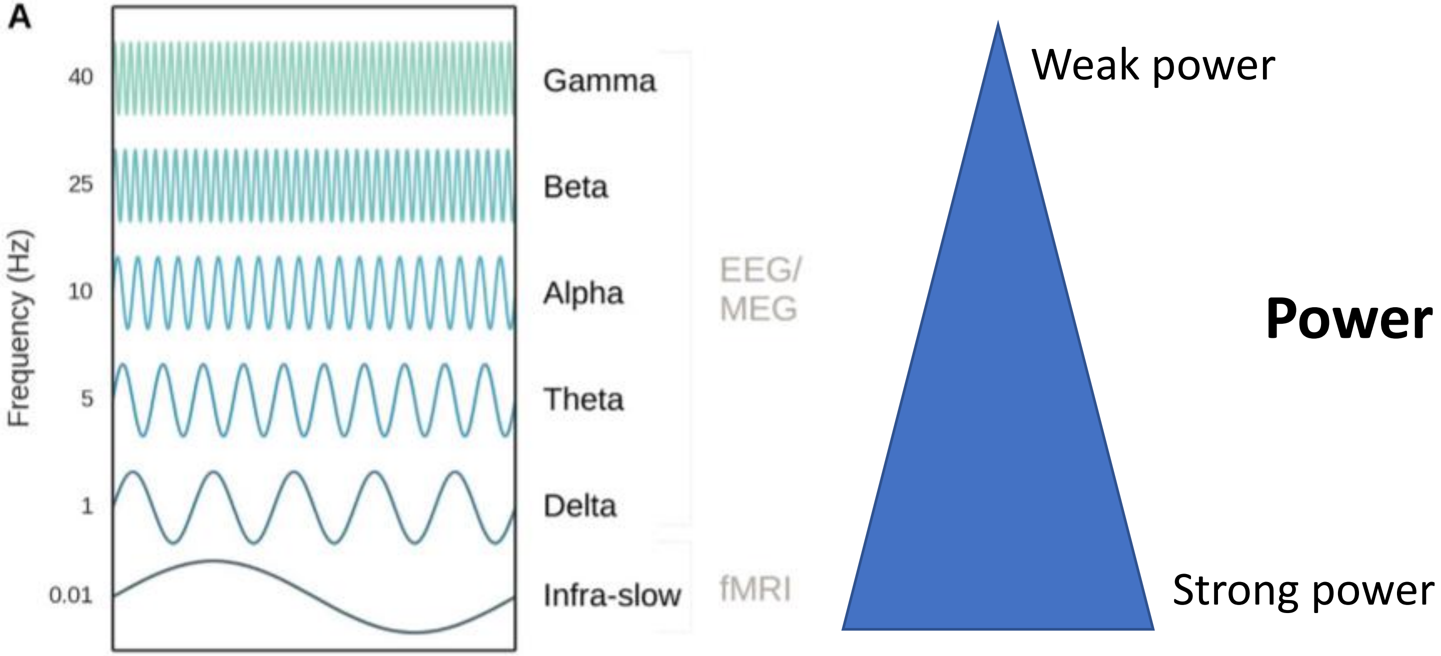


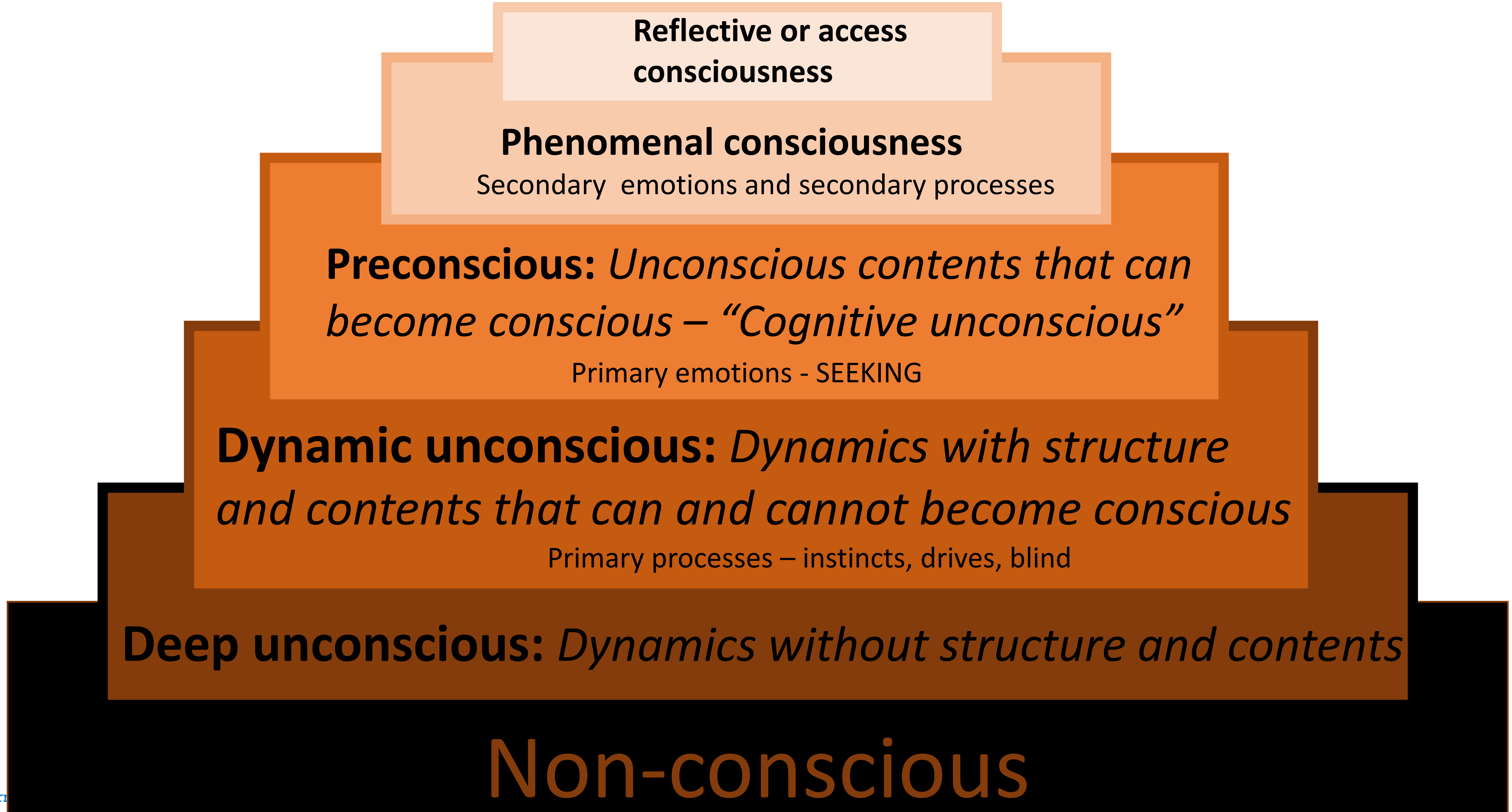
Figure 3b Examples of nestedness showing Russian dolls (upper left), Chinese crystal ball (upper right), and the brain's power spectrum (lower middle)



Caption Figure 3b

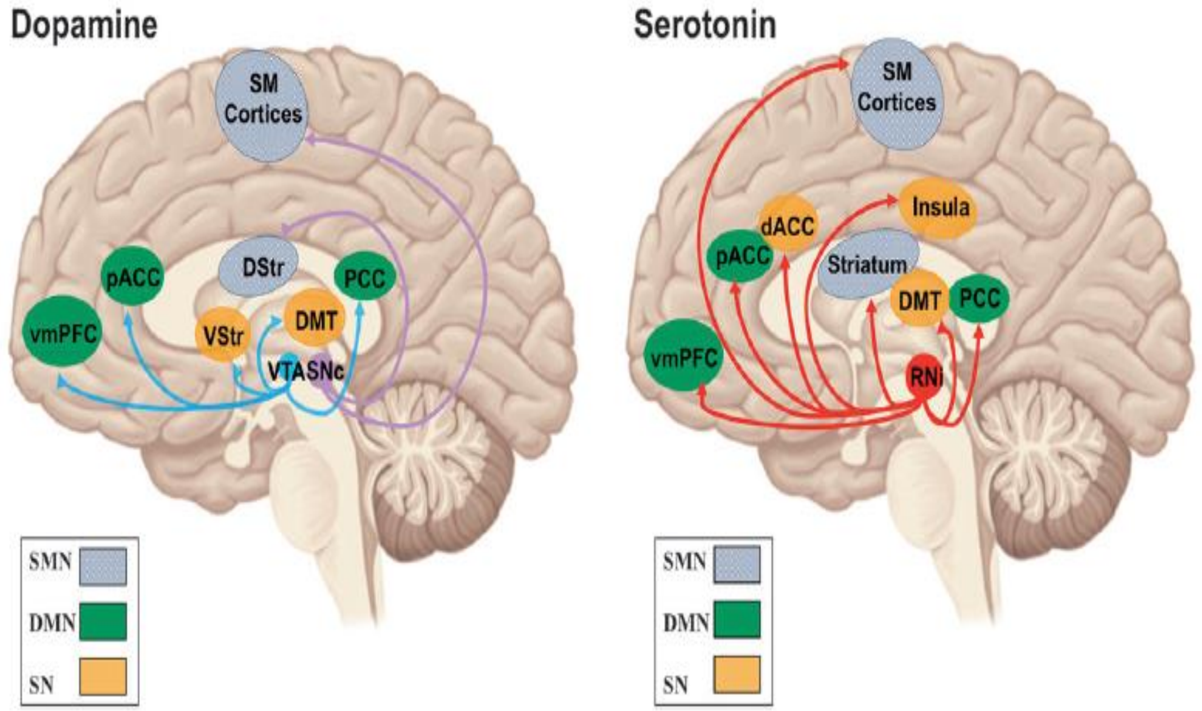
The figure shows three examples of nestedness. Upper left: the Russian dolls with smaller dolls being nested within the next larger one. Upper right: the same holds fort he Chinese crystal ball where different sizes of the same shape are nested and intricately contained and integrated within each other. Lower left and right: the power spectrum with its different frequencies (lower left) that show different degrees of power (lower right) is yet another example of nestedness where the strongly powered slower frequencies contain or nest the weakly powered faster frequencies.

Figure 3c Nested topographical hierarchy of unconscious and conscious



Chapter 6

Figure 1a Subcortical-cortical modulation by dopaminergic and serotoninergic pathways (left) and the cortical activity modulated by subcortical dopaminergic substantia nigra pars compacta (SNc) and serotoninergic raphe nuclei (RNi) (right)



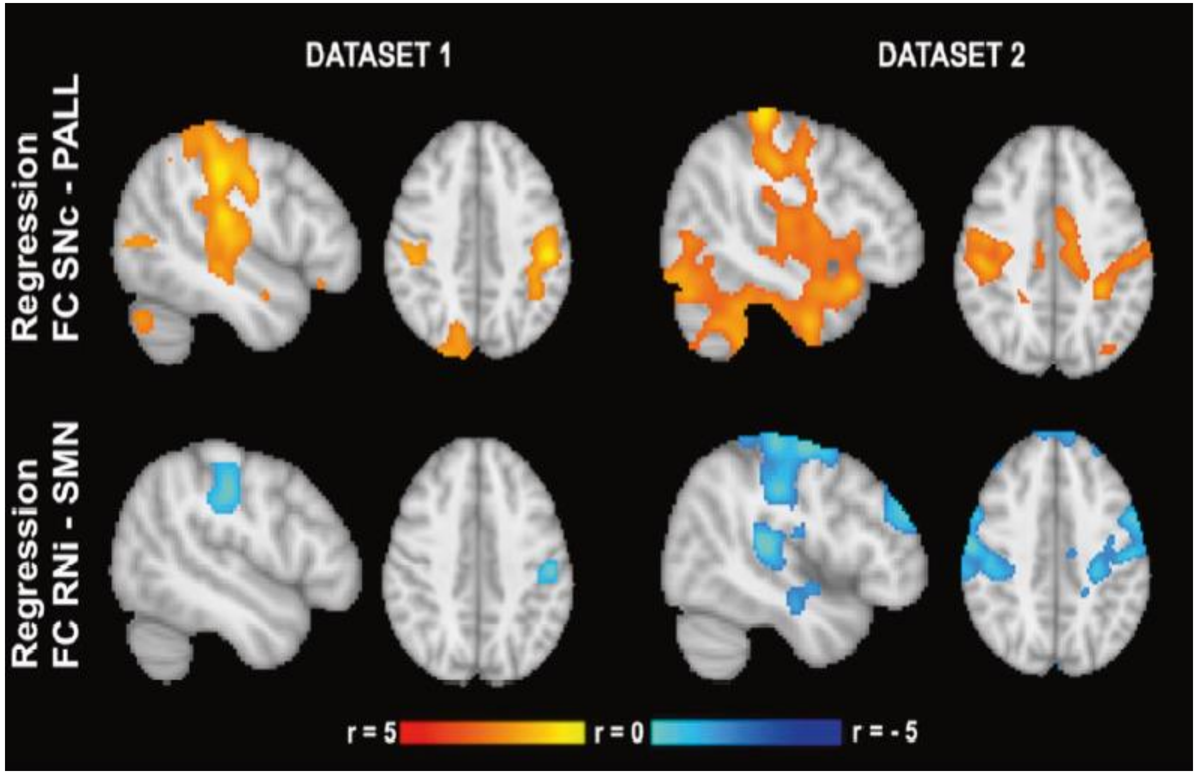


Figure 1b Autocorrelation window (ACW) and power law exponent (PLE) (upper part) and topographic maps (lower part) in the different sleep stages including dream (REM)

