

# Supplementary Material

## **Alpha Power and Functional Connectivity in Cognitive Decline: A Systematic Review and Meta-Analysis**

### **Supplementary Material 1: Studies Excluded due to Overlapping Samples**

To avoid biasing our results, we only included studies that were, to the best of our knowledge, based on independent samples. When several studies were based on completely or partially overlapping samples, we only included the most recent publication, the publication with the largest sample size, and/or the most prototypical study. Moreover, we prioritized publications with available means and standard deviations to maximize the amount of studies we could include in meta-analyses. When there was reason to believe several publications came from the same sample, we contacted authors of original studies to confirm whether or not the samples were independent.

Due to overlapping samples, we did not include several studies by Babiloni et al. [1–21]. Findings of these studies are in line with those we included, suggesting less alpha current source density in the lower alpha band in people with MCI than in cognitively healthy older adults, and in people with AD than in people with MCI [1–7, 9–13, 15–20]. For the same reason, we also excluded two studies by van der Hiele et al. [22, 23], and one study by Prieto del Val et al. [24], Gonzalez-Escamilla et al. [25], and Vialatte et al. [26].

## **Supplementary Material 2: Modified Newcastle-Ottawa Quality Assessment Scale for Case Control Studies and Quality Assessment for Each Study**

The modification of the scale was based on Reilly et al. [27]. Instead of calculating a summary measure of quality, the scoring for each study is shown in Supplementary Table 1. Stars (\*) mark items indicating a high level of quality.

### **Selection**

- 1) Is the case definition of MCI or dementia adequate?
  - a) yes, according to generally accepted diagnostic criteria (e.g., Albert et al. [28], Litvan et al. [29], Petersen et al. [30, 31], Winblad et al. [32] for MCI; McKhann et al. [33, 34] for AD; McKeith et al. [35] for DLB) or equivalent\*
  - b) yes, record linkage or according to customized criteria
  - c) no description
- Is the case definition of MCI ascribed to a particular type of dementia adequate?
  - a) yes, according to proposed diagnostic criteria (e.g., Albert et al. [28] for AD-MCI, Litvan et al. [29] for PD-MCI)\*
  - b) yes, confirmed by follow-up or postmortem examination\*
  - c) no description
- 2) Representativeness of cases
  - a) consecutive or obviously representative series of cases\*
  - b) potential for selection bias or not stated
- 3) Selections of controls
  - a) community controls\*
  - b) hospital controls
  - c) no description
- 4) Definition of controls
  - a) no objective (1/2\*) and subjective (1/2\*) cognitive deficits
  - b) no description of cognitive status

### **Comparability**

- 5) Comparability of cases and controls on the basis of the design or analysis
  - a) study controls for age\*
  - b) study controls for education\*

### **Exposure**

- 6) Ascertainment of alpha
  - a) neurophysiological analysis blinded to case/control status\*
  - b) neurophysiological analysis not blinded to case/control status
  - c) no description
- 7) Same method of ascertainment for cases and controls
  - a) yes\*
  - b) no
- 8) Missing or excluded EEG data rate
  - a) same rate for both groups\*
  - b) rate not statistically compared but described
  - c) rate different or no description

**Supplementary Table 1.** Assessment of each study included in the review according to the modified Newcastle-Ottawa scale. Stars (\*) mark items indicating a high level of quality.

