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Platinum Neuro Integration 2

From Signal to Perception: How the Brain Interprets Input



NEW ZEALAND COLLEGE of CHIROPRACTIC

TE KĀRETI KAIKOROHITI o AOTEAROA

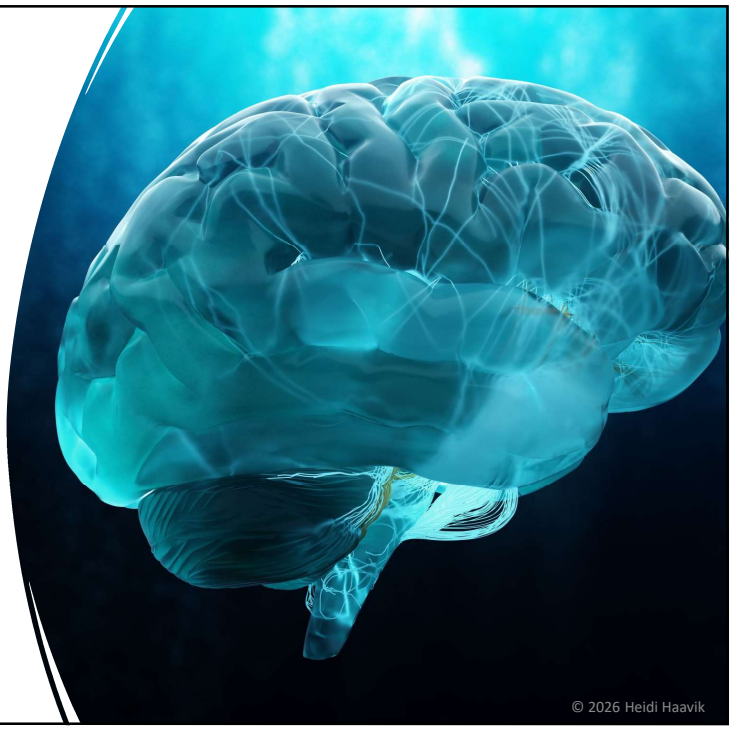
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Purpose

Understanding the move from raw signals → meaning →

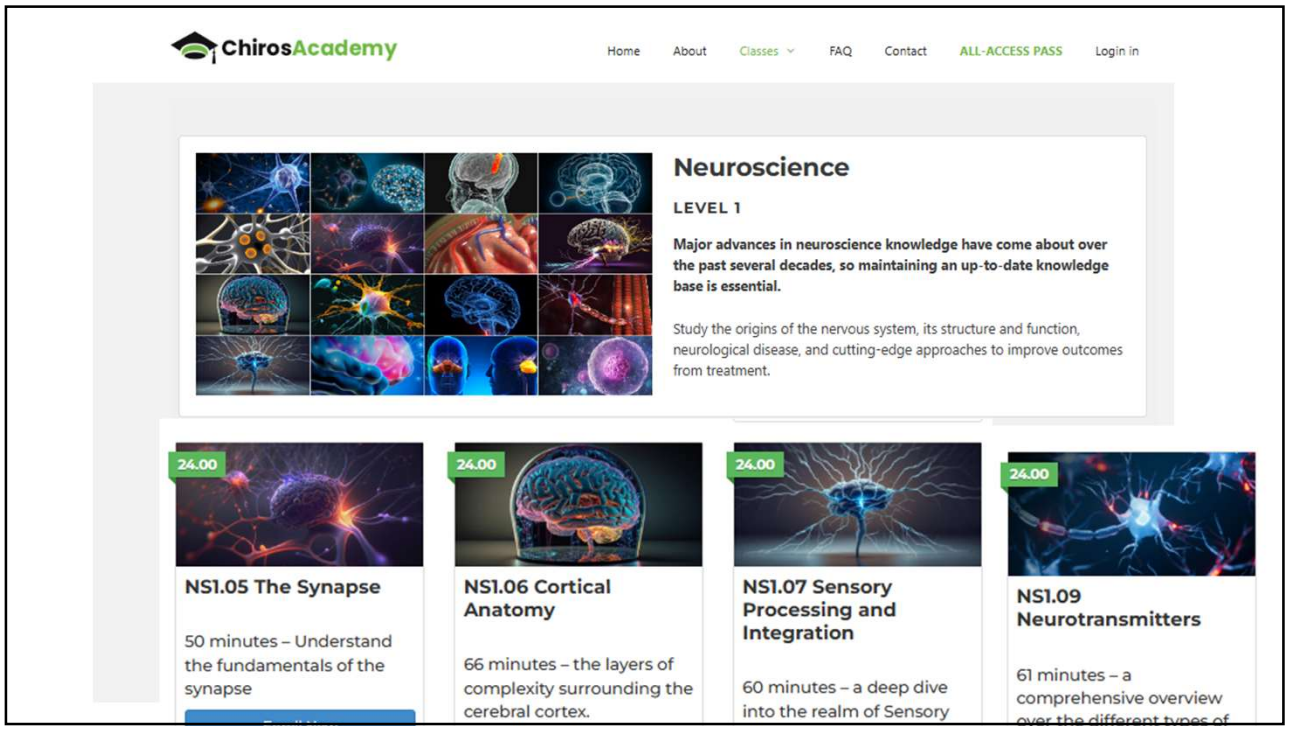
perception →

A person's reality



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Neuroscience
LEVEL 1
Major advances in neuroscience knowledge have come about over the past several decades, so maintaining an up-to-date knowledge base is essential.
Study the origins of the nervous system, its structure and function, neurological disease, and cutting-edge approaches to improve outcomes from treatment.
24.00
NS1.05 The Synapse
50 minutes – Understand the fundamentals of the synapse
24.00
NS1.06 Cortical Anatomy
66 minutes – the layers of complexity surrounding the cerebral cortex.
24.00
NS1.07 Sensory Processing and Integration
60 minutes – a deep dive into the realm of Sensory
24.00
NS1.09 Neurotransmitters
61 minutes – a comprehensive overview

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Connor Campbell
Jess Macaulay
Michael Carter
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4



Questions from you

Eric Topcu

Do you have a preference for the brain function / IQ Test you mentioned would be helpful data to collect as an outcome measure for research regarding our effect on the prefrontal cortex / executive brain function ?

I googled and came up with ICAR Framework or the Cognitive Reflection Test

5

ADEXI (Adult Executive Functioning Inventory)

Strengths

- very short
- free to use
- easy for patients
- measures everyday functioning rather than laboratory performance
- less contaminated by ADHD symptoms than many other executive questionnaires

ADULT EXECUTIVE FUNCTIONING INVENTORY (ADEXI)
SELF-REPORT VERSION

Below you will find a number of statements. Please circle a number to the right of each statement to indicate how well that statement describes how you are as a person. People that you know might feel differently about you – we want to know what <u>you</u> think about yourself. Try to respond as honestly as possible.

	Definitely not true 1	Not true 2	Partially true 3	True 4	Definitely true 5
1. I have difficulty remembering lengthy instructions	1	2	3	4	5
2. I sometimes have difficulty remembering what I am doing in the middle of an activity	1	2	3	4	5
3. I have a tendency to do things without first thinking about what could happen	1	2	3	4	5
4. I sometimes have difficulty stopping myself from doing something that I like even though someone tells me that it is not allowed.	1	2	3	4	5
5. When someone asks me to do several things, I sometimes remember only the first or last	1	2	3	4	5
6. I sometimes have difficulty refraining from smiling or laughing in situations where it is inappropriate	1	2	3	4	5
7. I have difficulty coming up with a different way of solving a problem when I get stuck	1	2	3	4	5
8. When someone asks me to fetch something, I sometimes forget what I am supposed to fetch	1	2	3	4	5
9. I have difficulty planning for an activity (e.g., remembering to bring everything necessary when going on a trip/to work/to school)	1	2	3	4	5
10. I sometimes have difficulty stopping an activity that I like (e.g., I watch TV or sit in front of the computer in the evening even though it is time to go to bed)	1	2	3	4	5
11. I sometimes have difficulty understanding verbal instructions unless I am also shown <u>how</u> to do something	1	2	3	4	5
12. I have difficulties with tasks or activities that involve several steps	1	2	3	4	5
13. I have difficulty thinking ahead or learning from experience	1	2	3	4	5
14. People that I meet sometimes seem to think that I am more lively/wilder compared to other people my age	1	2	3	4	5

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SCORING

Fill in the total score for the two factors WORKING MEMORY and INHIBITION and fill in the ADEXI total score.