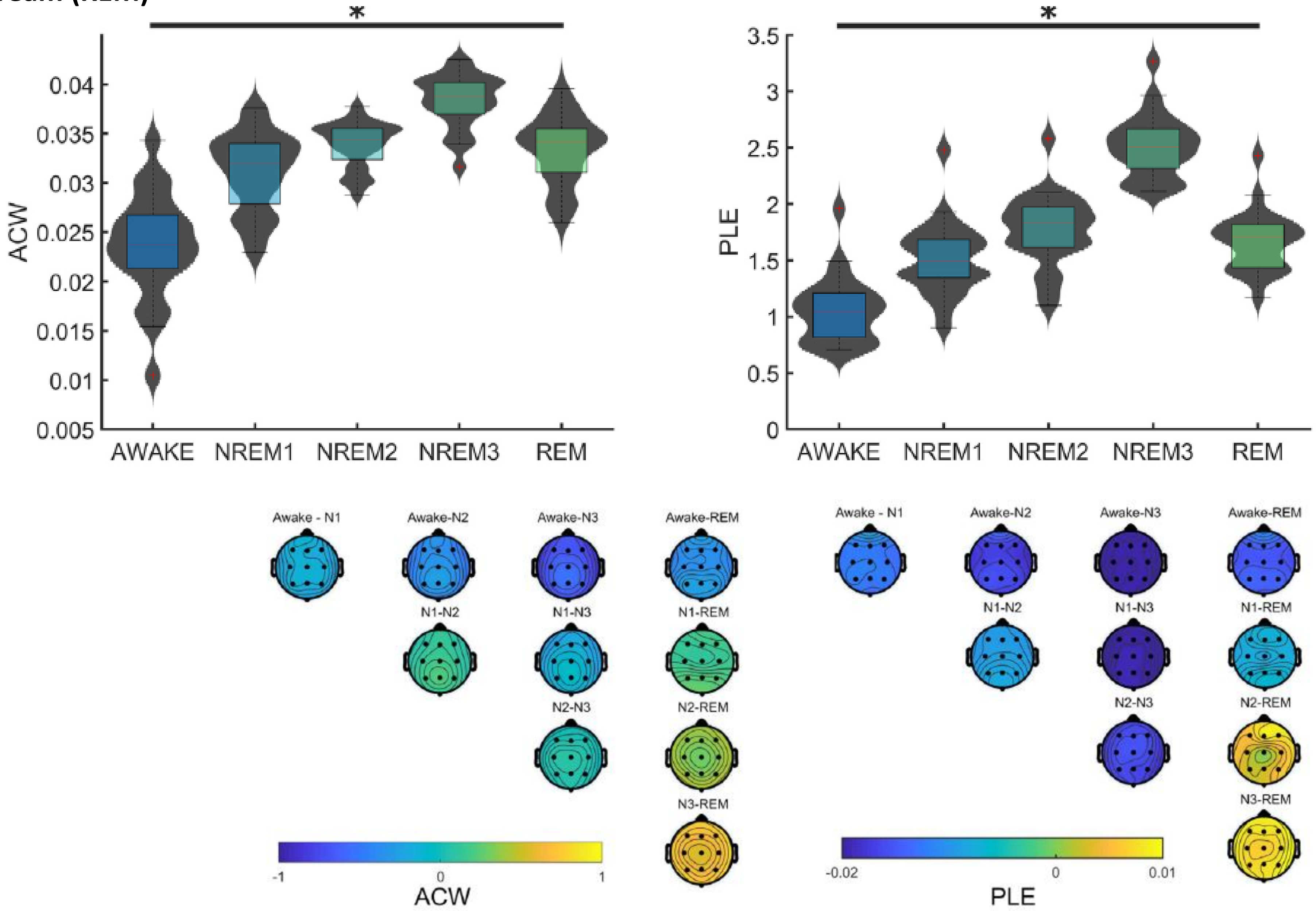


Figure 2a Topographic Re-organization model of Dreams (TRoD) with spatiotemporal dynamics as "common currency" of brain and psyche

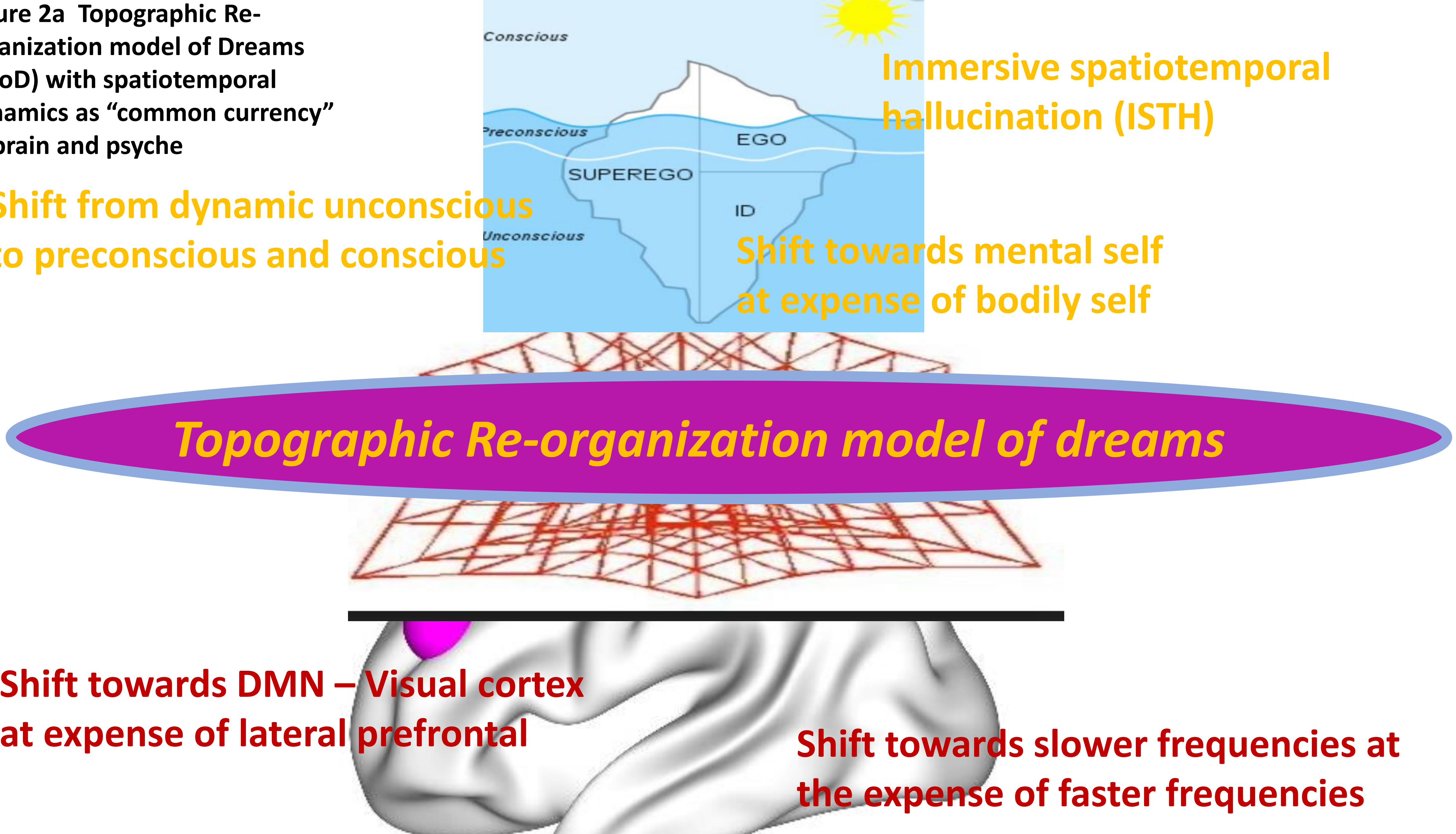


Figure 2b Topographic reorganization of the unconscious in dreams with broader inputs from the deep unconscious (left and middle) and subcortical-cortical connection (right) (dotted lines indicate the extension and change)

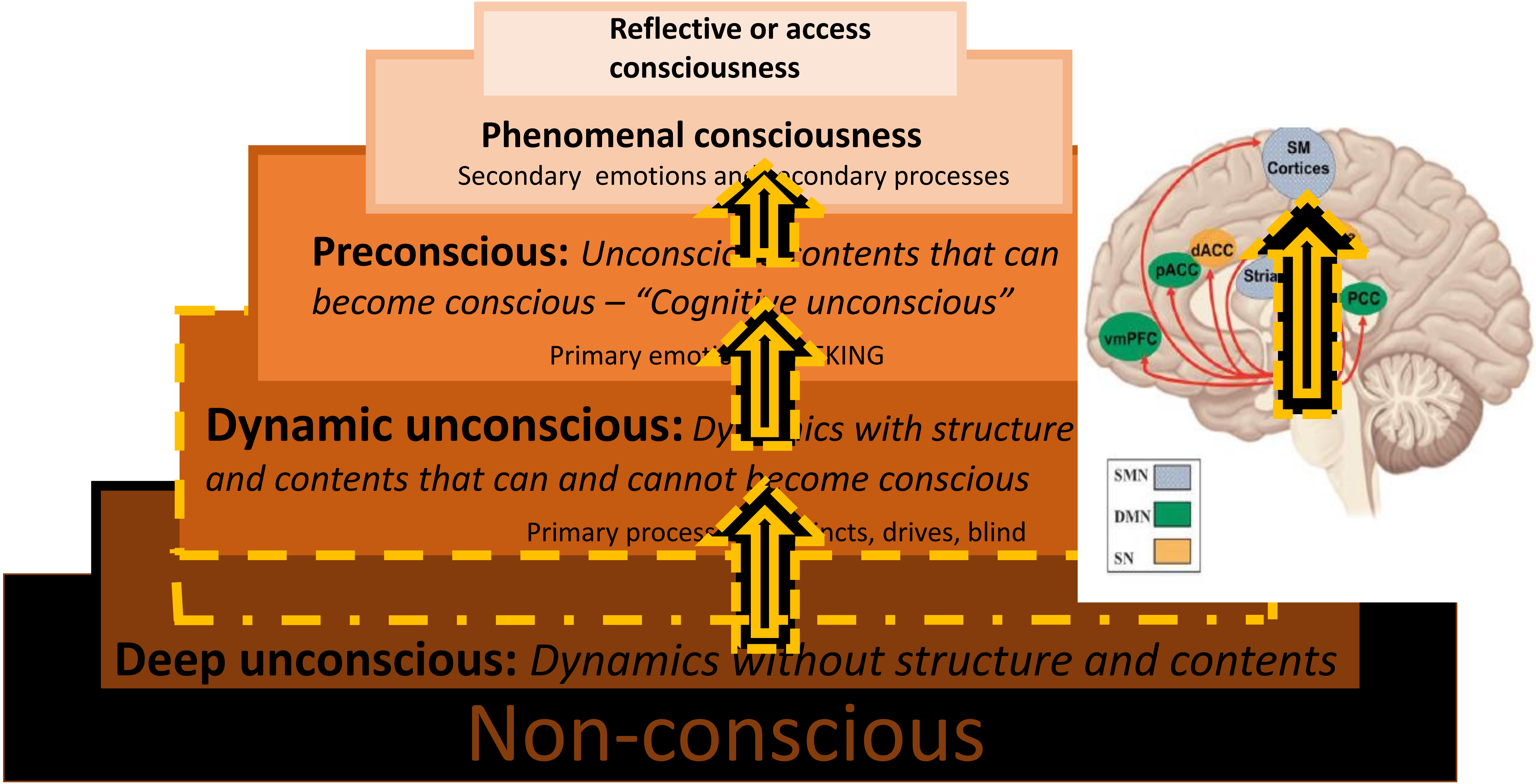
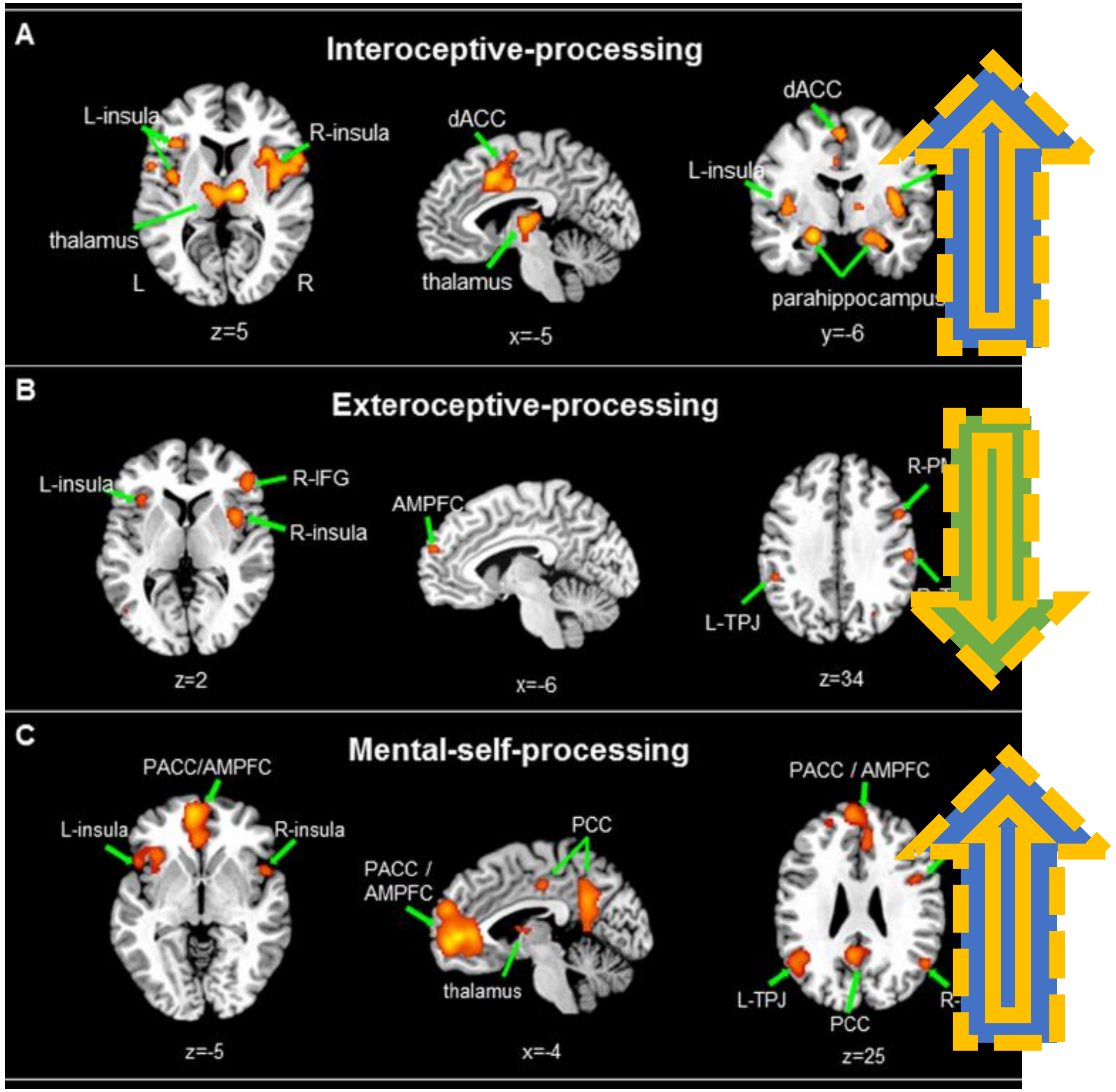