| Study                   | Selection                  |                                    |                |                                          |                       |                |                             |                                   |                       |          |                |                                       | Comparability                         |                | Exposure                    |                                   |              |           |                |                                                    |    |                                   |                                               |                                  |
|-------------------------|----------------------------|------------------------------------|----------------|------------------------------------------|-----------------------|----------------|-----------------------------|-----------------------------------|-----------------------|----------|----------------|---------------------------------------|---------------------------------------|----------------|-----------------------------|-----------------------------------|--------------|-----------|----------------|----------------------------------------------------|----|-----------------------------------|-----------------------------------------------|----------------------------------|
|                         | Definition of MCI/dementia |                                    |                | Definition of MCI due to AD, DLB, or FTD |                       |                | Representativeness of cases |                                   | Selection of controls |          |                | Definition of controls                |                                       |                | Comparability               |                                   | EEG analysis |           |                | Same method of alpha ascertainment for all groups? |    | Missing or excluded EEG data rate |                                               |                                  |
|                         | Diagnostic criteria*       | Record linkage/customized criteria | No description | Diagnostic criteria*                     | Follow-up/postmortem* | No description | Consecutive sample*         | Non-consecutive or no description | Community*            | Hospital | No description | No objective cognitive deficits 1/2 * | No subjective cognitive deficits 1/2* | No description | Control or matched for age* | Control or matched for education* | Blind*       | Not blind | No description | Yes*                                               | No | Same for all groups*              | Rate not statistically compared but described | Rate different or no description |
| Babiloni [36]           | x                          |                                    |                | n.a.                                     |                       |                |                             | x                                 | x                     |          |                | x                                     |                                       |                | x                           | x                                 | x            |           |                | x                                                  |    |                                   | x                                             |                                  |
| Babiloni [37]           | x                          |                                    |                | n.a.                                     |                       |                |                             | x                                 | x                     |          |                |                                       |                                       | x              | x                           | x                                 | x            |           |                | x                                                  |    |                                   | x                                             |                                  |
| Babiloni [38]           | x                          |                                    |                | x                                        |                       |                |                             | x                                 |                       |          | x              | x                                     | x                                     |                | x                           | x                                 | x            |           |                | x                                                  |    |                                   | x                                             |                                  |
| Babiloni [39]           | x                          |                                    |                | n.a.                                     |                       |                |                             | x                                 | x                     |          |                |                                       |                                       | x              | x                           | x                                 | x            |           |                | x                                                  |    |                                   | x                                             |                                  |
| Babiloni [40]           | x                          |                                    |                | x                                        |                       |                |                             | x                                 | x                     |          |                |                                       |                                       | x              | x                           | x                                 |              | x         |                | x                                                  |    |                                   | x                                             |                                  |
| Babiloni [41]           | x                          |                                    |                | x                                        |                       |                |                             | x                                 |                       |          | x              | x                                     |                                       |                | x                           | x                                 | x            |           |                | x                                                  |    |                                   | x                                             |                                  |
| Babiloni [42]           | x                          |                                    |                | x                                        |                       |                |                             | x                                 | x                     |          |                | x                                     | x                                     |                | x                           | x                                 | x            |           |                | x                                                  | x  |                                   |                                               |                                  |
| Bonanni [43]            | x                          |                                    |                |                                          | x                     |                |                             | x                                 | x                     |          |                | x                                     | x                                     |                | x                           | x                                 | x            |           |                | x                                                  |    |                                   | x                                             |                                  |
| Bousleiman [44]         | x                          |                                    |                | n.a.                                     |                       |                |                             | x                                 | x                     |          |                |                                       |                                       | x              | x                           | x                                 |              | x         |                | x                                                  |    |                                   | x                                             |                                  |
| Cantero [45]            | x                          |                                    |                | n.a.                                     |                       |                |                             | x                                 | x                     |          |                | x                                     | x                                     |                | x                           | x                                 |              | x         |                | x                                                  |    |                                   | x                                             |                                  |