= **Subscale 1: Working Memory**
Total score for items: 1, 2, 5, 7, 8, 9, 11, 12, 13

= **Subscale 2: Inhibition**
Total score for items: 3, 4, 6, 10, and 14

TOTAL SCORE

Scientific articles using the ADEXI:

Holst, Y. & Thorell, L.B. (2016). *Adult Executive Functioning Inventory (ADEXI): Validity, Reliability, and Relations to ADHD.* Manuscript under revision for publication

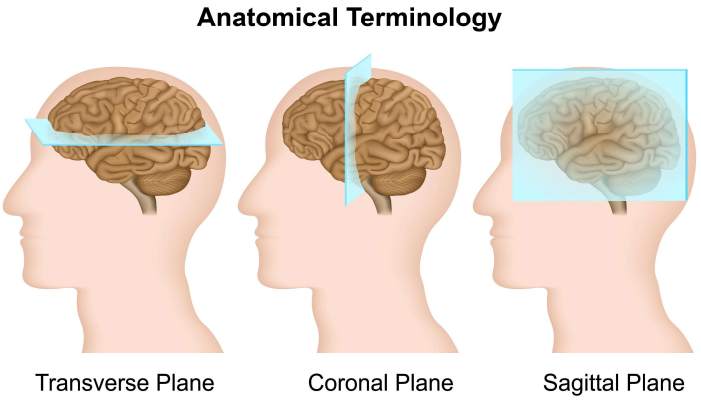
Holst, Y. & Thorell, L.B. (in press). Neuropsychological functioning in adults with ADHD and adults with other psychiatric disorders: The issue of specificity, *Journal of Attention Disorders*

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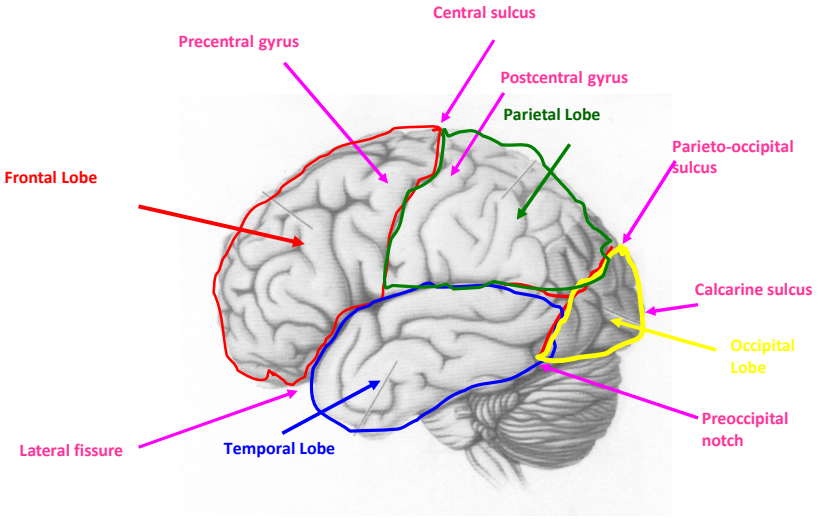
8

Cortical Anatomy Review for Chiros



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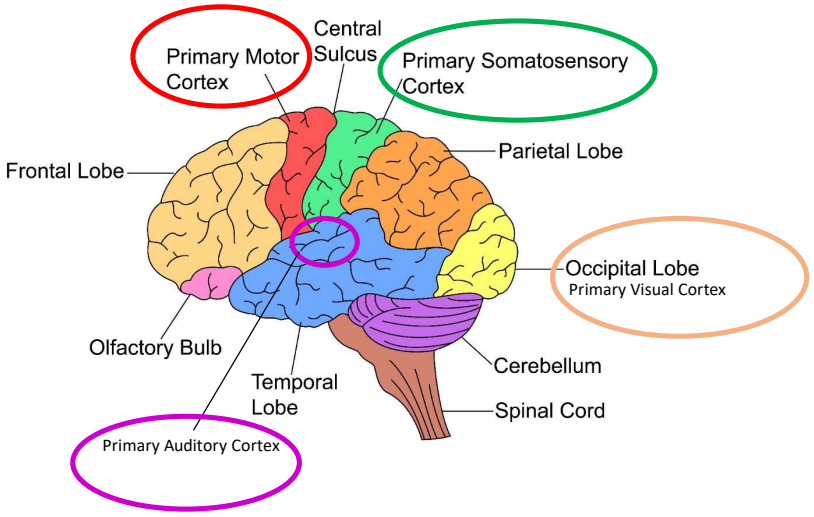
Lobes, Sulci & Gyri



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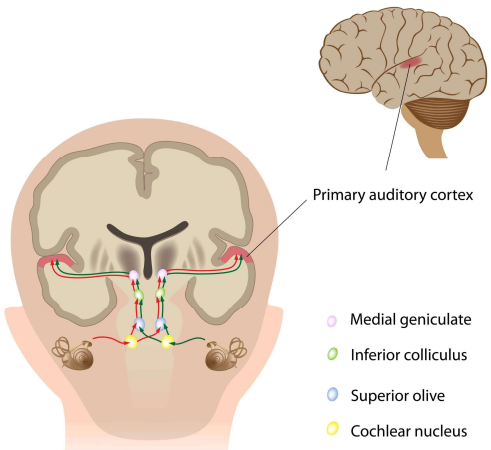
Location of the Primary Sensory (Exteroception) and Motor Cortices

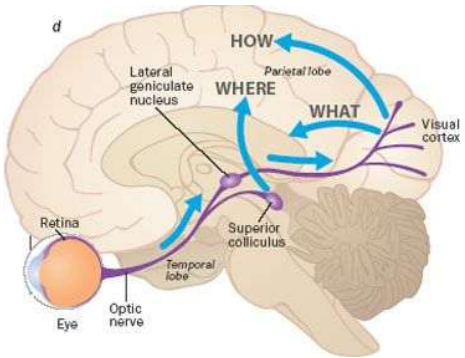


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Interpreting sound and visual information

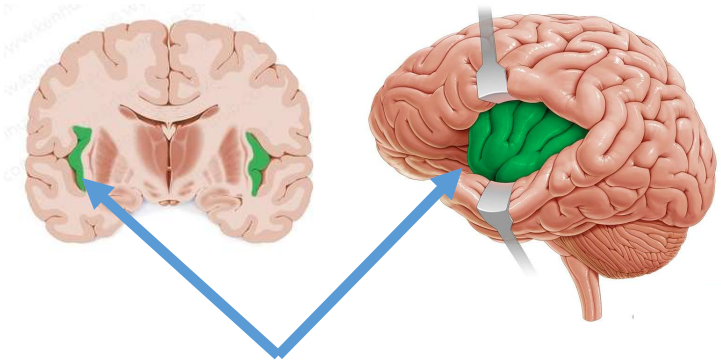




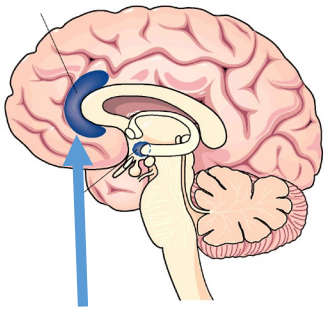
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Key Brain Areas Involved in Interoception



Insular cortex:
Monitoring Your
Internal World



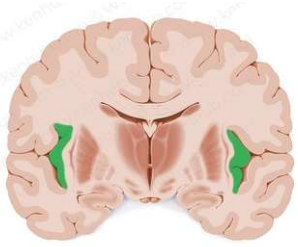
Anterior cingulate cortex:
Deciding What To Do About It

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The Insular Cortex

Critical for your brains inner body map of what is happening inside your body



"The Insular cortex integrates all affective bodily feelings, including cool, warm, pricking pain, burning pain, itch, muscle ache and C-fibre affective (sensual) touch, as well as taste, hunger, thirst, 'air hunger', bowel distension, urge to urinate and so on."