Figure 2c Topographic reorganization of the brain (left) and its self (right) in dreams with increases in the mental and interoceptive self (upward arrow) and decreases in the exteroceptive self (downward arrow)



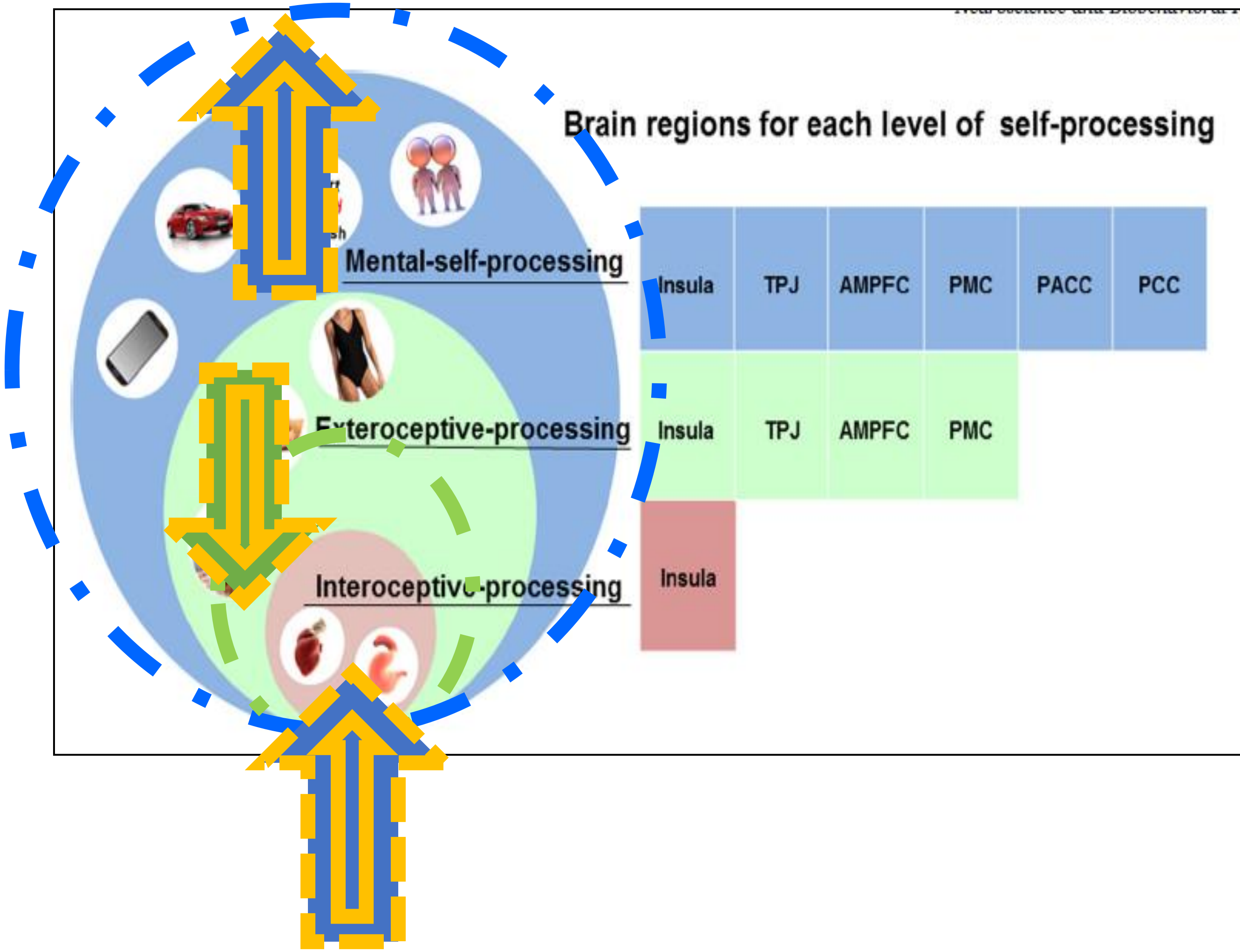
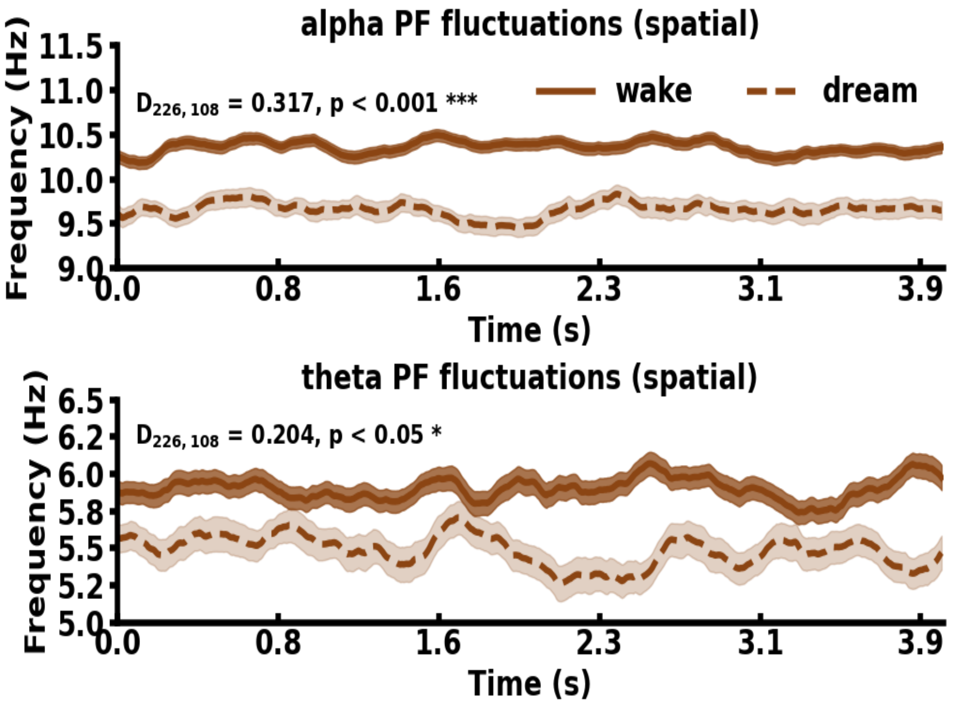
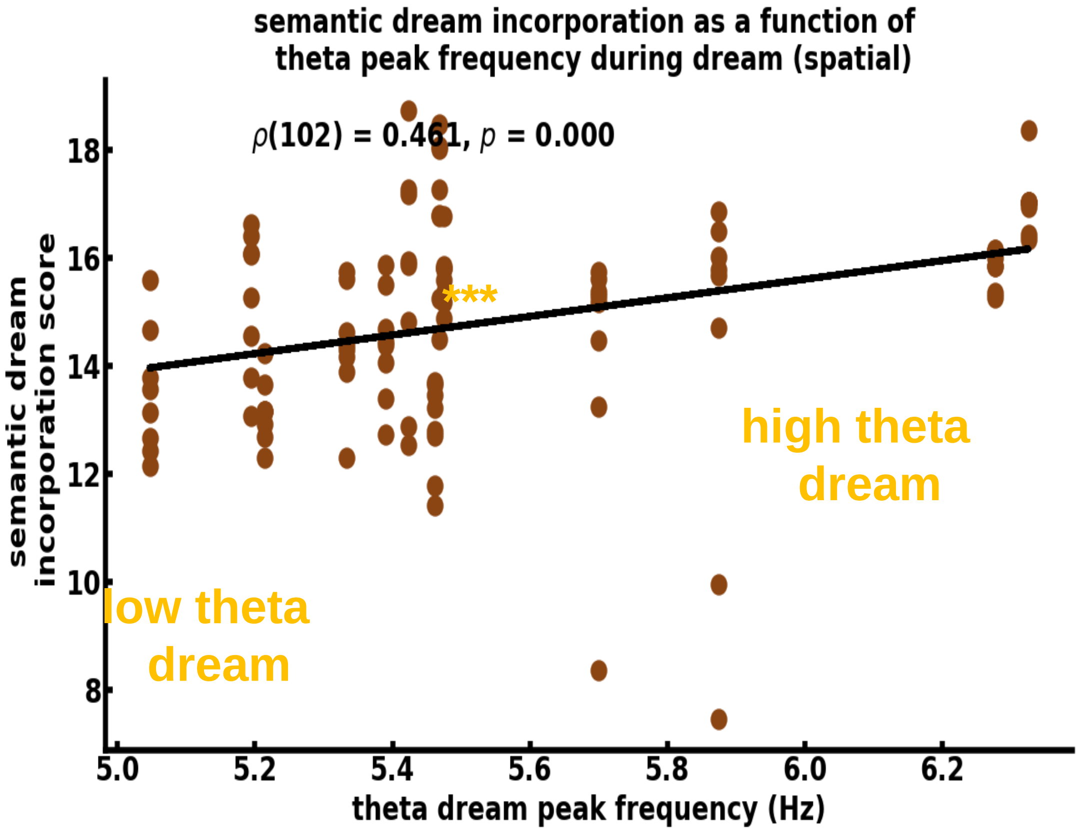


Figure 2d Theta peak frequency during dreams of spatial (upper left) and tennis (lower left) and the relation of theta peak frequency (upper right) and its dream-awake similarity (lower right) to the degree of semantic association, i.e., dream incorporation score (right)





Chapter 7

Figure 1a Altered global signal topography in schizophrenia (Yang et al. 2017)