| Caravaglios [46]        | x                          |                                    |                | n.a.                                     |                       |                |                             | x                                 | x                     |          |                |                                       |                                       | x              | x                           | x                                 |              | x         |                | x                                                  |    |                                   | x                                             |                                  |
| Carmona Arroyave [47]   | x                          |                                    |                | n.a.                                     |                       |                |                             | x                                 | x                     |          |                | x                                     | x                                     |                | x                           | x                                 |              | x         |                | x                                                  |    |                                   | x                                             |                                  |
| Caviness [48]           | x                          |                                    |                | n.a.                                     |                       |                | x                           |                                   | x                     |          |                | x                                     |                                       |                |                             |                                   |              | x         |                | x                                                  |    |                                   | x                                             |                                  |
| Caviness [49]           | x                          |                                    |                | n.a.                                     |                       |                | x                           |                                   | x                     |          |                |                                       |                                       | x              | x                           |                                   |              | x         |                | x                                                  |    |                                   | x                                             |                                  |
| Chaturvedi [50]         | x                          |                                    |                | n.a.                                     |                       |                |                             | x                                 | x                     |          |                |                                       |                                       | x              | x                           | x                                 |              | x         |                | x                                                  |    |                                   | x                                             |                                  |
| Dauwels [51]            |                            |                                    | x              |                                          | x                     |                |                             | x                                 |                       |          | x              | ?                                     | ?                                     |                | x                           |                                   | x            |           |                | x                                                  |    | x                                 |                                               |                                  |
| Deiber [52]             | x                          |                                    |                | n.a.                                     |                       |                |                             | x                                 | x                     |          |                | x                                     |                                       |                | x                           | x                                 |              | x         |                | x                                                  |    |                                   | x                                             |                                  |
| Fodor [53]              | x                          |                                    |                | n.a.                                     |                       |                |                             | x                                 | x                     |          |                | x                                     |                                       |                | x                           | x                                 |              | x         |                | x                                                  |    | x                                 |                                               |                                  |
| Fonseca [54]            | x                          |                                    |                | n.a.                                     |                       |                |                             | x                                 | x                     |          |                | x                                     |                                       |                |                             | x                                 |              | x         |                | x                                                  |    |                                   | x                                             |                                  |
| Fraga [55]              | x                          |                                    |                | n.a.                                     |                       |                |                             | x                                 | x                     |          |                | x                                     |                                       |                | x                           | x                                 |              | x         |                | x                                                  |    |                                   | x                                             |                                  |
| Gonzalez-Escamilla [56] | x                          |                                    |                | n.a.                                     |                       |                |                             | x                                 | x                     |          |                | x                                     |                                       |                | x                           | x                                 |              | x         |                | x                                                  |    |                                   | x                                             |                                  |
| Goodman [57]            | x                          |                                    |                | n.a.                                     |                       |                |                             | x                                 | x                     |          |                |                                       |                                       | x              | x                           | x                                 |              | x         |                | x                                                  |    |                                   | x                                             |                                  |
| Gouw [58]               | x                          |                                    |                | x                                        |                       |                |                             | x                                 | n.a.                  |          |                | n.a.                                  |                                       |                | x                           | x                                 | x            |           |                | x                                                  |    |                                   | x                                             |                                  |
| He [59]                 | x                          |                                    |                | n.a.                                     |                       |                |                             | x                                 | x                     |          |                |                                       |                                       | x              | x                           |                                   |              | x         |                | x                                                  |    |                                   | x                                             |                                  |