Strigo & Craig 2016

"Insular cortex in humans not only process interoceptive activity but rather integrates and modulates cardiovascular, respiratory and emotional signals to create an integrated emotional experience."

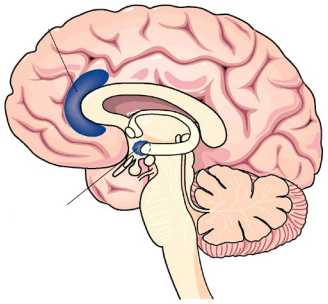
Strigo & Craig 2016

So the insula isn't just detecting signals. It's helping create your subjective experience of how your body feels.

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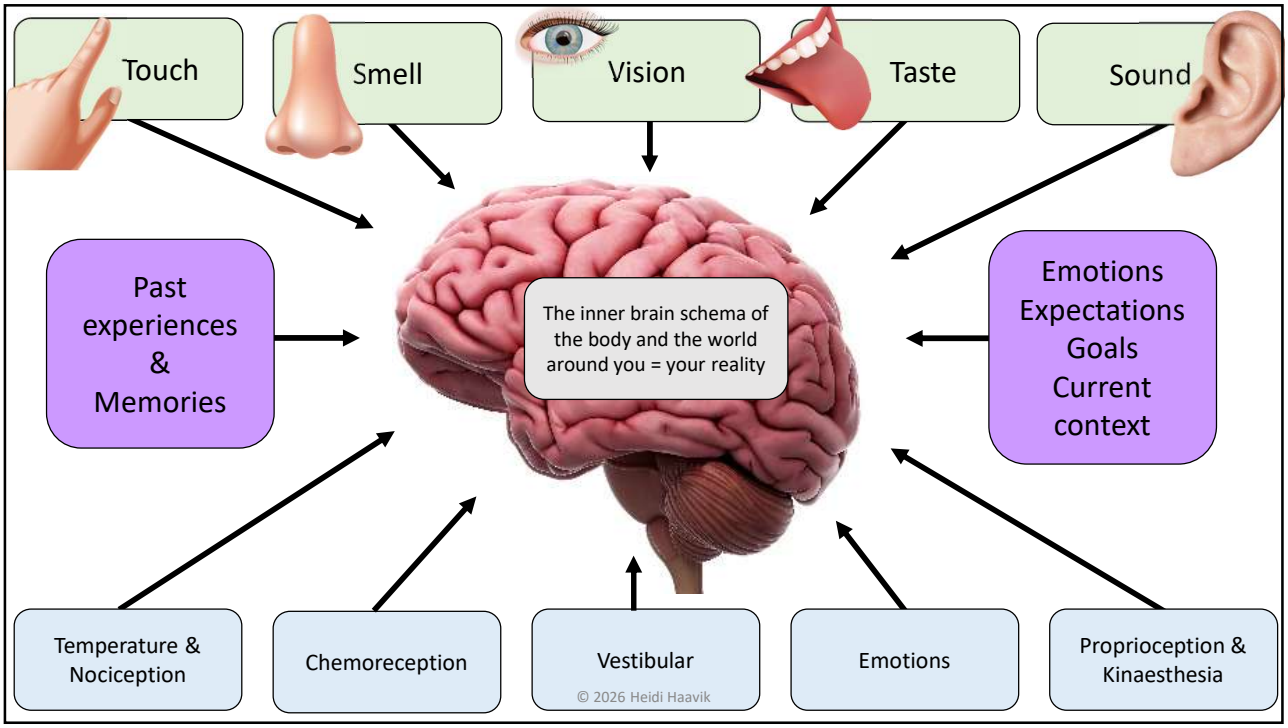
The Anterior Cingulate Cortex



- From Feeling to Action
- The ACC helps translate internal bodily information into behaviour, autonomic responses, attention and motivation.

- As chiropractors we spend a lot of time thinking about pain and movement.
- But if spinal dysfunction alters the quality of sensory information reaching the brain, which it does, then it most likely influences the brain's internal model of the body.
- And if that internal model changes, it has the potential to influence not only movement, but also attention, autonomic regulation, stress responses, emotional processing and ultimately how the brain predicts the body's physiological state.

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Multimodal Integration, Perception & Reality

Multimodal Integration

- The brain compares, weights and combines all of this information into one coherent internal model.

Perception = Your conscious experience of:

- your body
- your symptoms
- your environment
- your movement
- your emotions

Your brain doesn't simply detect reality!
It creates your experience of reality

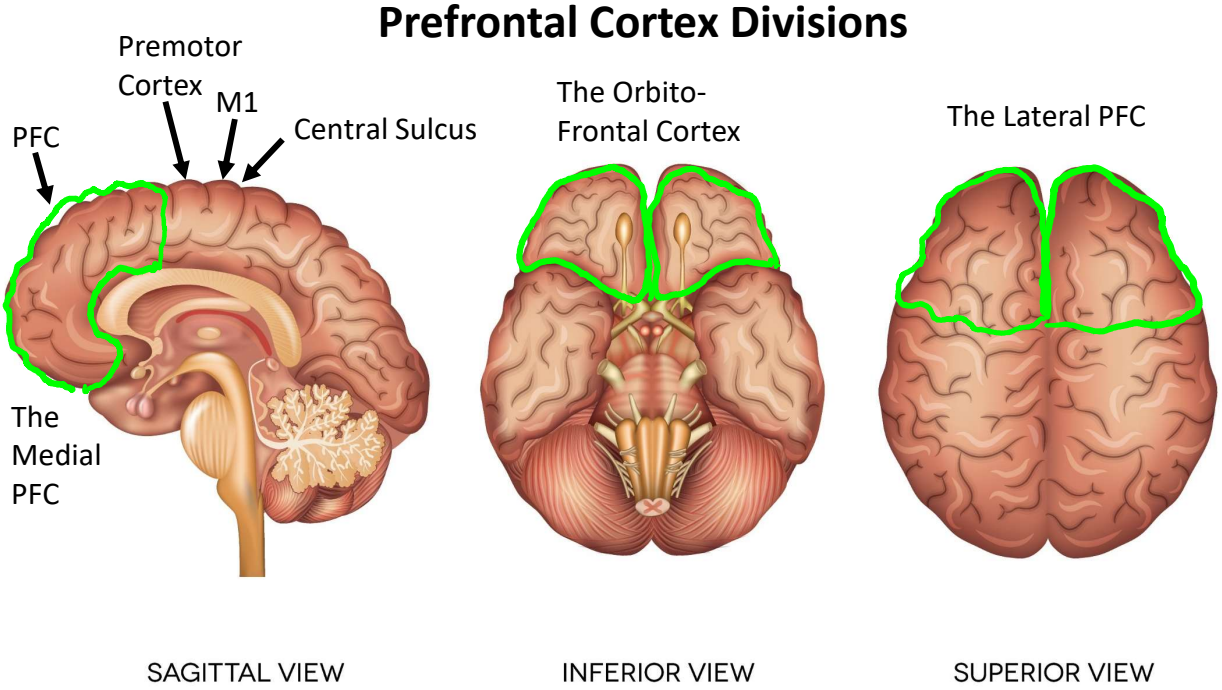
Your Reality

- The reality you experience is **your brain's best interpretation** of what is happening inside you and around you, not a direct copy of the internal & external world.

