# Decoding Meditation Mechanisms underlying Brain Preservation and Psychological Outcomes in Older Expert Meditators

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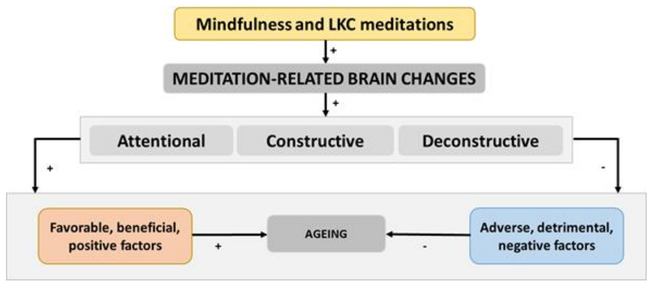
## Introduction & Objective

**Background:** Meditation is a mental training approach expected to improve mental health and well-being in ageing[1]. The rare previous studies reported both structural and functional brain preservation in older expert meditators compared to controls[2], and meditation is also associated to better psychological outcomes[2]. However, the mechanisms underlying these effects remain unknown. The Medit-Ageing model proposes that meditation, in ageing, operates through attentional, constructive and deconstructive mechanisms upregulating positive psychological outcomes and downregulating negative ones[3].

**Figure 1: Adapted Medit-Ageing Model**




**We aim at testing this model in investigating whether and which meditation mechanism mediate the relationships between the brain and psychological changes in older expert meditators.**

## Participants & Methods

AGE-WELL — **Older expert meditators**

AGE-WELL — **Cognitively unimpaired older adults**

**Table 1: Demographics**

| Characteristics | Older controls | Older expert meditators | p-value |
|---|---|---|---|
| **Sample size** | 135 | 25 | - |
| **Age** | 69.302 ± 3.8 | 70.297 ± 4.53 | 0.31 |
| **Education** | 13.15 ± 3.09 | 15.16 ± 3.46 | **0.01** |
| **Sex** | 52/83 (61/39) | 16/9 (64/36) | **0.03** |
| **MMSE** | 29.04 ± 1.03 | 28.92 ± 1.04 | 0.61 |
| **Formal practice (hours)** | n.a | 32501 ± 31121 (10184 - 164250) | |
| **Retreat practice (hours)** | n.a | 16366 ± 32262 (1461 - 164250) | |

**All participants underwent neuroimaging exams and filled self-reported questionnaires.**

**Multimodal neuroimaging**

**Structural MRI – Grey Matter Volume**
(n=135)
T1-Weighted scan (Segmented & normalized to the MNI template)

**Early-AV45 PET – Perfusion**
(n=133)
0-6min scan post-injection

**Psychological outcomes**

➢ **Positive psychological outcome:**
A composite score reflecting positive schemes by averaging standardized scales such as compassion or well-being.

➢ **Negative psychological outcome:**
A composite score reflecting negative schemes by averaging standardized scales such as anxiety of depressive feelings.