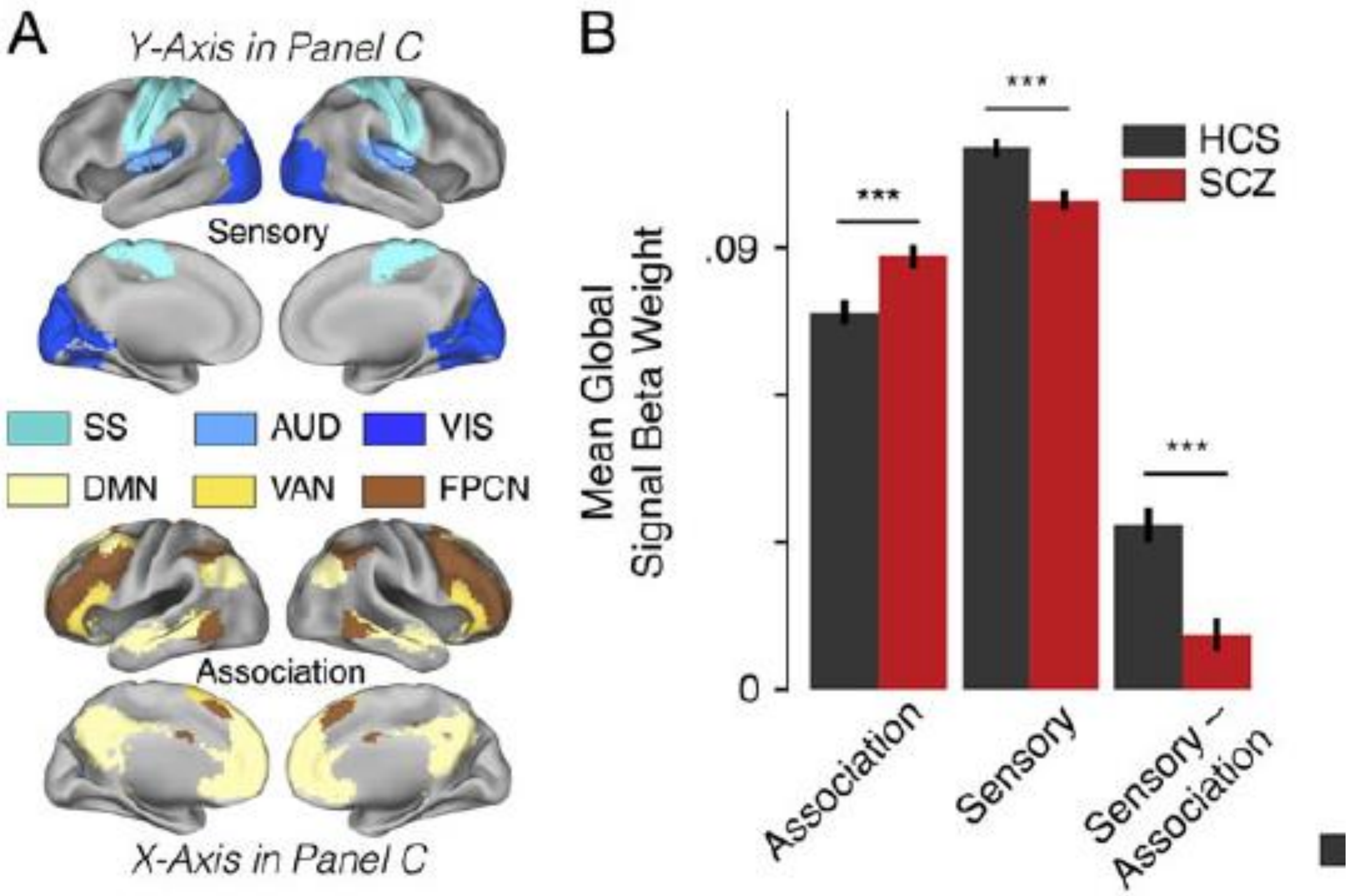
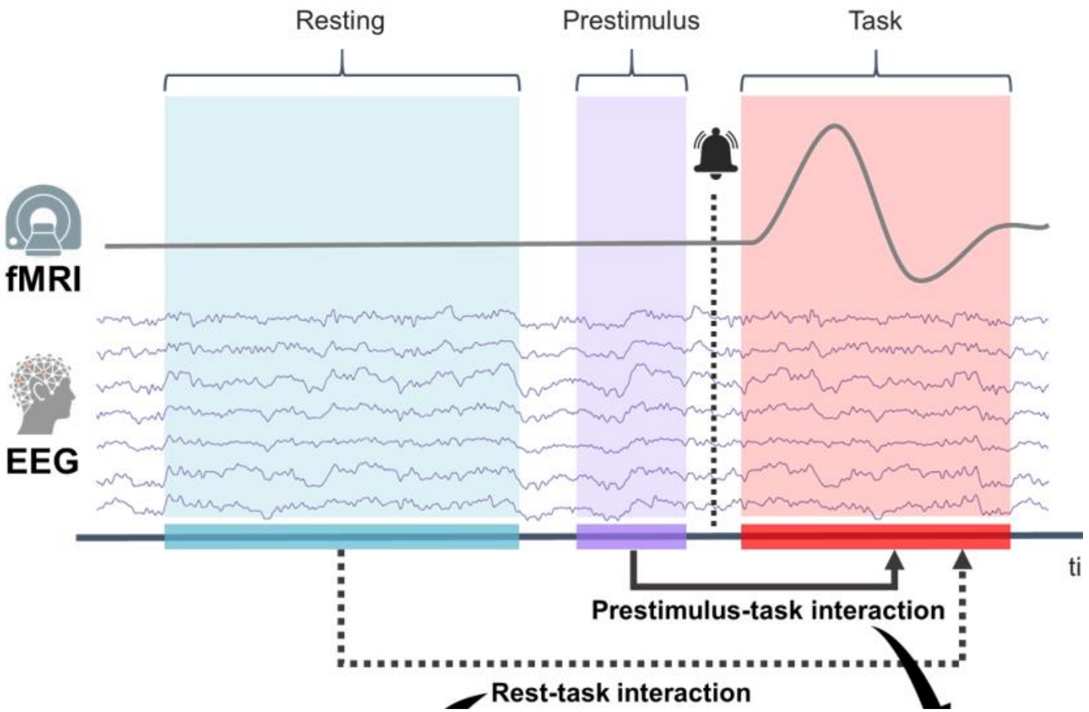


Figure 1a: **Global signal topography in schizophrenia (Yang et al. 2017).** The figures show the distribution or representation of global brain activity in different sensory and association networks (left) and their comparison in healthy and schizophrenia subjects (right).

Figure 1b Pre-poststimulus differences in schizophrenia (left: method; right: results)



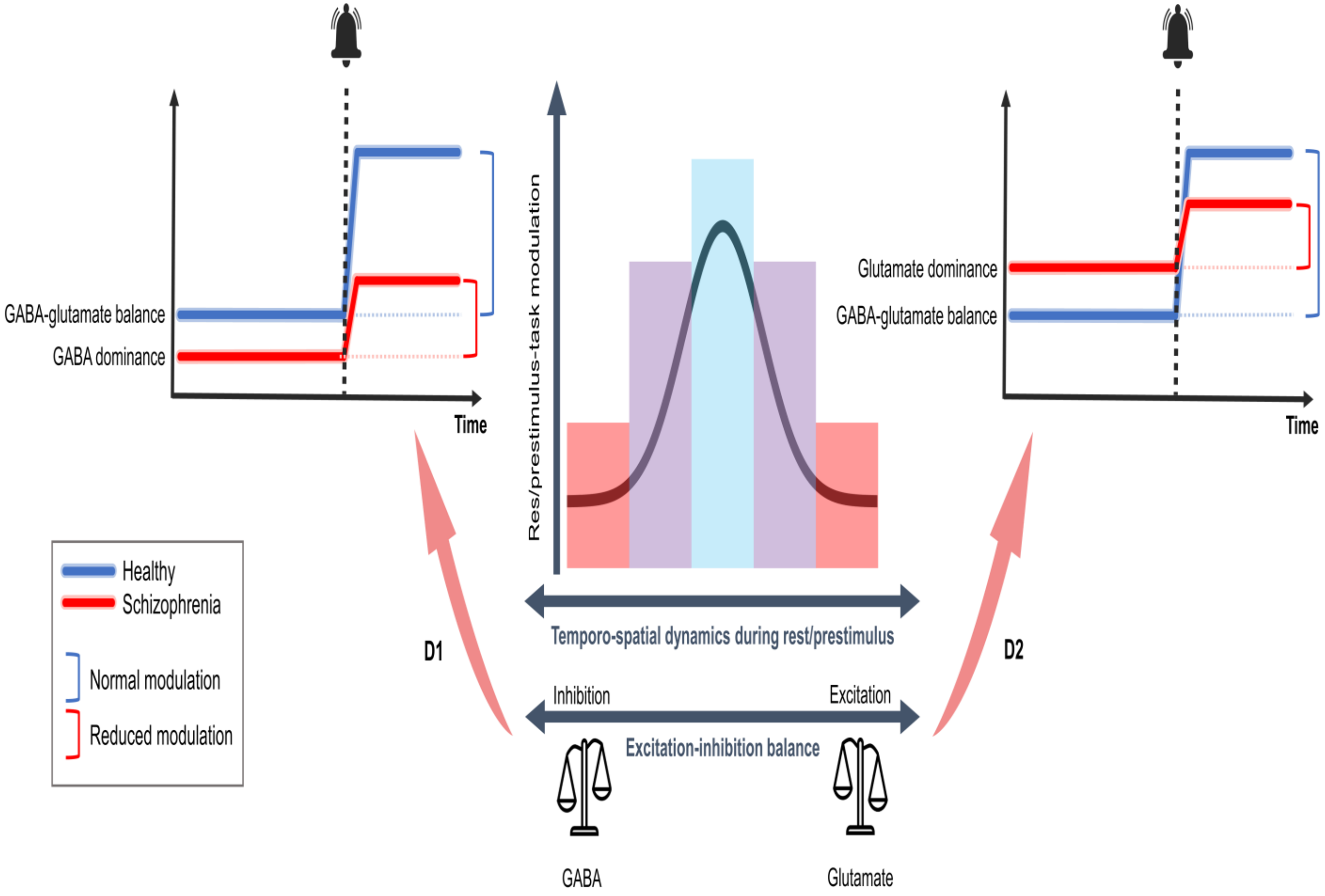


Figure 1c Decreased pre-poststimulus difference in schizophrenia (red line) compared to healthy controls (blue line) in two graph-theoretic measures in EEG

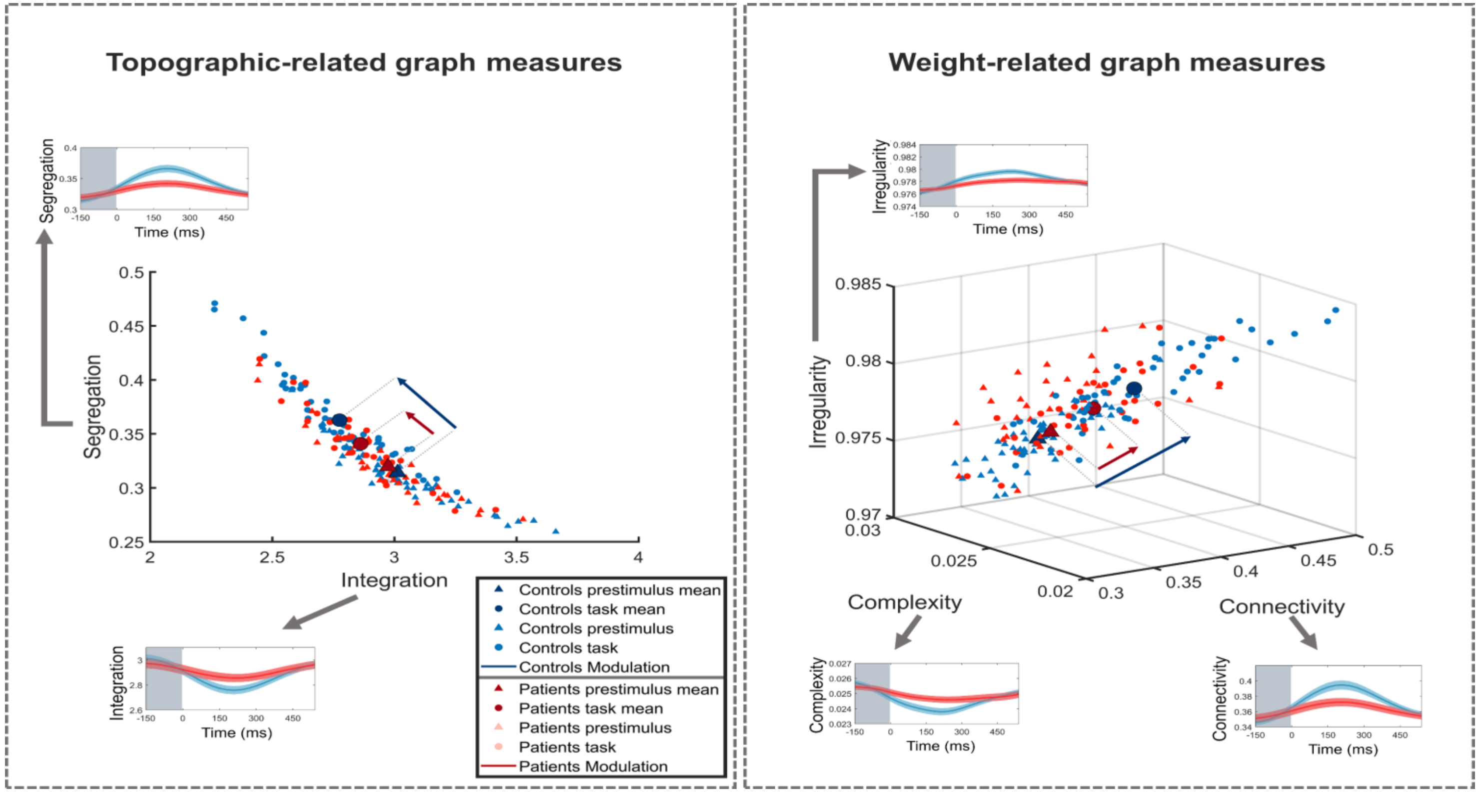


Figure 1c **Temporospatial dynamics of chronnectomic measures during prestimulus-task modulation in healthy and schizophrenia subjects.** Schizophrenia subjects show reduced temporospatial dynamics both for the topographic-related graph measures (A) and for the weight-related graph measures (B). Figure 1b: **Rest-prestimulus-task modulation in healthy (left) and schizophrenia (right) subjects.** Left part: the interaction of resting state and prestimulus activity with task-related activity is schematically visualized. Right part: The modulation from prestimulus to task-related activity is depicted with a blue line for controls and red line for patients, showing reduced prestimulus-task differences in the five dynamic domains (integration, segregation, complexity, connectivity, irregularity).