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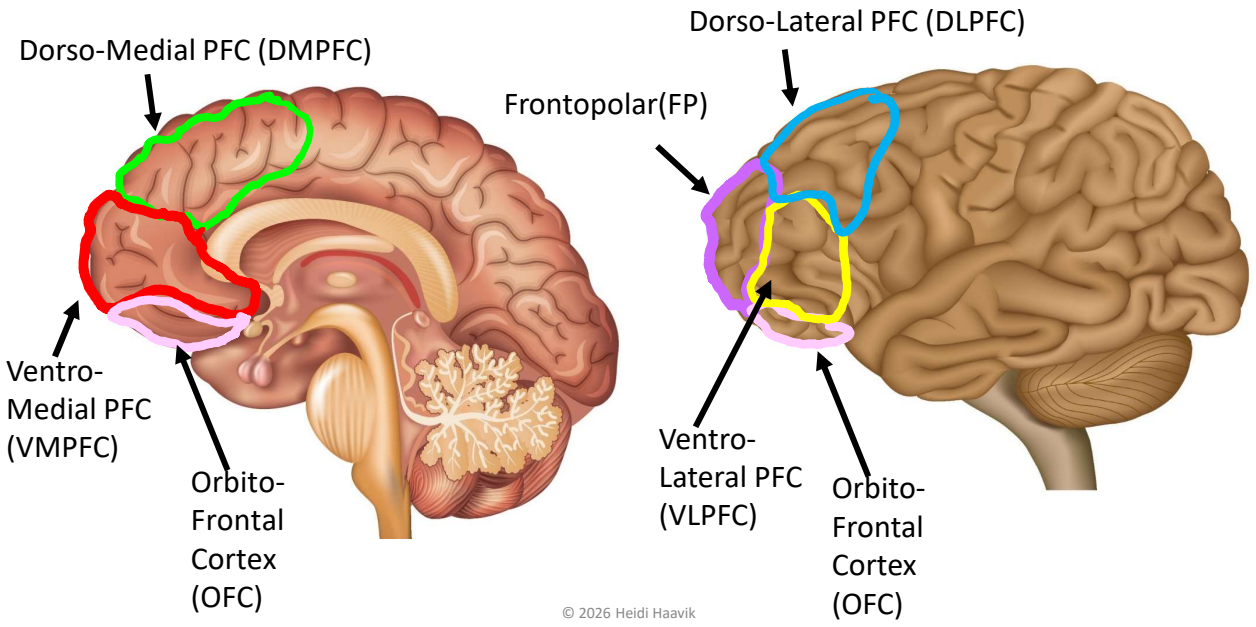
Prefrontal Cortex Divisions



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Prefrontal Cortex Six Main Regions



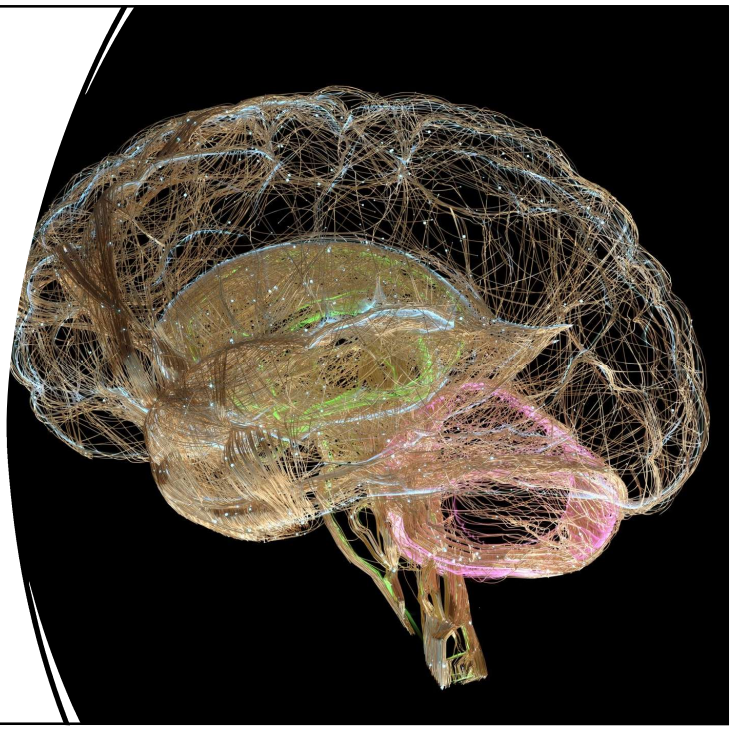
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As Chiropractors, you are not just working on structure.

You are influencing the quality of information going into the brain!

This alters the brains perception and its interpretation of reality

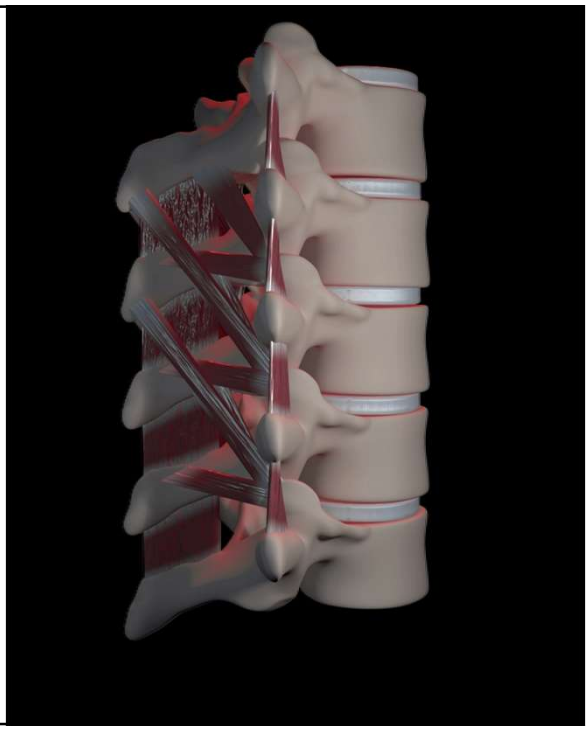


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The spine is a major sensory input system

- In the brain based model of chiropractic, the spine is not viewed simply as a mechanical structure, but as a critical sensory organ.
- The deep muscles and joints of the spine are densely packed with proprioceptive receptors that continuously inform the brain about body position, movement, and segmental spinal function.
- This incoming information is essential for the brain to maintain an accurate internal representation of the body, often referred to as the body schema, and to integrate this with information from the external environment (i.e. impacting our brains external world schema).



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VS today vs 2 years ago

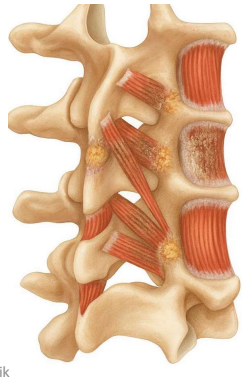
- Confused Brain
- Possibly clumsy
- Possibly feel pain



- Inaccurate inner body scheme or external world schema
- Poor body awareness
- Poor body control
- Reduced resilliance
- Probably causing microtraumas daily
- May not be retaining learnt movements

- Larger in size
- Slow-twitch fibre type
- Minimal fatty infiltration
- Move freely
- Healthy stretch receptors (muscle spindles)



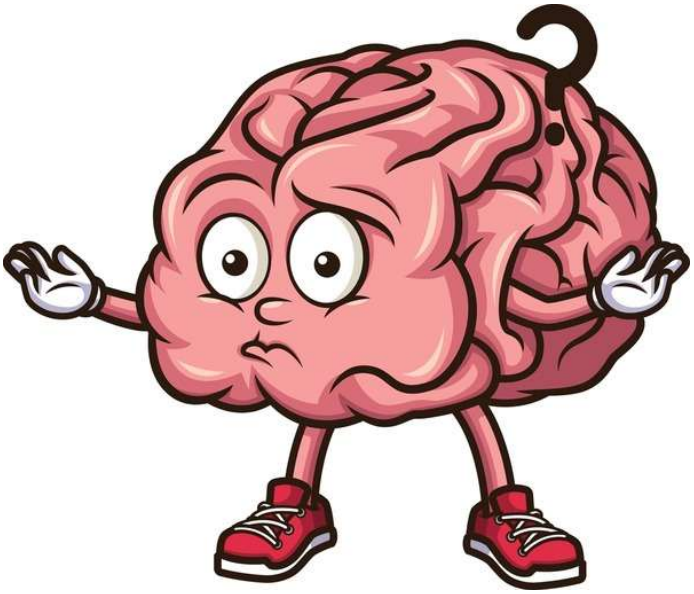


- Stiff and Fibrotic
- Atrophied (shrunk)
- Fatty infiltration
- Change fibre type
- Stretch receptors dysfunction

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A confused brain is worse than you might think!



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Rheumatology 2005;44:509–516 doi:10.1093/rheumatology/keh529
Advance Access publication 11 January 2005

Simulating sensory–motor incongruence in healthy volunteers: implications for a cortical model of pain

C. S. McCabe, R. C. Haigh[1], P. W. Halligan[2] and D. R. Blake

Objectives. Conflict between motor–sensory central nervous processing has been suggested as one cause of pain in those conditions where a demonstrable or local nociceptive aetiology cannot be convincingly established (e.g. complex regional pain syndrome type 1, repetitive strain injury, phantom limb pain and focal hand dystonia). The purpose of this study was to discover whether pain could be induced in pain-free healthy volunteers when this conflict was generated transiently in a laboratory setting.