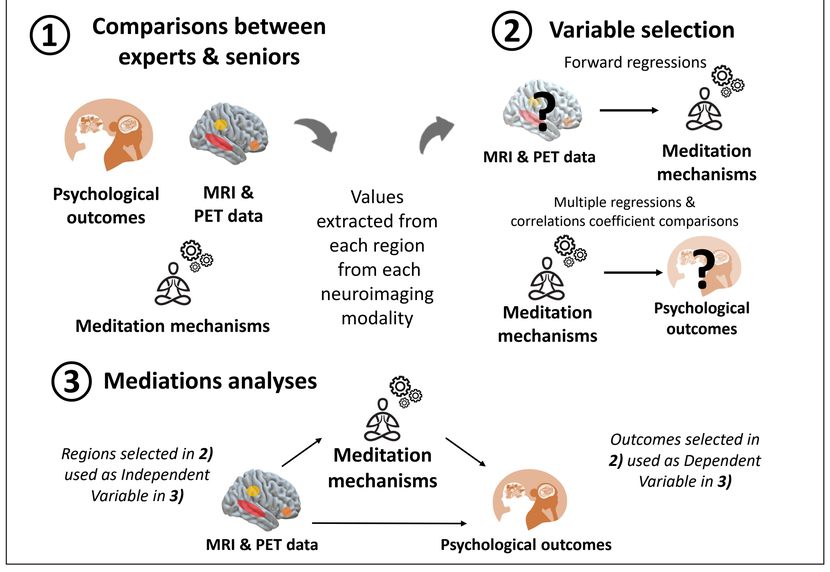
**Meditation mechanisms[4]**

➢ **Attentional mechanism:**
A composite score reflecting capacities to **initiate, direct and sustain attention.**

➢ **Constructive mechanism:**
A composite score thought to reflect skills in **nurturing positive feelings** through **reappraisal.**

➢ **Deconstructive mechanism:**
A composite score reflecting skills in **self-inquiry** to investigate the **dynamics of conscious experience** to **deconstruct maladaptive self-schemas**.

**Statistical analyses** *(corrected for age, sex and education)*

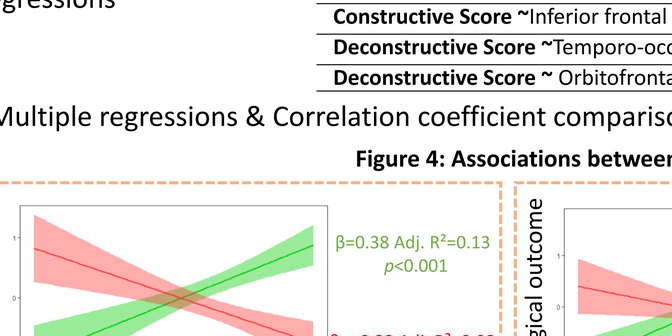



## Results

### ① Comparisons between meditators & controls

➢Whole brain voxel wise

**Figure 2: Comparisons of GMV and perfusion between meditators and controls**




*P<0.005 (uncorrected, k>230 for MRI and k>650 for PET)*

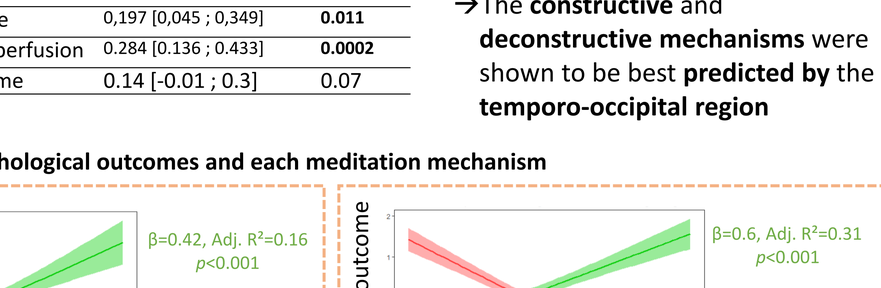
**Brain corticies for volume:**
1.Inferior frontal
2.Orbitofrontal
3.Posterior cingulate

**Brain regions for perfusion:**
4.Temporal region
5.Temporo-occipital
6.Temporo-occipito-parietal
7.Temporo-parietal

**Meditators** compared to **controls** presented:
**- Greater grey matter volume** in the **inferior frontal gyrus**, **orbitofrontal cortex** and **posterior cingulate cortex**
**- Greater perfusion** in **temporo-occipito-parietal** regions

➢Psychological outcomes

**Figure 3: Comparisons of the psychological outcomes between meditators and controls**




**Meditators** compared to **controls** presented:
**- Greater positive psychological outcome** & **Reduced negative psychological outcome**

**Table 2: Comparisons of the mechanisms**

| Meditation mechanisms | F | *p* |
|---|---|---|
| **Attentional** | 28.16 | **$3.85^{e-07}$** |
| **Constructive** | 22.85 | **$4.04^{e-06}$** |
| **Deconstructive** | 37.69 | **$6.66^{e-09}$** |