Figure 1d Spatiotemporal dynamic, predictive coding and internally- and externally-oriented cognition

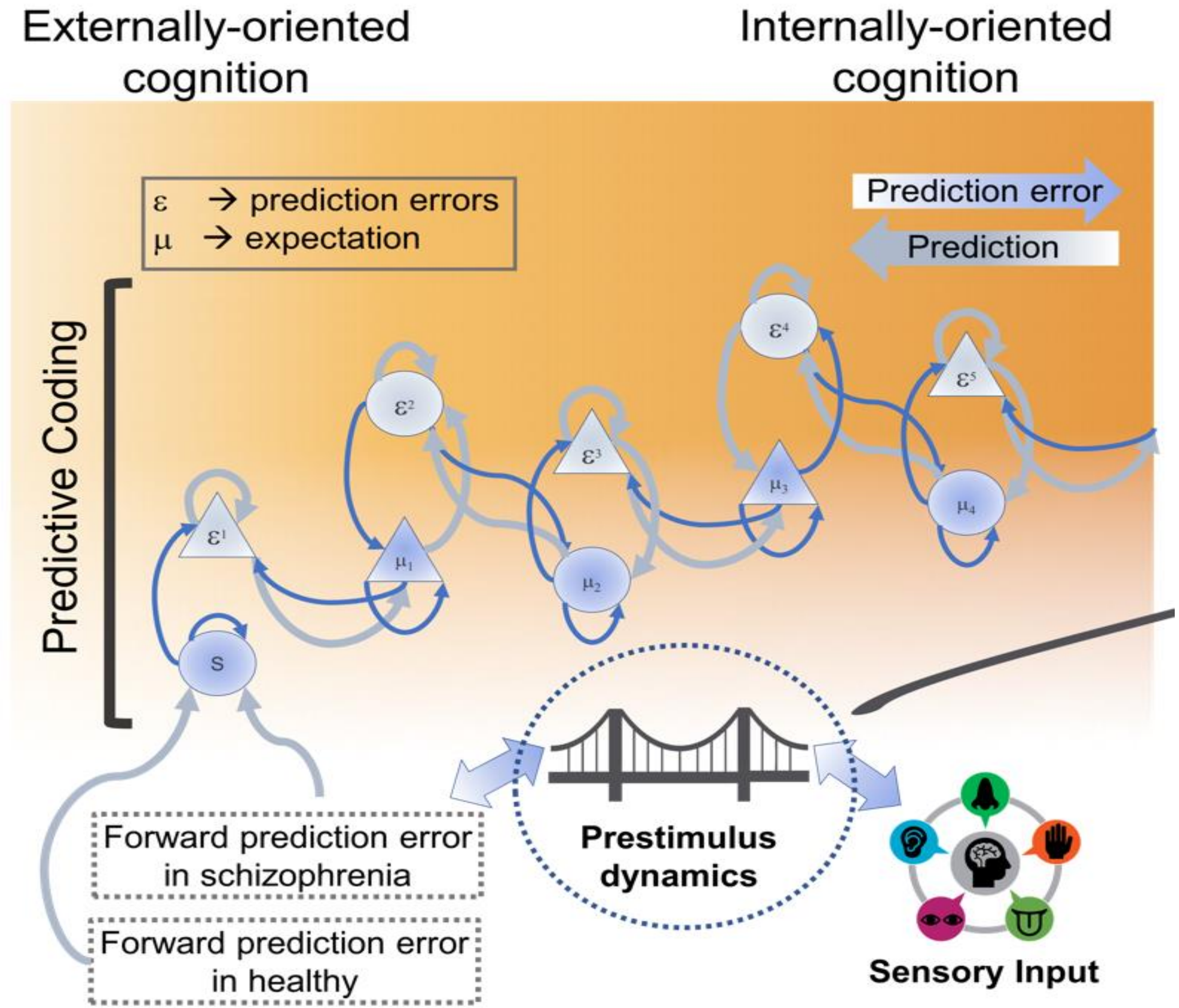
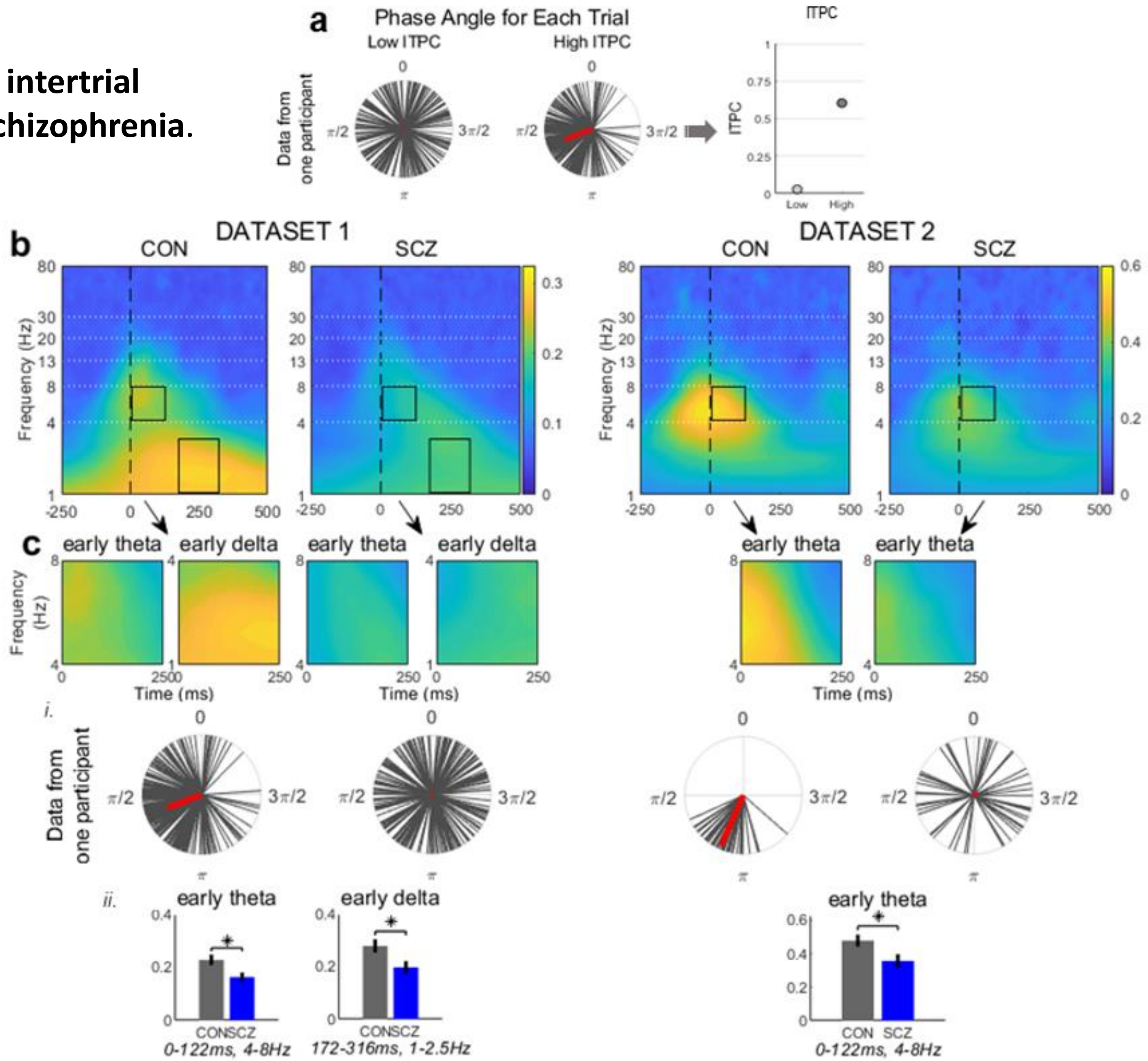


Figure 1d **Relevance of spatiotemporal dynamics in internally- and externally-oriented cognition. S**patiotemporal dynamics during the prestimulus provide a bridge of neuronal and mental activity serving as "common currency". The altered neural dynamics in schizophrenia is received by predictive coding modeling as the forward prediction error input, ultimately affecting the internally-oriented cognition including the differentiation of self/self-objects (internal) and objects (external).

Figure 2a Decreased intertrial phase coherence in schizophrenia.



Decreased intertrial phase coherence in schizophrenia. (a) ITPC is calculated based on the phase angle at a specific timepoint and frequency (here shown as 6 Hz at stimulus onset or 0 ms) for all trials. The dark gray lines in the polar phase plot represent the phase angle for each trial (216 trials so 216 phase angles). In low ITPC (left), there is no preferred phase, so the distribution of phase angle is uniform, or spread evenly around the circle. In contrast, in high ITPC (right), there is a greater proportion of the phase angles in one part of the circle and not phase angles at another part; the distribution is nonuniform so not evenly spaced around the circle. The red bar (difficult to see in the low ITPC case) signifies the ITPC resulting from the individual gray lines. The longer the red bar, the higher the ITPC (shown at right scatter plot), with a maximum of 1. (b) ITPC in both datasets for the first 500 ms after stimulus onset. After visualizing the contour plots, data from two areas in Dataset 1 (theta and delta bands) and one area in Dataset 2 (theta band) (c) were extracted (black rectangles). (i) Polar histograms (each bin = 20◦) measuring percent of participants preferred (mean) phase angle at 6 Hz and stimulus onset in bins. For example, if the top of a bar touches the 20% radius, then 20% of the participants in that group have a preferred phase angle in that bin. (ii) The data extracted in a/b were statistically compared, with lower phase coherence found in the SCZ participants in both datasets.

Figure 2b Temporal deficits in input processing in schizophrenia.

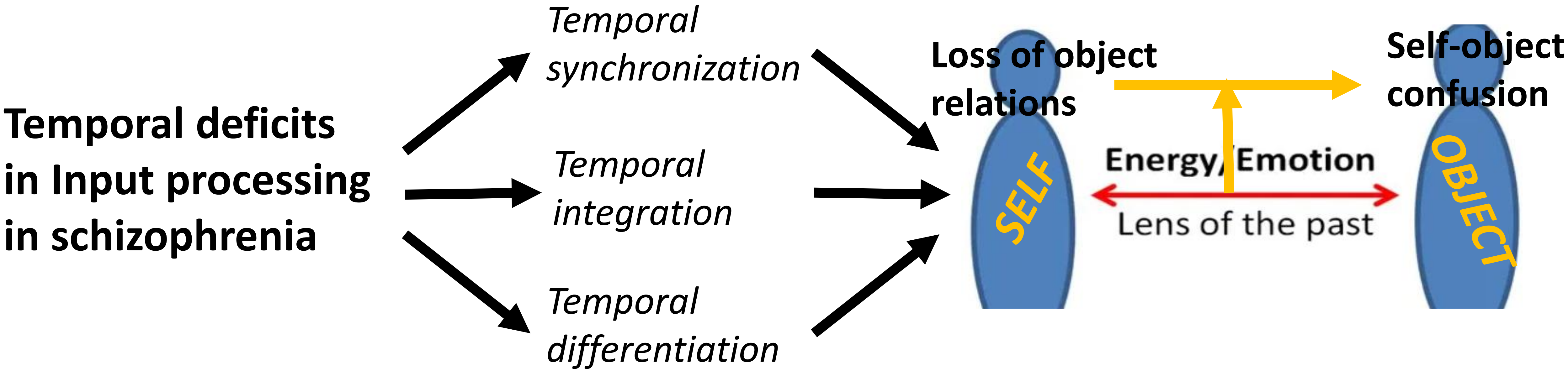


Figure 2b **From temporal deficits in input processing (left) to loss of object relations and self-object confusion in schizophrenia (right)**