Methods. Forty-one consecutively recruited healthy adult volunteers without a history of motor or proprioceptive disorders performed a series of bilateral upper and lower limb movements whilst viewing a mirror/whiteboard, which created varied degrees of sensory–motor conflict during congruent/incongruent limb movements. A qualitative method recorded any changes in sensory experience.

Results. Twenty-seven subjects (66%) reported at least one anomalous sensory symptom at some stage in the protocol despite no peripheral nociceptive input. The most frequent symptoms occurred when incongruent movement was performed whilst viewing the reflected limb in the mirror condition, the time of maximum sensory–motor conflict. Symptoms of pain were described as numbness, pins and needles, moderate aching and/or a definite pain. Other sensations included perceived changes in temperature, limb weight, altered body image and disorientation. There were indications that some individuals were more susceptible to symptom generation than others.

Conclusions. Our findings support the hypothesis that motor–sensory conflict can induce pain and sensory disturbances in some normal individuals. We propose that prolonged sensory–motor conflict may induce long-term symptoms in some vulnerable subjects.

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(McCabe et al 2005)

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66% reported at least one of the following symptoms:

- Numbness
- Pins and needles
- Change in temperature
- Change in limb weight
- Body image distortion
- Moderate aching
- Definite pain

(McCabe et al 2005)

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The Adjustment

- A **specific sensory input**
  - it drives action potentials
  - it changes membrane activity
  - it alters firing patterns
  - it engages regulatory systems (e.g. glia, networks)



- You are changing how the system fires, not just where the joint sits.

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"The brain-based model of chiropractic care proposes that chiropractic adjustments work by stretching specific dysfunctional spinal tissues, triggering a powerful proprioceptive signal to the brain that can recalibrate neural processing and improve overall function."

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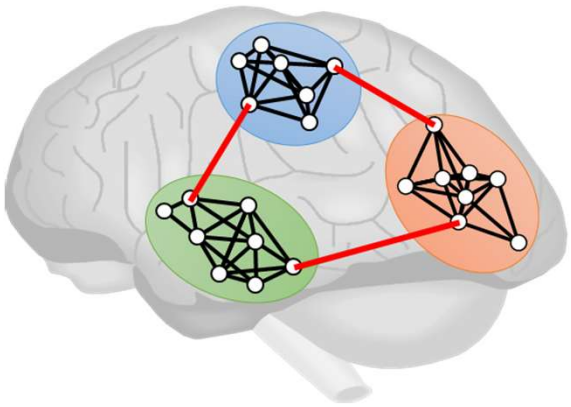
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Biological Networks in the Brain (and Hubs)

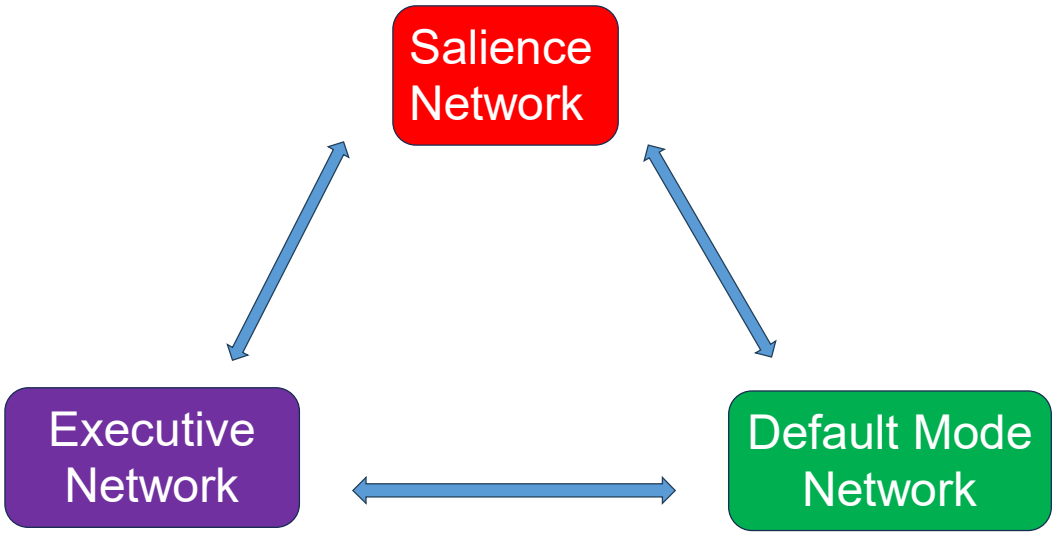
- A biological neural network in the brain is a complex network of neurons that are chemically connected by synapses.
- Neurons send and receive electrochemical signals to each other, and the brain uses these signals to process information.



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Triple Brain Network

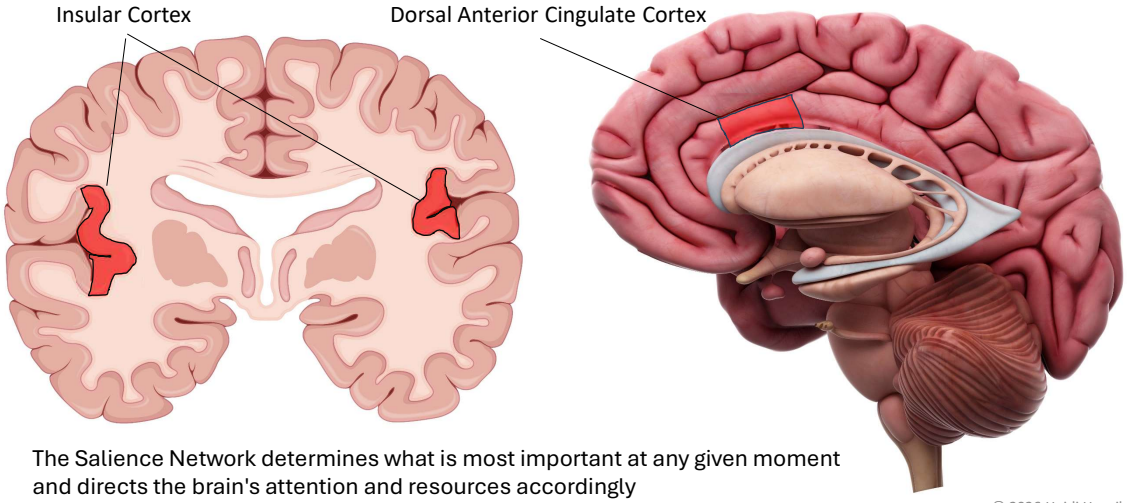


(De Ridder et al. 2022)

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Salience Network



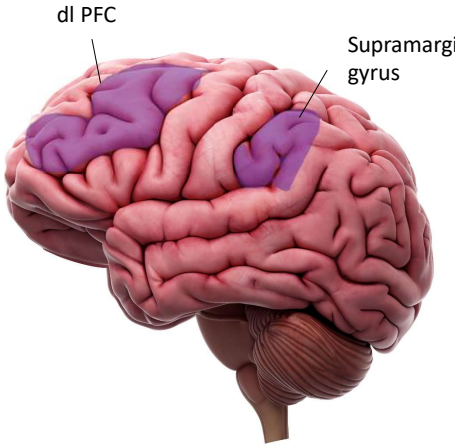
The Salience Network determines what is most important at any given moment and directs the brain's attention and resources accordingly

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Central Executive (Fronto-parietal) Network

- It is Goal and Task oriented
- When you are actively engaged in a task
- Actively paying attention (and <u>not</u> judging)
- Capable of recruiting a wide variety of brain systems
- Multiple CE / FP networks
- Key Regions
  - Dorsolateral PFC
  - Posterior parietal cortex (supramarginal gyrus)



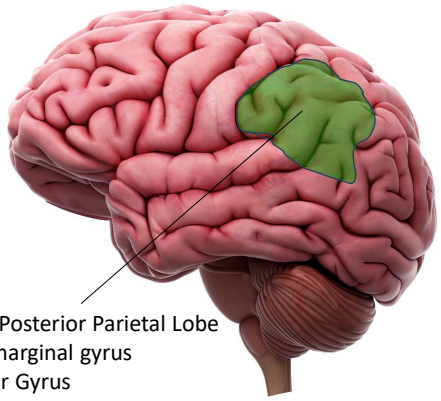
(Witt, van Ettinger-Veenstra et al. 2021; Menon and D'Esposito 2022; Menon and D'Esposito 2022)