The **attentional**, **constructive** and **deconstructive** scores were found to be **greater** in older expert **meditators** than in meditation-naive **controls.**

### ② Variable selection

➢Forward stepwise regressions

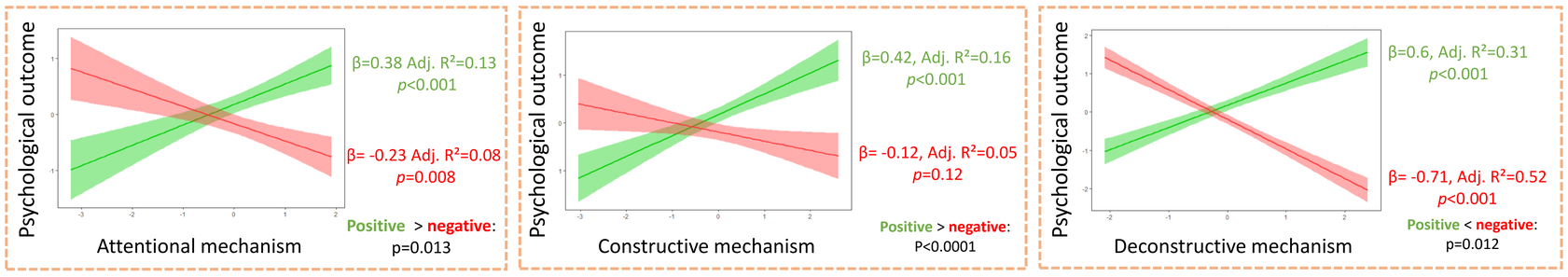
**Table 3: Selection of the best predicting region of each meditation mechanism**

| Meditation mechanisms | Coefficient [95% CI] | *p*-value |
|---|---|---|
| **Attentional Score ~**Temporo-parietal perfusion | 0.3 [0.146 ; 0.455] | **0.0002** |
| **Constructive Score ~**Temporo-occipital perfusion | 0.175 [0.021 ; 0.329] | **0.026** |
| **Constructive Score ~**Inferior frontal volume | 0,197 [0,045 ; 0,349] | **0.011** |
| **Deconstructive Score ~**Temporo-occipital perfusion | 0.284 [0.136 ; 0.433] | **0.0002** |
| **Deconstructive Score ~** Orbitofrontal volume | 0.14 [-0.01 ; 0.3] | 0.07 |

→The **attentional mechanism** was found to be best **predicted by** the **temporo-parietal region**
→The **constructive** and **deconstructive mechanisms** were shown to be best **predicted by** the **temporo-occipital region**

➢Multiple regressions & Correlation coefficient comparisons

**Figure 4: Associations between psychological outcomes and each meditation mechanism**




→The **attentional** and **constructive mechanism** were found to predominantly **predict** the **positive psychological outcome**

→The **deconstructive mechanism** was shown to best **predict** the **negative psychological outcome**

### ③ Mediations analyses

**Table 3: Detailed statistics of the mediation models**

| | ADE | | | ACME | | |
|---|---|---|---|---|---|---|
| | Estimate | 95% CI | *p* Value | Estimate | 95% CI | *p* Value |
| **model 1** | 0.17 | [0.02 ; 0.32] | **0.03** | 0.11 | [0.03 ; 0.21] | **$<2.6^{E-16}$** |
| **model 2** | 0.05 | [-0.09 ; 0.18] | 0.42 | 0.08 | [0.01 ; 0.15] | **0.02** |
| **model 3** | 0.22 | [0.06 ; 0.36] | **0.006** | 0.07 | [0.001 ; 0.13] | **0.048** |
| **model 4** | -0.07 | [-0.18 ; 0.07] | 0.31 | -0.2 | [-0.31 ; -0.08] | **$<2.6^{E-16}$** |
| **model 5** | 0.09 | [-0.12 ; 0.9] | 0.77 | -0.12 | [-0.27 ; 0.01] | 0.08 |
| **model 6** | 0.03 | [-0.12 ; 0.11] | 0.98 | -0.13 | [-0.25 ; 0.01] | 0.034 |