|                                |         |         |         |      |            |   |      |      |   |   |   |   |   |   |   |                           |
|--------------------------------|---------|---------|---------|------|------------|---|------|------|---|---|---|---|---|---|---|---------------------------|
| Hsiao [60]                     | x       |         |         | n.a. |            | x | n.a. | n.a. | x |   |   | x | x |   |   | x                         |
| Hsiao [61]                     | x       |         |         | n.a. |            | x | n.a. | n.a. | x |   |   | x | x |   |   | x                         |
| Huang [62]                     |         | x       |         | n.a. | x          |   | x    |      | x | x |   | x | x |   |   | x                         |
| Jelic [63]                     | x       |         |         | n.a. | x          |   | x    |      | x | x |   | x | x |   |   | x                         |
| Jelic [64]                     | x       |         |         | n.a. |            | x | x    |      |   |   | x | x | x | x |   | x                         |
| Koenig (NY sample) [65]        | x (AD)  | x (MCI) |         | n.a. | x          |   | x    |      | x | x |   | x |   | x |   | x                         |
| Koenig (Stockholm sample) [65] | x       |         |         | n.a. | x          |   | x    |      | ? | ? |   | x |   | x |   | x                         |
| Kurt [66]                      | x       |         |         | n.a. | x          |   |      | x    | x |   |   | x | x |   |   | x                         |
| Kwak [67]                      | x       |         |         | n.a. |            | x |      | x    |   |   | x | x |   | x |   | x                         |
| Luckhaus [68]                  | x       |         |         | n.a. |            | x | n.a. | n.a. | x | x |   | x | x |   |   | x                         |
| Mazaheri [69]                  | x       |         |         | n.a. |            | x | n.a. | n.a. |   |   |   |   | x | x |   | x                         |
| McBride [70]                   |         | x       |         | n.a. |            | x | x    |      |   |   | x | x | x |   |   | x                         |
| Michels [71]                   |         |         | x       | n.a. |            | x |      | x    |   |   | x | x | x |   | x |                           |
| Moretti [72]                   | x       |         |         | n.a. |            | x | x    |      |   |   | x | x | x |   |   | x                         |
| Moretti [73]                   | x (FTD) |         | x (MCI) |      |            | x | n.a. | n.a. |   |   | x | x |   | x |   | x                         |
| Mostile [74]                   | x       |         |         | n.a. | x          |   | x    |      |   |   | x |   | x |   |   | x                         |
| Musaeus [75]                   | x       |         |         | n.a. | x (mostly) |   | x    |      | x |   | x | x | x |   | x |                           |
| Musaeus [76]                   | x       |         |         | n.a. | x (mostly) |   | x    |      | x |   | x | x | x |   |   | x (control analyses done) |
| Musaeus [77]                   | x       |         |         | n.a. | x          |   | x    |      | x | x |   | x | x |   | x |                           |
| Musaeus [78]                   | x       |         |         | n.a. | x          |   | x    |      | x | x |   | x | x |   | x |                           |
| Nguyen [79]                    | x       |         |         | n.a. |            | x |      | x    | x | x |   | x | x |   | x |                           |
| Núñez [80]                     | x       |         | x       |      |            | x |      | x    |   |   | x | x | x |   |   | x                         |
| Pijnenburg [81]                | x       |         |         | n.a. | x          |   | n.a. | n.a. | x |   |   | x | x |   |   | x                         |
| Poil [82]                      | x       |         |         | n.a. |            | x | n.a. | n.a. |   |   |   | x | x |   |   | x                         |
| Pons [83]                      | x       |         |         | n.a. |            | x |      | x    | x | x |   | x | x |   |   | x                         |
| Poza [84]                      | x       |         | x       |      |            | x |      | x    | ? | ? |   | x | x |   |   | x                         |
| Prieto del Val [85]            | x       |         | x       |      |            | x | x    |      | x | x |   | x | x |   | x |                           |
| Roh [86]                       | x       |         |         | n.a. |            | x | x    |      |   |   | x | x |   | x |   |                           |
| Rossini [87]                   | x       |         |         | n.a. |            | x | n.a. | n.a. |   |   |   | x | x |   |   | x                         |
| Ruiz-Gómez [88]                | x       |         | x       |      |            | x |      | x    | x |   |   | x | x |   |   | x                         |
| Scrase [89]                    | x       |         |         | n.a. |            | x | n.a. | n.a. |   |   |   | x | x |   |   | x                         |
| Sharma [90]                    |         | x       |         | n.a. |            | x | x    |      |   |   | x | x | x |   |   | x                         |
| Smailovic [91]                 | x       |         |         | n.a. |            | x | n.a. | n.a. |   |   |   | x | x |   |   | x                         |
| Stam [92]                      | x       |         |         | n.a. | x          |   | n.a. | n.a. |   |   |   | x | x |   |   | x                         |
| Teipel [93]                    | x       |         |         | n.a. |            | x | x    |      | x | x |   | x | x |   |   | x                         |
| Utianski [94]                  | x       |         |         | n.a. |            | x | x    |      | x |   |   | x | x |   |   | x                         |
| van der Hiele [95]             | x       |         |         | n.a. | x          |   | x    |      | x |   |   | x | x |   | x |                           |
| van der Hiele [96]             | x       |         |         | n.a. |            | x | x    |      |   | x |   | x | x |   | x |                           |
| van der Hiele [97]             | x       |         |         | n.a. |            | x | x    |      |   | x |   | x | x |   |   | x                         |
| Vecchio [98]                   | x       |         |         | n.a. |            | x |      | x    |   |   | x | x | x |   | x |                           |