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Default Mode Network

Integrates information from multiple senses to create the brain's internal representation of the body and guide how we interact with the world



Inferior Posterior Parietal Lobe
- Supramarginal gyrus
- Angular Gyrus

(Dumas et al 2014)

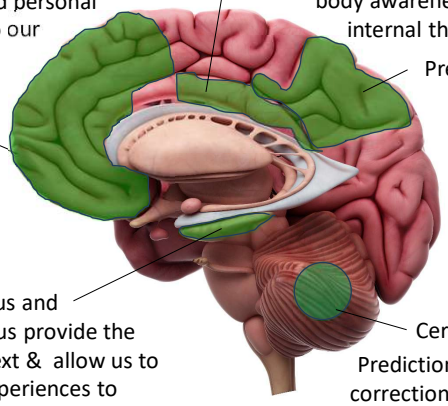
Integrates memories, emotions and personal meaning into our sense of self.

PCC

Constructing sense of self by integrating memories, body awareness and internal thoughts

Precuneus

Medial PFC



The hippocampus and parahippocampus provide the brain with context & allow us to draw on past experiences to make sense of the present and to imagine possible futures.

Cerebellum

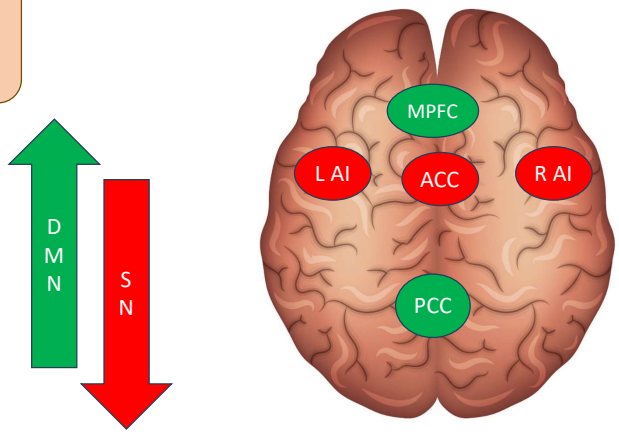
Prediction & Error correction, SMI and Internal models

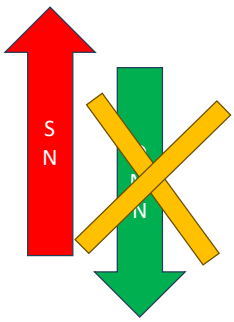
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‘Normal’ ‘Healthy’ Conditions

NOTE this changes in chronic problems!!





Mind wandering

Safety

Threat

Paying attention to threat

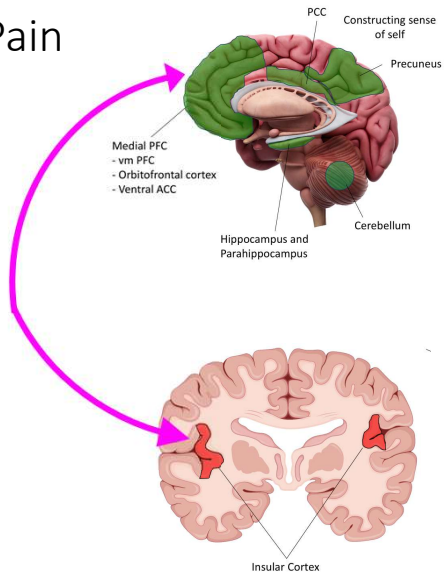
(Adapted from Johansson et al 2023)

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Increased connectivity in Chronic Pain

- The default mode network, which controls self-representational processing has been suggested to become pathologically coupled to pain provoking networks in chronic pain.
- The longer the pain exists, the stronger the connections between the insular cortex and the medial prefrontal cortex.



(De Ridder et al. 2022; Baliki et al 2014)

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Changes in Salience network in Chronic Pain

- ↑ Salience Network activity in chronic pain
- ACC and anterior insula amplify pain unpleasantness and catastrophising
- ↑ Anterior insula–DMN connectivity correlates with catastrophising
- Chronic suffering → emotional distress, disability, anxiety, and depression
- Anxiety: SN (amygdala)–DMN (dmPFC)
- Depression: ACC (Salience Network)

Pain catastrophising

- Magnification of threat value of pain stimulus
- Sense of helplessness
- Rumination on pain thoughts and
- embodiment of pain

(van Ettinger-Veenstra, Lundberg et al. 2019; Kim, Mawla et al. 2019; De Ridder et al 2022)

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Changes in Default Mode Network with Chronic Pain

- Not deactivating under threat or pain stimuli
- Hyper connectivity anterior insular cortex (Salience Network) - *medial PFC (DMN & SN)*
  - Degree of hyperconnectivity correlates with:
    - duration of pain
    - pain catastrophizing
    - Pain ruminating
  - This hyperconnectivity also occurs in Depression and Anxiety - common mechanisms
- Chronic LBP patients have hyperconnectivity between
  - S1 – SN
  - S1 – DMN (The longer pain exists the stronger the connection)
  - S1 - CEN
- *DMN changes explain why pain becomes embodied (part of self) and maintained after injury heals!!!*

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(Kuner & Flor 2017; Baliki et al 2015; Weiss 2016; De Ridder et al 2022; Jiang, Y., et al. 2016; Johansson et al. 2023; Brandl et al 2022; Kim et al. 2019)

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Changes in FPN / CEN in Chronic Pain

Normal role
- Executive function
- Working memory
- Attention and cognitive control
- Decision making
- Top-down regulation of thoughts and behaviour

Changes in chronic pain
- Reduced executive function and cognitive flexibility
- Impaired attention and working memory ("brain fog")
- Altered connectivity within the CEN
- Increased coupling between the CEN and DMN
- Reduced segregation between the CEN and Salience Network (SN)

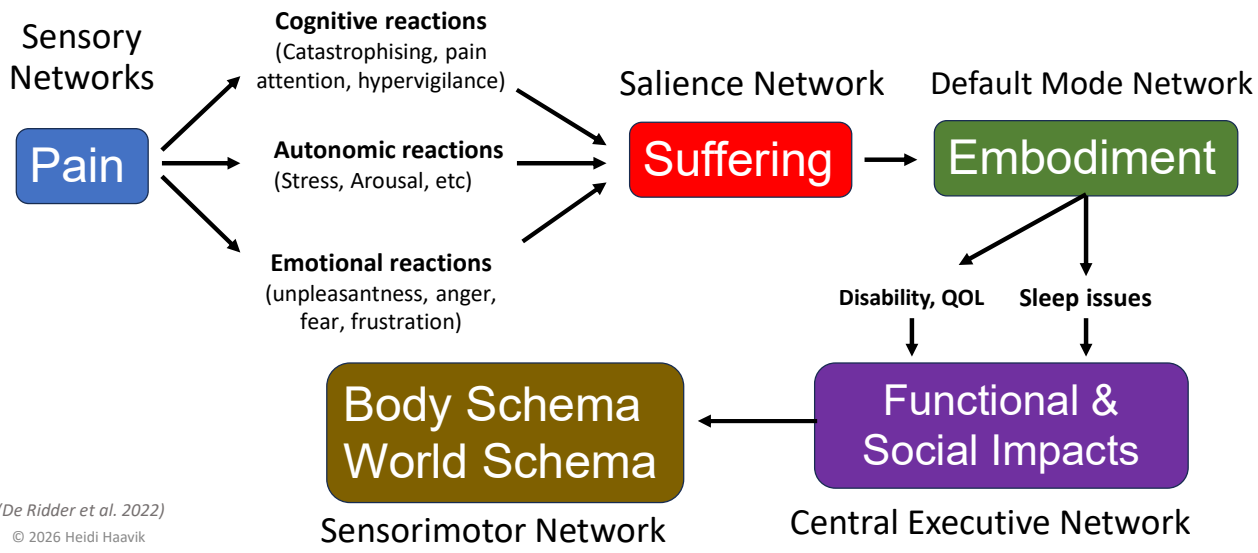
Clinical consequences
- Difficulty shifting attention away from pain
- Reduced cognitive performance
- Increased rumination and pain-related thinking
- Poorer emotional regulation and decision making
- Greater pain-related disability

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(Jiang et al 2016; De Ridder et al 2022)

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The Chronicity of Pain, Mood & Neurological Disorders



(De Ridder et al. 2022)

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Why might these changes occur?