→ The **attentional mechanism** was shown to **mediate** the **relationship** between **temporo-parietal perfusion** and **positive psychological outcome**
→The **constructive mechanism** was found to **mediate** the **relationship** between **temporo-occipital perfusion/inferior frontal volume** and **positive psychological outcome**
→The **deconstructive mechanism** was shown to **mediate** the **relationship** between **temporo-occipital perfusion/orbitofrontal volume** and **negative psychological outcome**

Following step 2, both dependant and independent variables were selected so that **6 mediation models were tested** and **5 were significant**

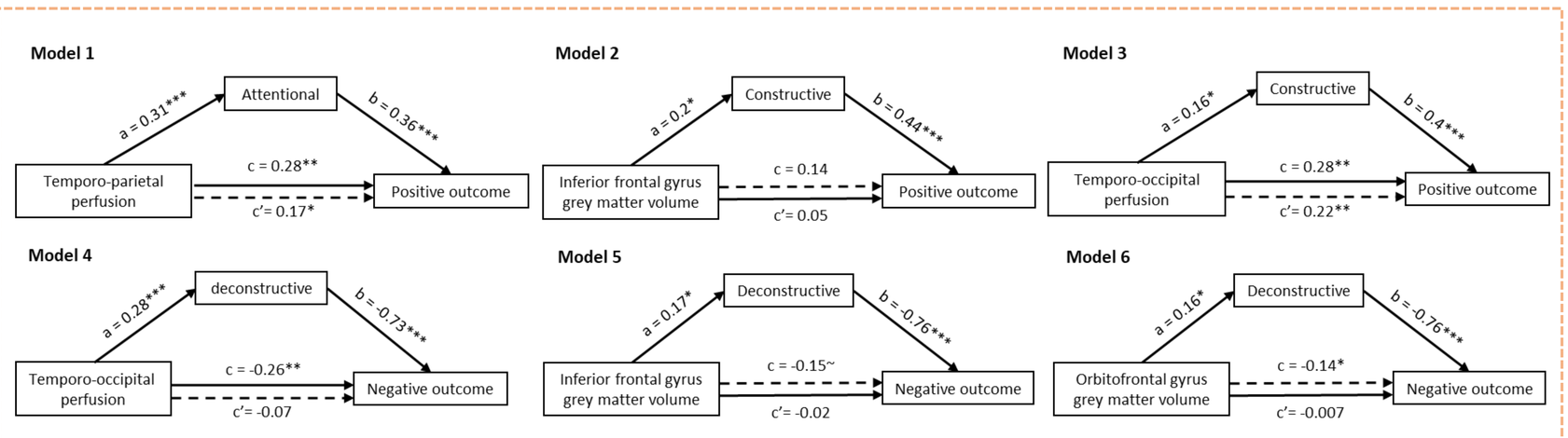



**Figure 5: Mediations analyses of the associations between brain integrity and psychological outcomes**

## Conclusion

Our findings **support the Medit-Ageing model**, showing that, in ageing, i) **meditation** operates through a **dual process**: **downregulating negative psychological schemes** and **upregulating positive ones**; and ii) these processes are **related to brain changes** and **mediated by partly specific mechanisms** : deconstructive mechanism for the former versus attentional and constructive mechanisms for the latter. We found this **specificity** to be **only relative** though, suggesting that these **mechanisms** are **entangled** and **interact** to concomitantly **act on both negative and positive outcomes**. These findings shed light on the potential neurobiological and psychological mechanisms underlying the benefits of meditation in ageing population, providing insights to refine meditation interventions for better development of active components.

**References:**
[1] Tang *et al.*, 2015.
[2] Klimecki *et al.*, 2019.
[3] Lutz *et al.*, 2021
[4] *Schlosser et al., 2022*

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