Figure 3a Disbalance of environment- and self-focus in depression

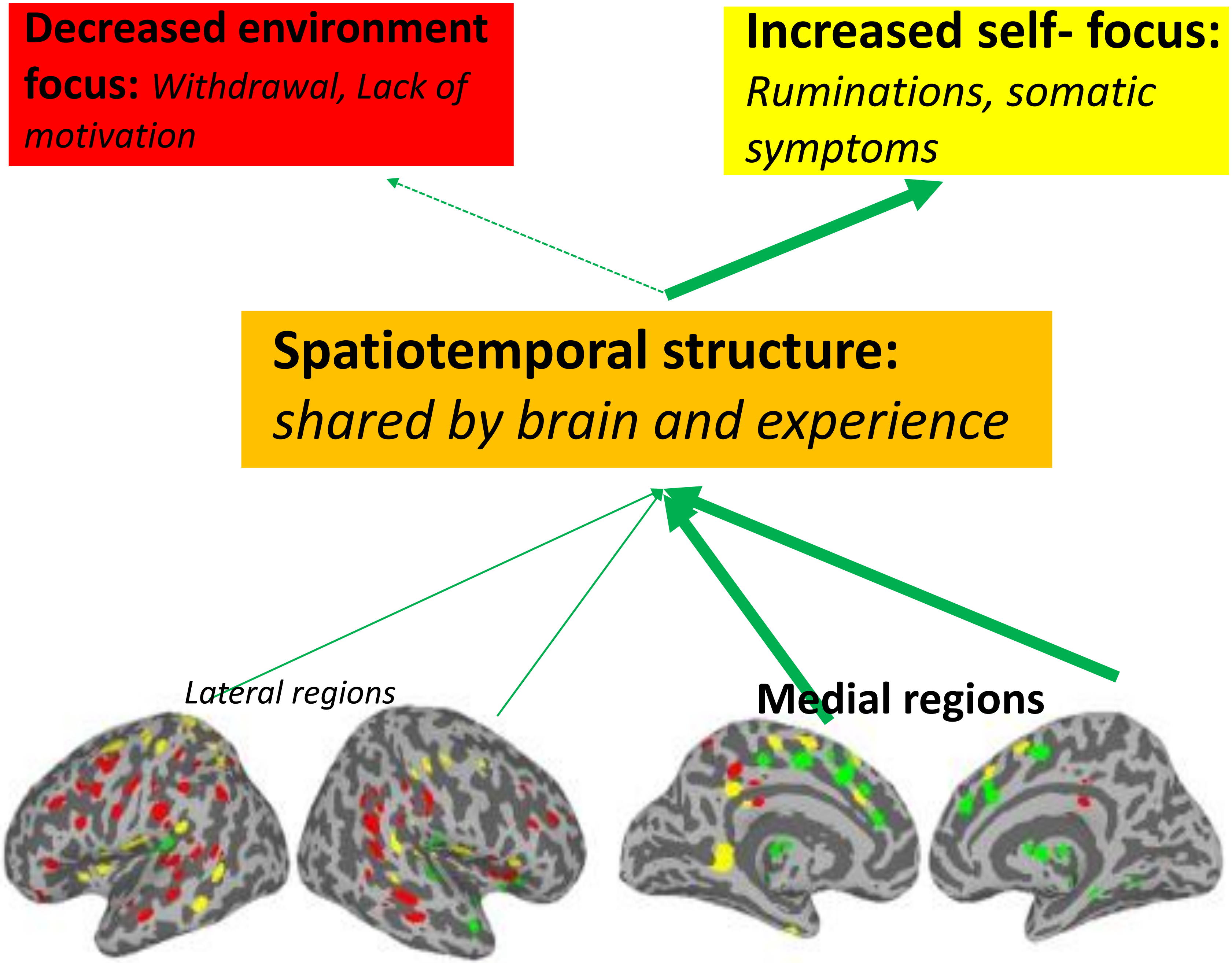


Figure 3a **_Topographic changes in depression._** _Medial-lateral prefrontal disbalance in the spatio-temporal structure (lower part) shifts the balance of self (increased self-focus) and environment (decreased environment-focus) (upper part)_

Figure 3b Topographic changes in the global brain activity of depression

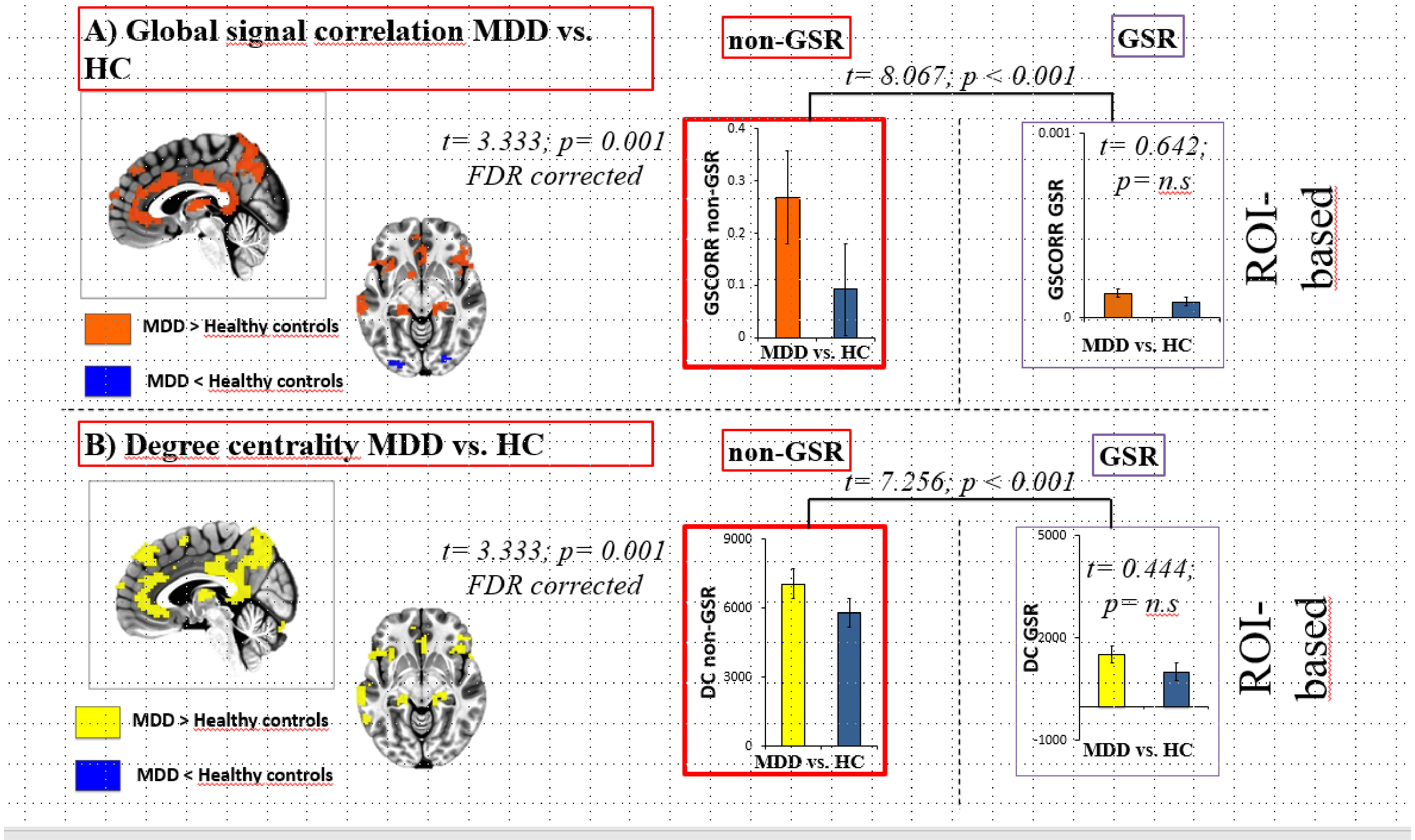
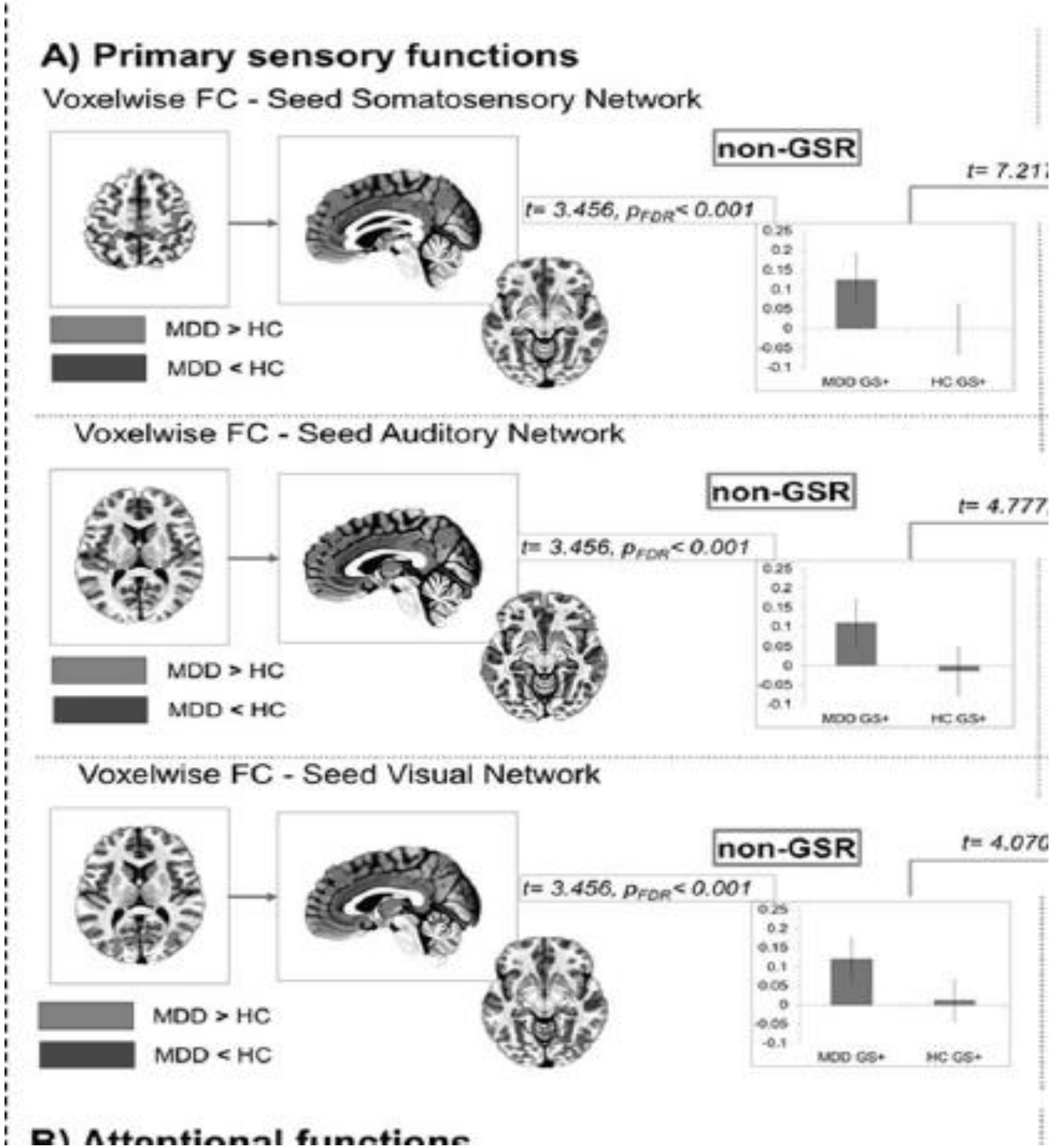
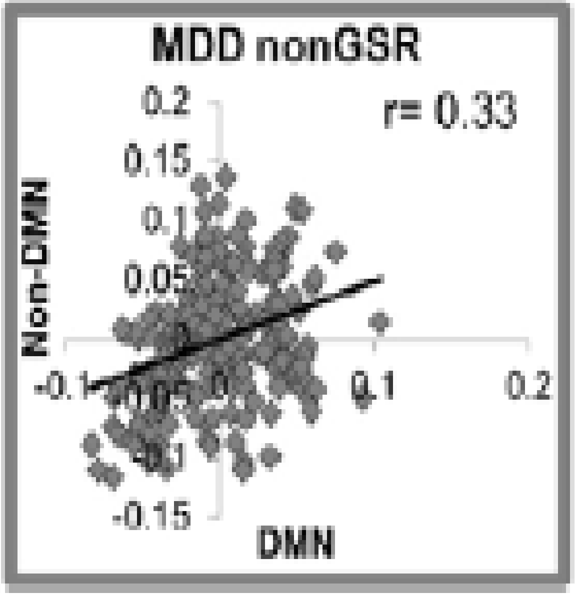


Figure 3b **_Topographic changes in the global brain activity of depression._** *The figures shows on the left two measures of the topography of global brain activity, the global signal correlation (upper left) and the degree centrality (lower left). Both are calculated once with and once without global signal regression (Non-GSR, GSR) as in the middle and left part of the figure.*

Figure 3c ***Topographic changes of sensory regions with the DMN in depression.***