Sympathetic system activation increases energy consumption by **15–35%**

Acute pain increases the daily energy expenditure by **60%**

Acute Fear increases the daily energy expenditure by **22%**

Chronic pain increases the daily energy expenditure by **15%**

Chronic Anxiety increases the daily energy expenditure by **6%**

"Energy expenditure could be reduced by rewiring the pain pathways to connect to the default mode network, which overlaps with the parasympathetic central network and disconnect from the energy consuming sympathetic nervous system."

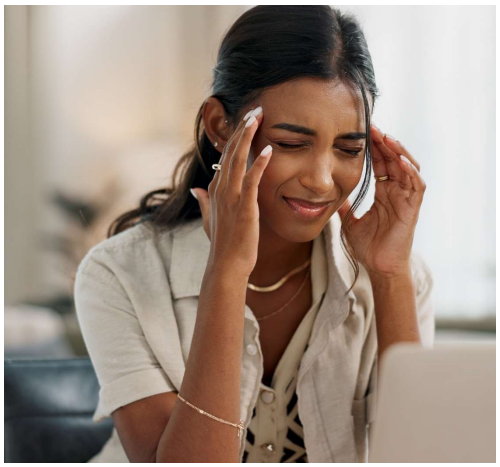
(De Ridder et al. 2022)

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Why Pain Becomes Chronic

- "The relevance of this finding is enormous, since it could provide a neurobiological explanation for why in chronic pain becomes embodied, that is, becomes an integral part of the self, making treatments more difficult."
- "When the suffering is chronic, not only may the pain become a part one's identity, but fear can develop into worry/anxiety and the sadness into depression."



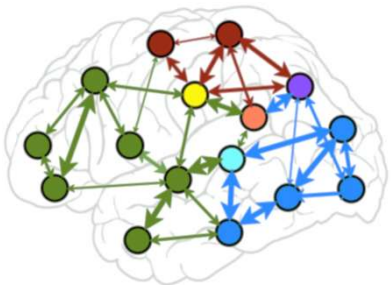
(De Ridder et al. 2022)

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Characterising brain network activity changes following chiropractic care using whole head electroencephalography (EEG)
4 week RCT in people with chronic LBP







- As seen on Russell Brand show



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UK Study Results

Control Group

NO significant changes at all

Chiropractic Group

- Improved QOL overall
- Improved Physical function
- Less Depression
- Less anxiety
- Less Fatigue
- Less pain interference
- Less pain intensity

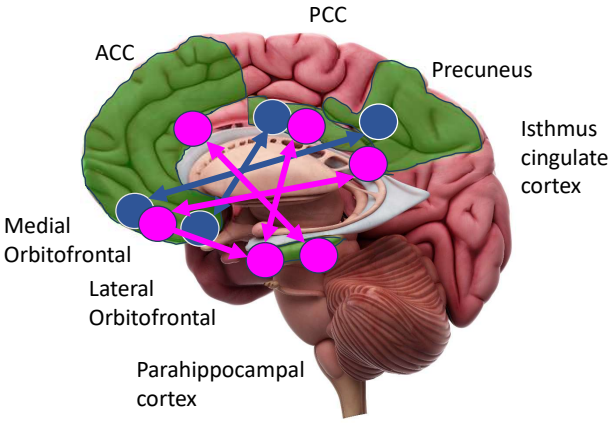


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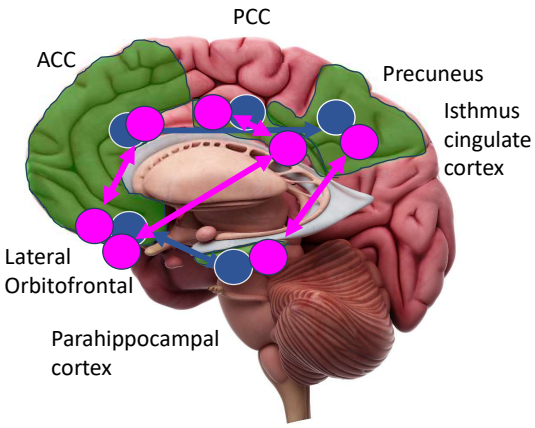
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Default Mode Network Changes with Chiro

Pre and Post Chiro



Pre and Post 4 weeks Chiro



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Unmedicated depressed people have significantly increased functional connectivity between the Precuneus and the prefrontal cortex

Increased functional connectivity of the posterior cingulate cortex with the lateral orbitofrontal cortex in depression (Cheng, Rolls et al. 2018B)



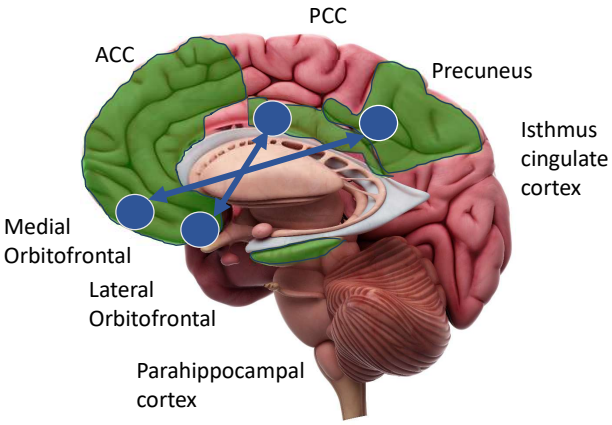
"The increased connectivity of the precuneus and/or PCC with the prefrontal cortex short-term memory system may contribute to the rumination about low self-esteem in depression."

(Cheng, et al 2018A; Cheng, Rolls et al. 2018B*)*

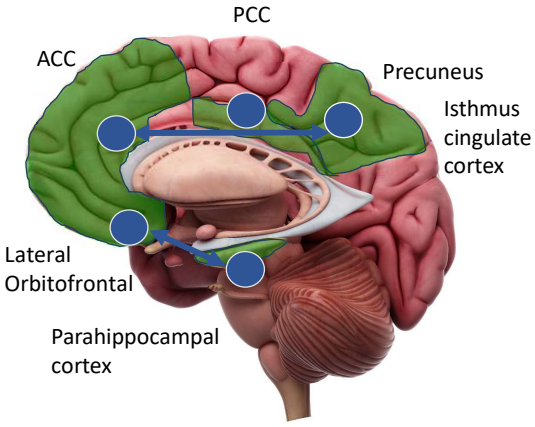
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Pre and Post Chiro



Pre and Post 4 weeks Chiro



DMN changes after Chiro Care

(Haavik et al 2024, Brain Sciences)

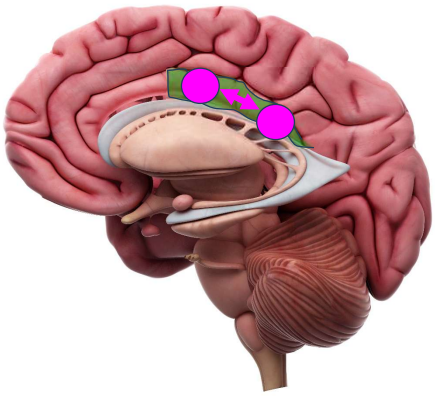
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In depression there is asymmetry in the thickness of Posterior Cingulate Cortex

- PCC deals with internally focused, self-referential processing
- I.e. Construction of the narrative sense of self, including autobiographical memories
- Implicated in depression: ↑ cortical thickness in left vs right PCC
- Depressed individuals with higher somatic symptoms (e.g. sleep disturbance, appetite disturbance, and fatigue or loss of energy) have greater asymmetry in **PCC** thickness

(Dotson et al. 2021; van Eijndhoven et al. 2013)