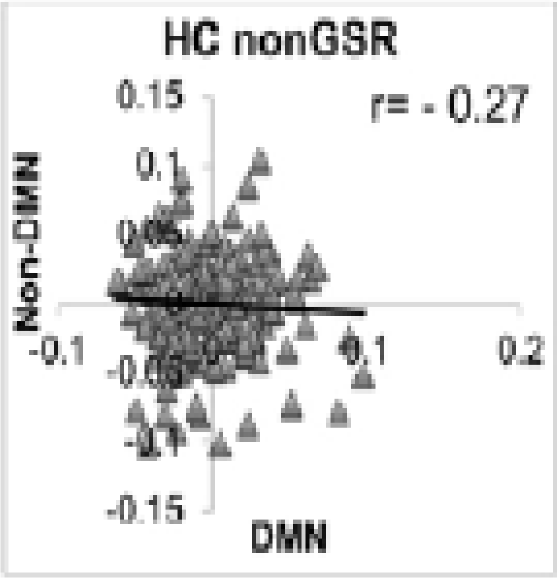
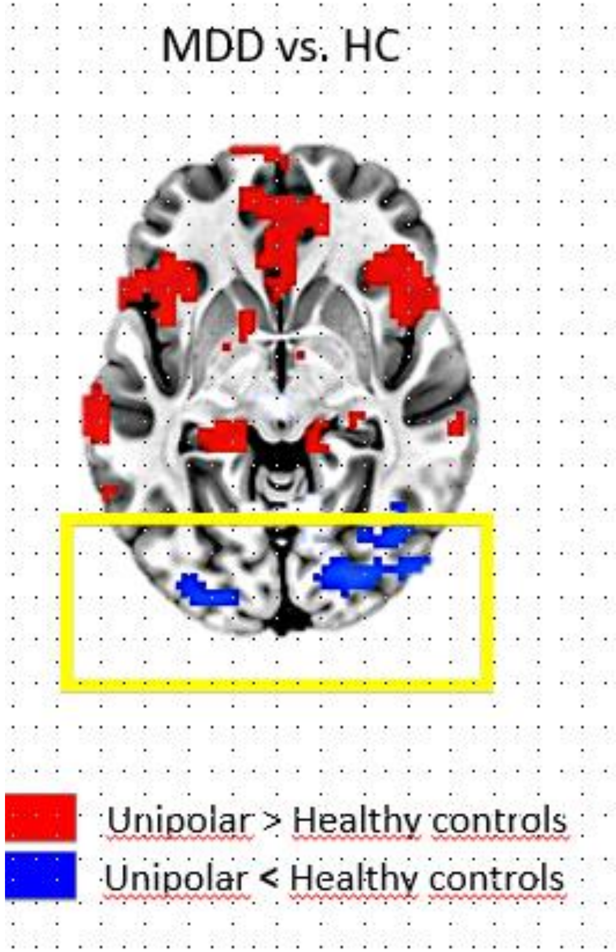
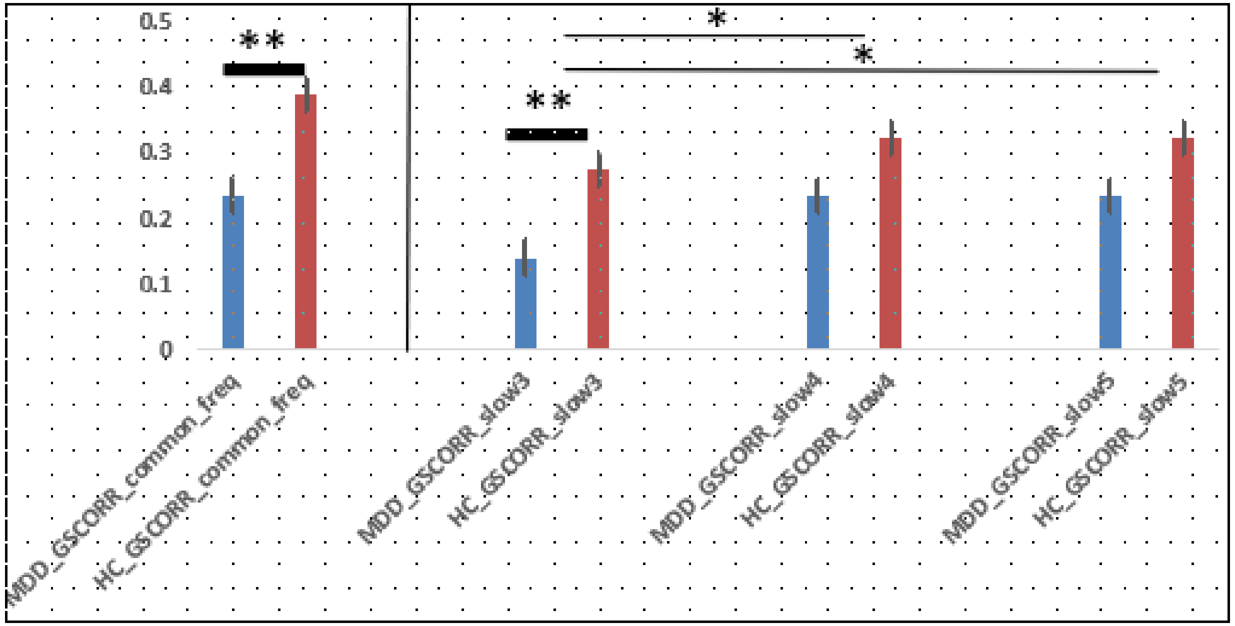


Figure 3c ***Topographic changes of sensory regions with the DMN in depression.*** *The figure shows the increased functional connectivity of three sensory networks to the rest of the brain including especially the default-mode network (left). Moreover, it shows the increased correlation of the DMN with all non-DMN regions of the brain in depression compared to healthy subjects (right) (Scalabrini et al. 2020).*

Figure 4a ***Temporal dynamic in occipital cortex of depression.***





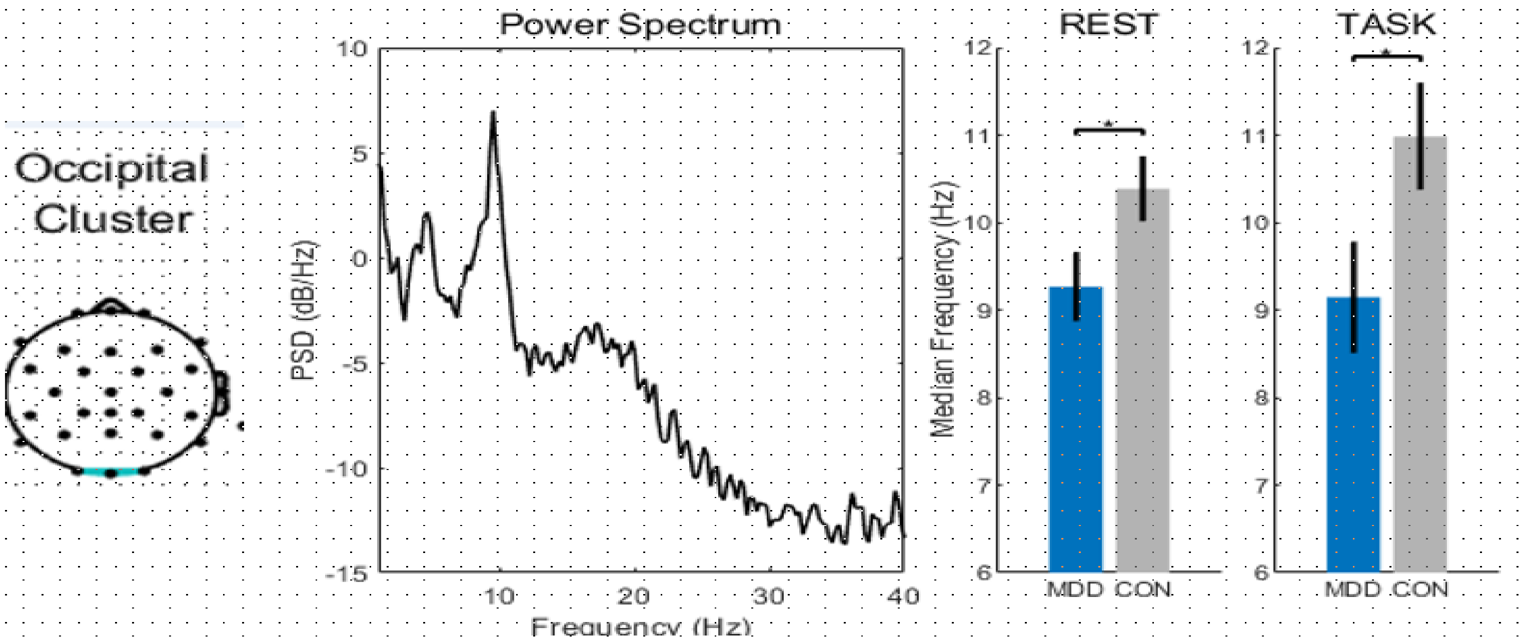
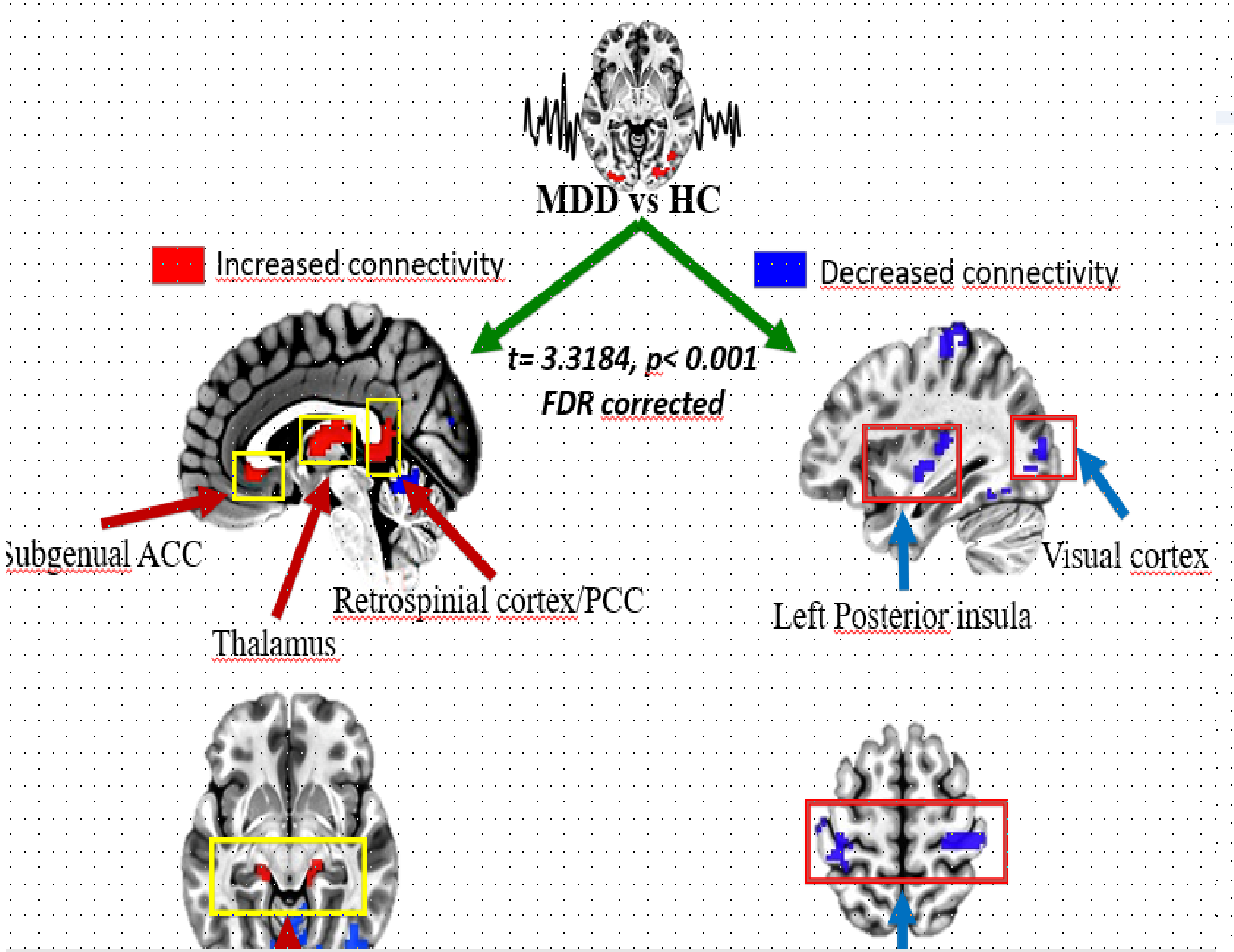


Figure 4a **_Temporal dynamic in occipital cortex of depression._** *The figure shows the decreased global signal representation in occipital cortex of depression (left) in different frequency bands (upper part) as obtained in fMRI (left, upper). Additionally, the power spectrum with median frequency (lower middle and right), as obtained in EEG, are shown for occipital cortex in depression (lower middle left).*

Figure 4b ***Connection of occipital cortex with other regions in the brain of depression.***



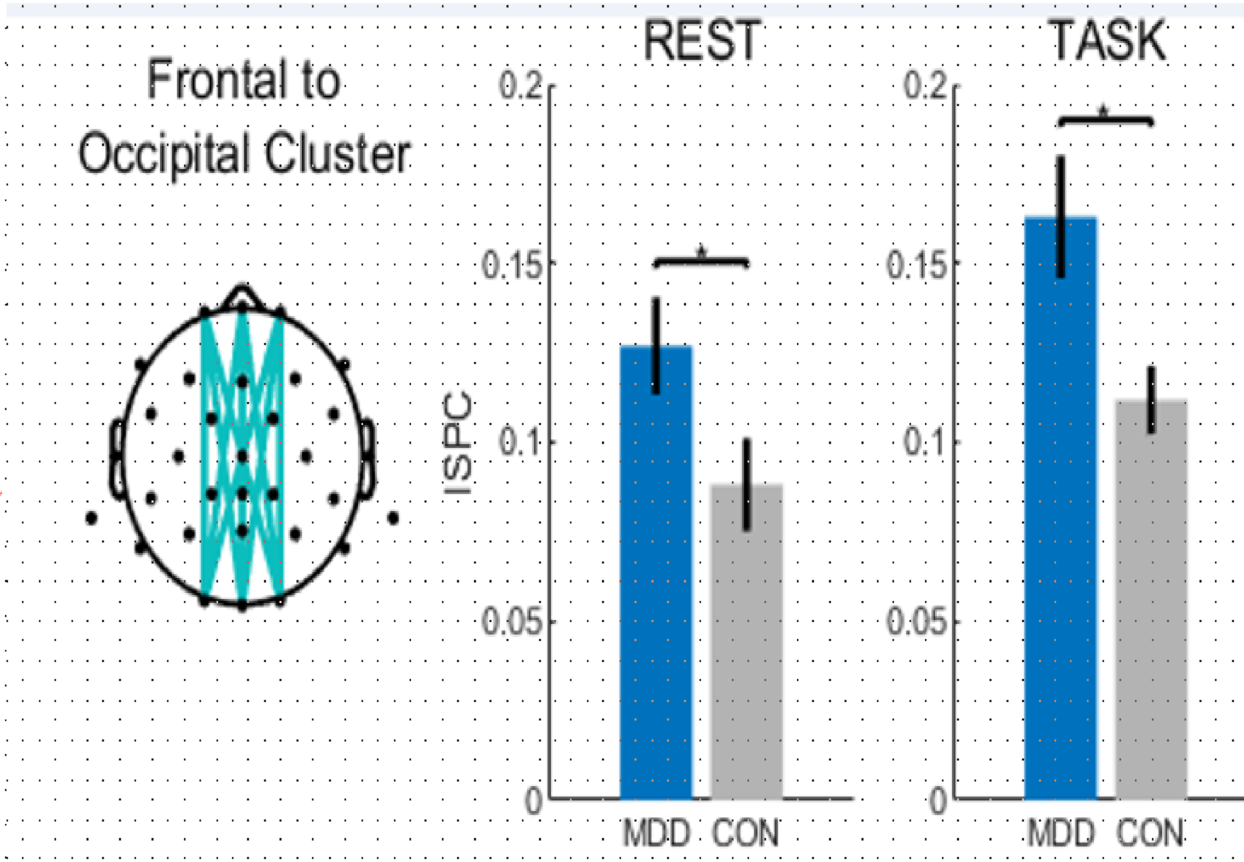


Figure 4b **_Connection of occipital cortex with other regions in the brain of depression._** *The figure shows the functional connectivity from occipital cortex to the rets of the brain as obtained in fMRI (right part). Analogously, coherence of occipital and frontal electrodes in EEG of depression also shown (middle and right part).*

Figure 4c Psychodynamic processes in *depression*.

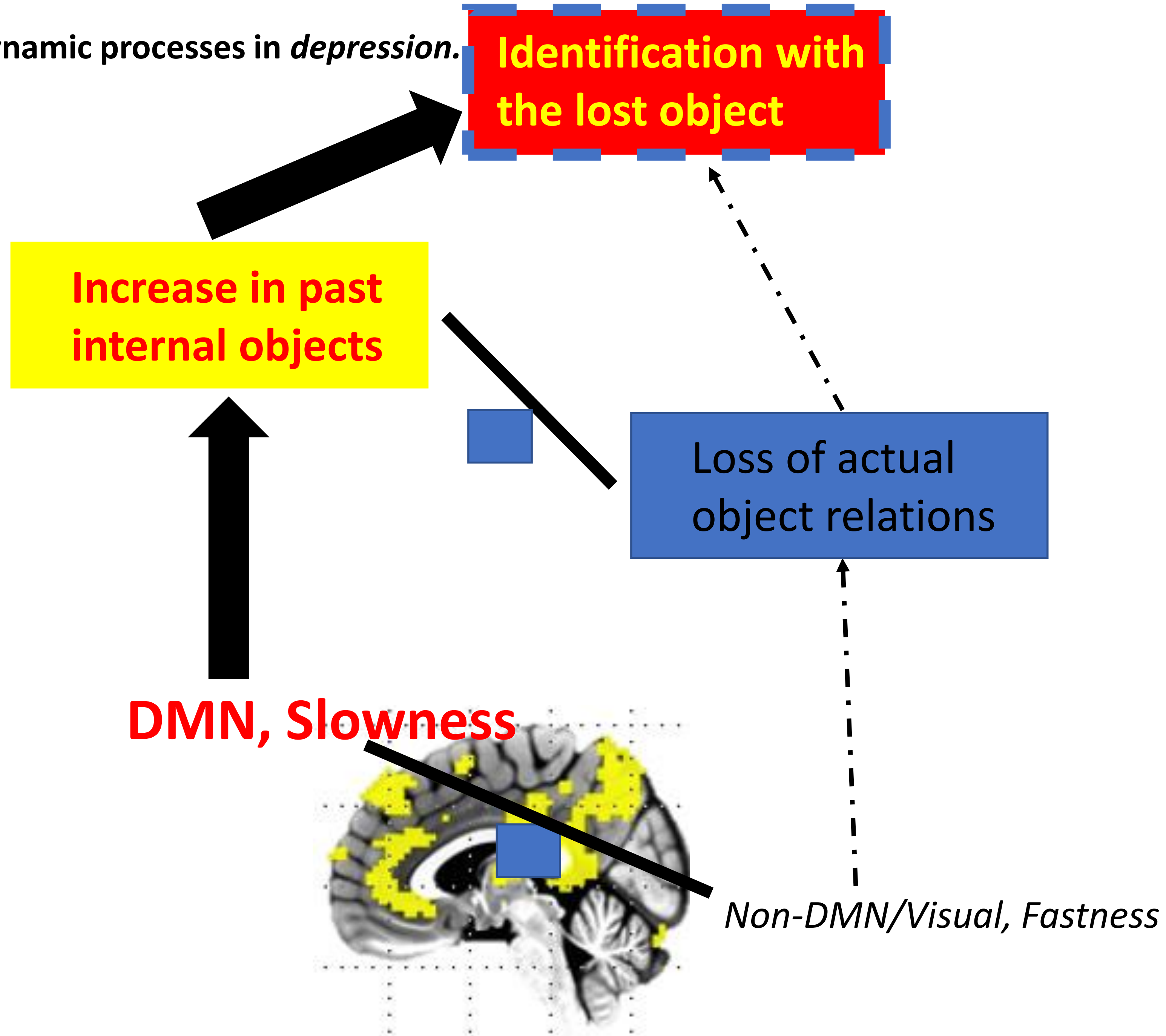


Figure 4c ***Neuronal basis of psychodynamic mechanisms in depression.*** *The figure shows topographic and dynamic disbalance of DMN and visual cortex (lower part) as basis for the disbalance of past internal objects and actual object relation (middle part) which, in turn, results in the Identification with the lost object (upper part).*

Conclusion

Figure 1a Freud's "Project for a Scientific Psychology" and Solms' "(New) Project for a Scientific Psychology" leave open the "Gap of contingency" (red dotted lines indicating insufficient, i.e., contingent connection) due to discrepant models of brain and psyche

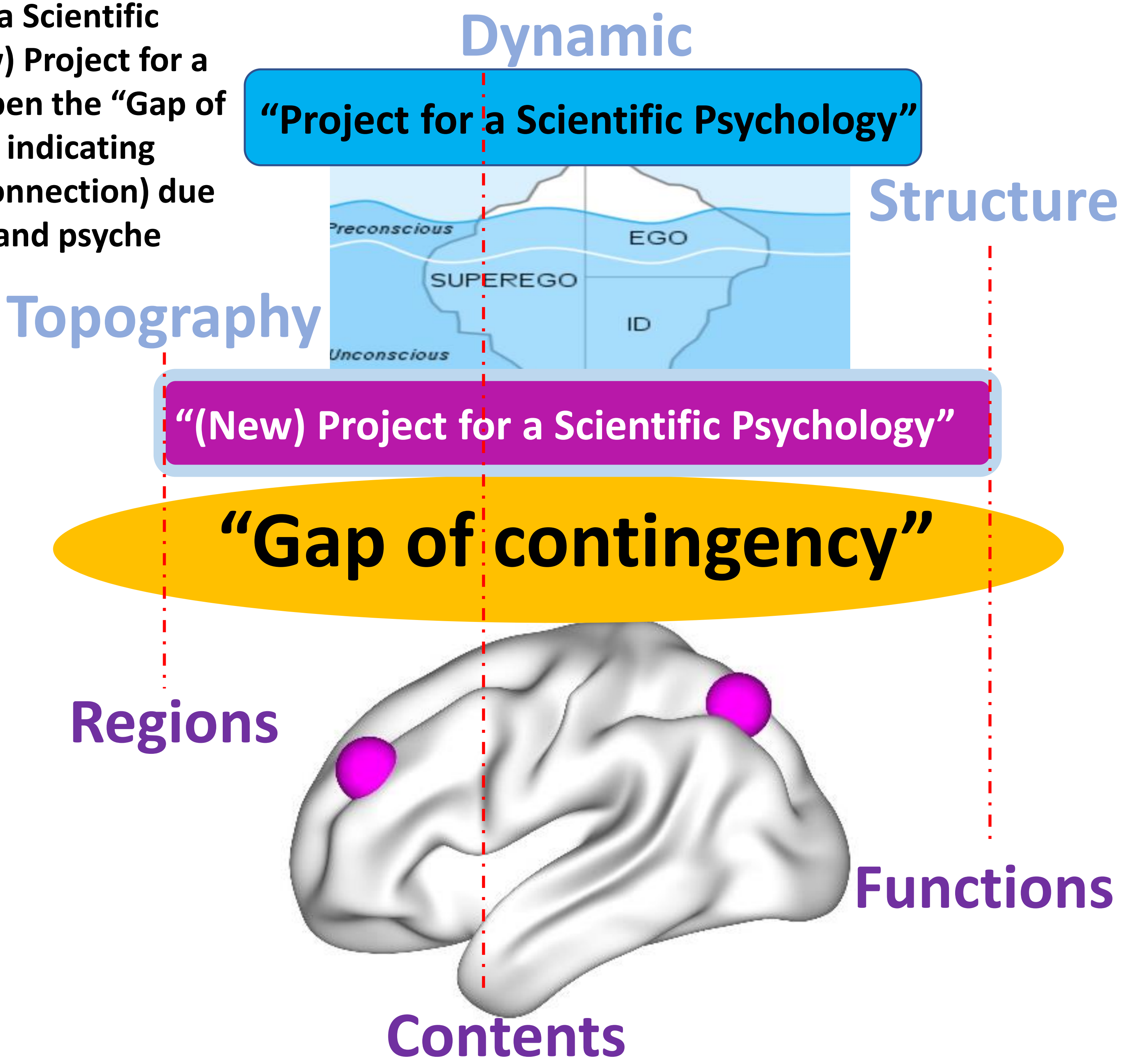


Figure 1b “Project for a Spatiotemporal Neuroscience” closes the “gap of contingency” (solid vertical lines) as it presupposes analogous models of brain and psyche with topography, dynamic, and spatiotemporal structure

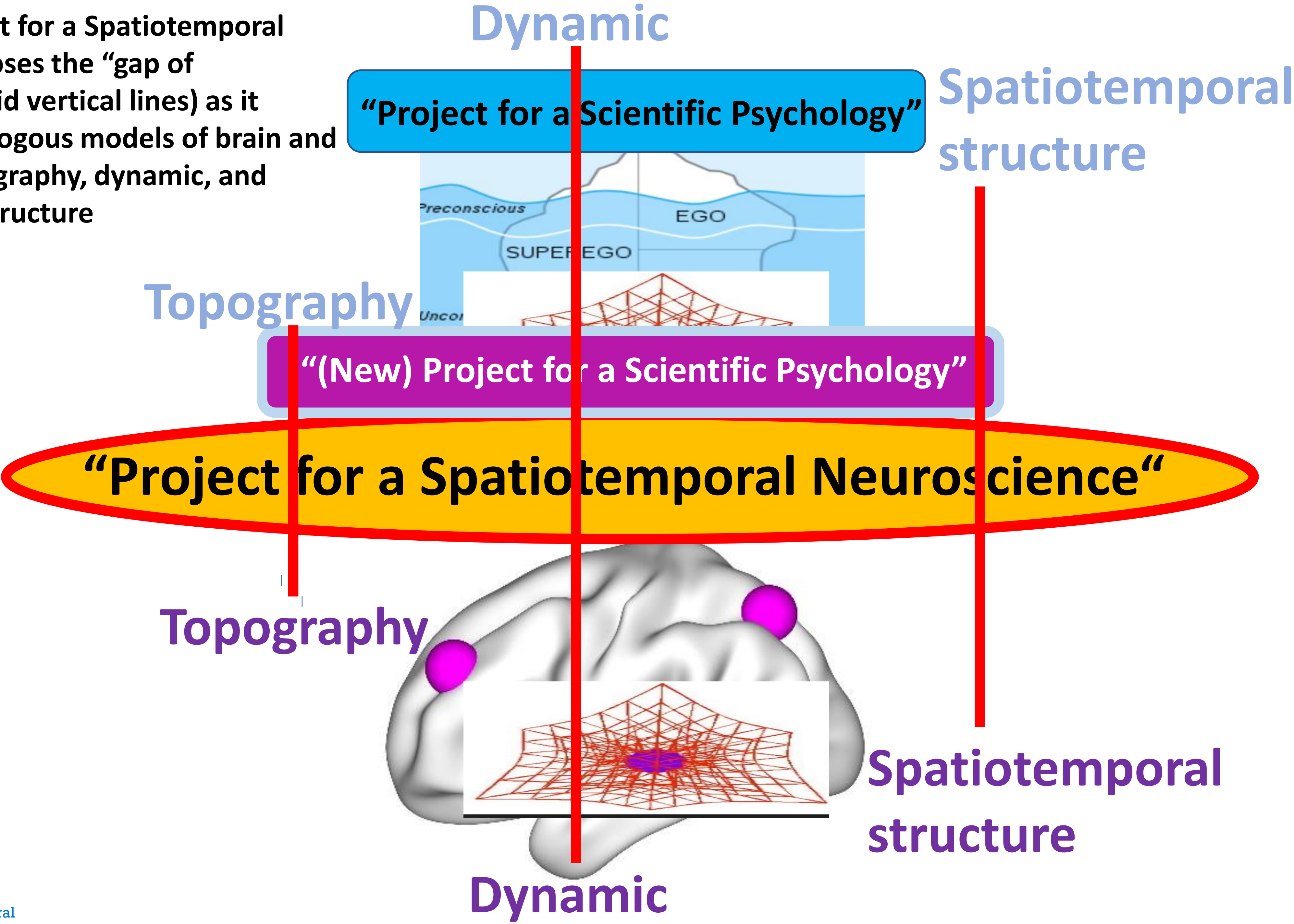


Figure 2 Visual representation of Spatiotemporal Psychotherapy