SEPs Alpha ↑ L isthmus-cingulate- R PCC

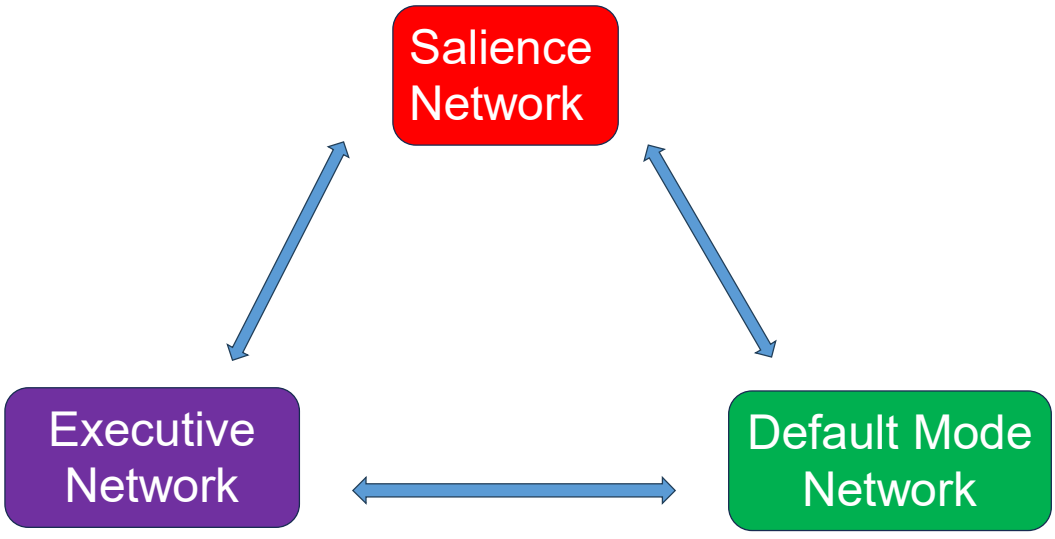
"Thus, this change may reflect altered narrative sense of self in a manner that is reducing symptoms of depression and improvements in fatigue"

(Haavik et al 2024, Brain Sciences)

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Triple Brain Network

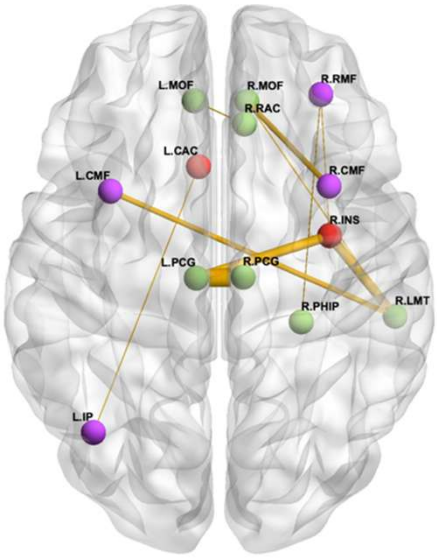


(De Ridder et al. 2022)

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After first Adjustment session Chiro Group



Preliminary Results NOT published yet

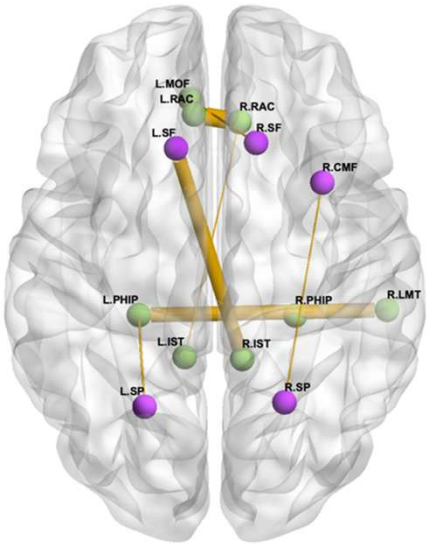
Alpha

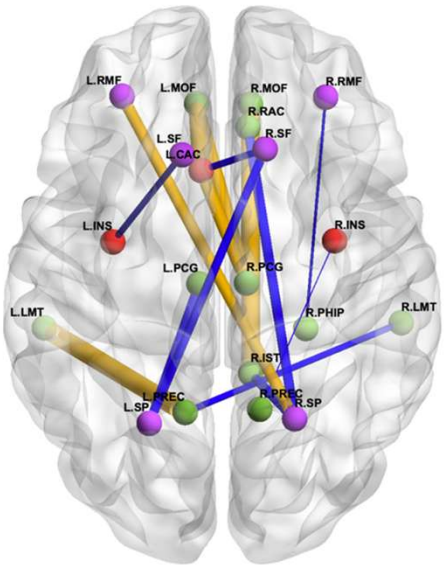
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Preliminary Results NOT published yet

After 4 weeks Chiro Group Brain changes



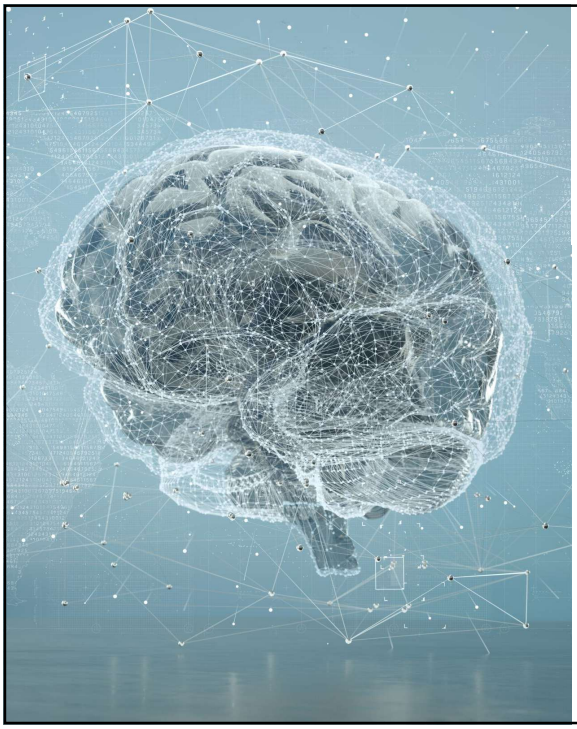


Alpha

Beta

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Heidi's Hypothesis

- Adjustments engage the Salience Network, prompting the brain to re-evaluate what is happening both inside the body and in the external environment
- Brain 'resets' its interpretation of what is happening inside and outside it
- This updated interpretation may influence both the Default Mode Network (how we perceive ourselves) and the Central Executive Network (how we think, plan and interact with the world)
- If the brain updates its internal model, many downstream functions have the potential to change, Including:
  - how we feel (our perception of the body, symptoms and pain)
  - how we think (attention, cognitive flexibility and decision making)
  - how we regulate ourselves (autonomic function and stress responses)
  - how we move (motor control and behaviour)
  - what we prioritise (motivation and goal-directed behaviour)

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I bet most of you have a spine model in your practice!



Do you have a brain model in your practice?



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Homework to complete before the live session

ChriosAcademy Classes:

- **NS1.08 Neural Plasticity**
- **NS1.10 The Prefrontal Cortex**
- **NS1.25 The Cerebellum**

Readings:

- De Ridder, D., Adhia, D. and Vanneste, S., 2021. The anatomy of pain and suffering in the brain and its clinical implications. *Neuroscience & Biobehavioral Reviews*, *130*, pp.125-146.
  - https://www.sciencedirect.com/science/article/pii/S0149763421003560
- De Ridder, D., Vanneste, S., Smith, M. and Adhia, D., 2022. Pain and the triple network model. *Frontiers in neurology*, *13*, p.757241.
  - https://www.frontiersin.org/journals/neurology/articles/10.3389/fneur.2022.757241/full?utm_source=Email_to_rerev_&utm_medium=Email&utm_content=T1_11.5e4_reviewer&utm_campaign=Email_publication&journalName=Frontiers_in_Neurology&id=757241
- Haavik, H., Niazi, I.K., Amjad, I., Kumari, N., Ghani, U., Ashfaque, M., Rashid, U., Navid, M.S., Kamavuako, E.N., Pujari, A.N. and Holt, K., 2024. Neuroplastic responses to chiropractic care: broad impacts on pain, mood, sleep, and quality of life. *Brain sciences*, *14*(11), p.1124.
  - https://www.mdpi.com/2076-3425/14/11/1124

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Questions



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