|             |   |  |  |      |  |   |   |   |  |   |   |   |   |   |   |  |   |   |  |  |   |   |
|-------------|---|--|--|------|--|---|---|---|--|---|---|---|---|---|---|--|---|---|--|--|---|---|
| Wen [99]    | x |  |  | n.a. |  | x | x |   |  |   |   | x | x | x |   |  | x | x |  |  |   | x |
| Xu [100]    | x |  |  | n.a. |  | x | x |   |  | x | x |   | x | x |   |  | x | x |  |  | x |   |
| Ya [101]    | x |  |  | x    |  |   | x | x |  |   | x | ? |   | x |   |  | x | x |  |  |   | x |
| Yener [102] | x |  |  | n.a. |  | x |   | x |  |   |   |   | x | x | x |  | x | x |  |  |   | x |
| Yener [103] | x |  |  | n.a. |  | x | x |   |  | x |   |   | x | x | x |  | x | x |  |  |   | x |

Question marks indicate that information was unclear. n.a., not applicable.

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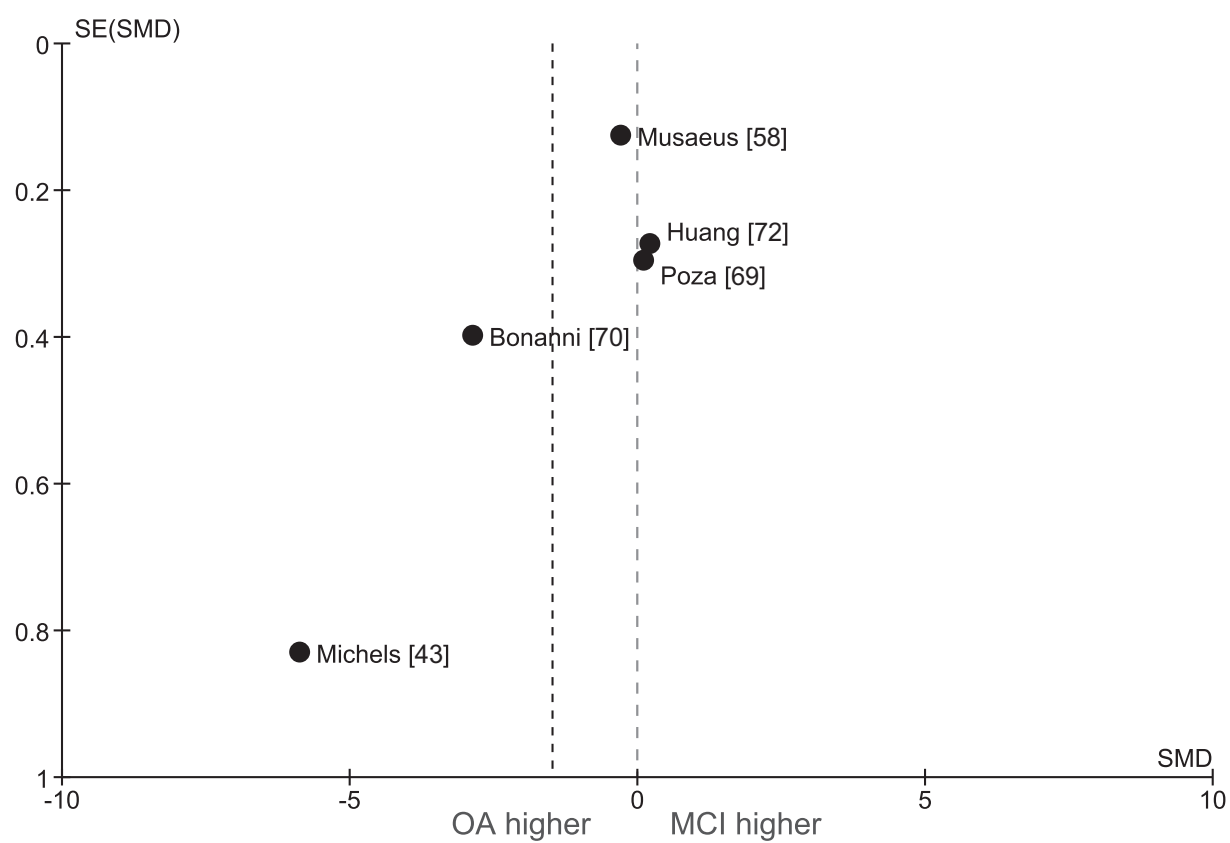
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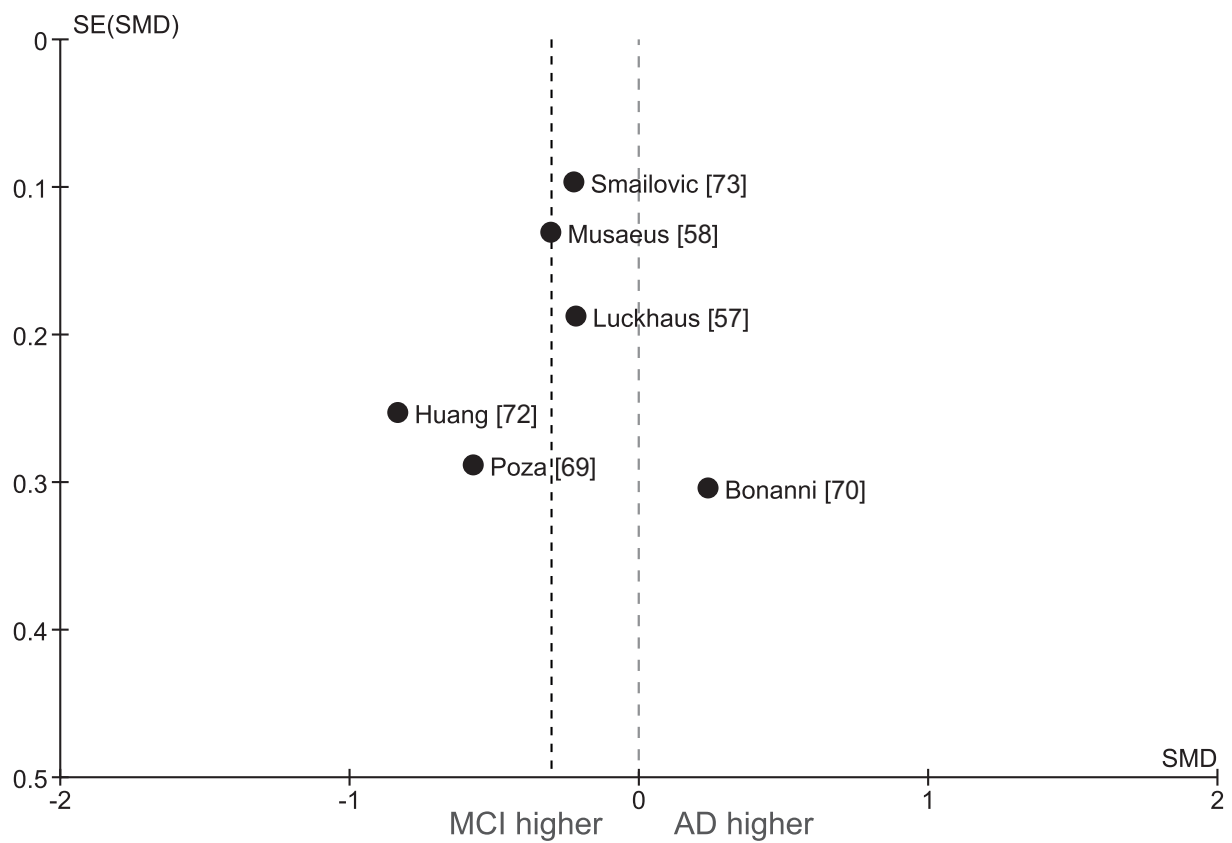
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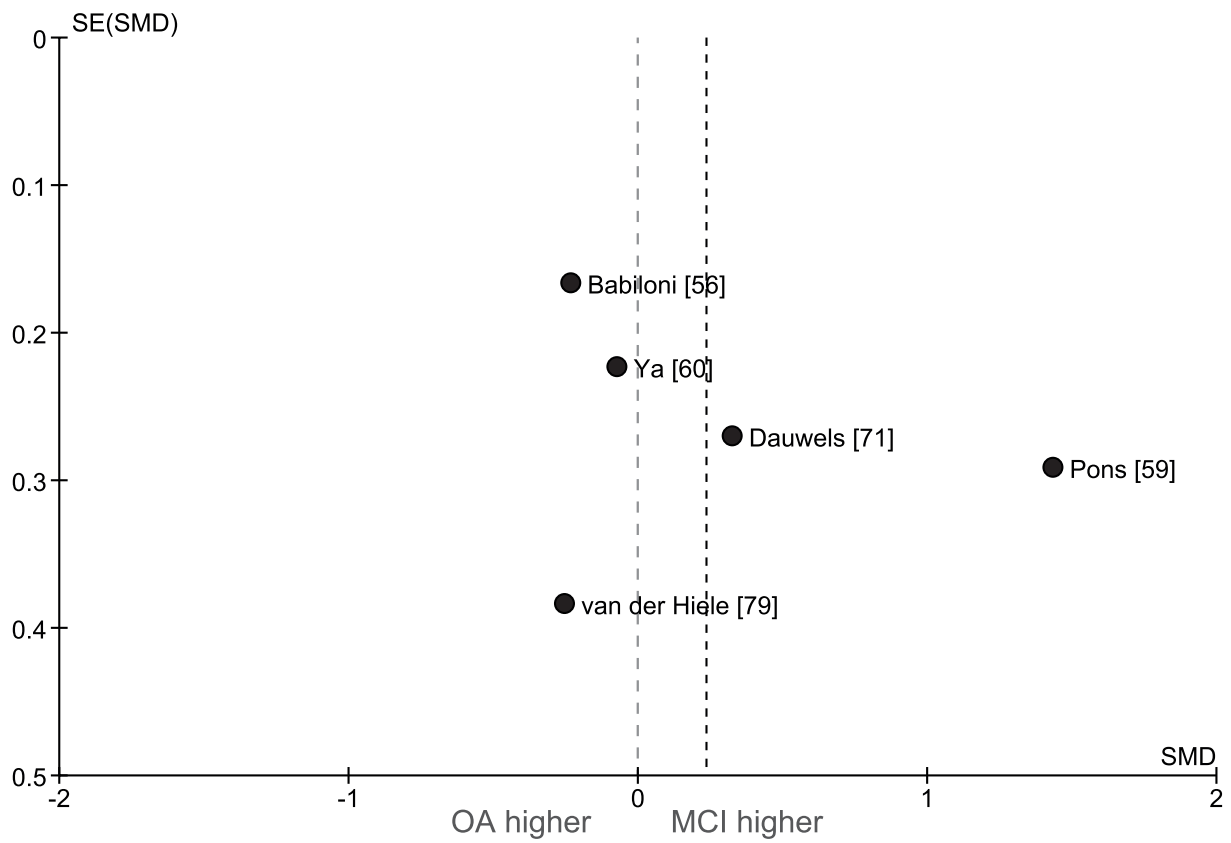
### Supplementary Material 3: Funnel Plots



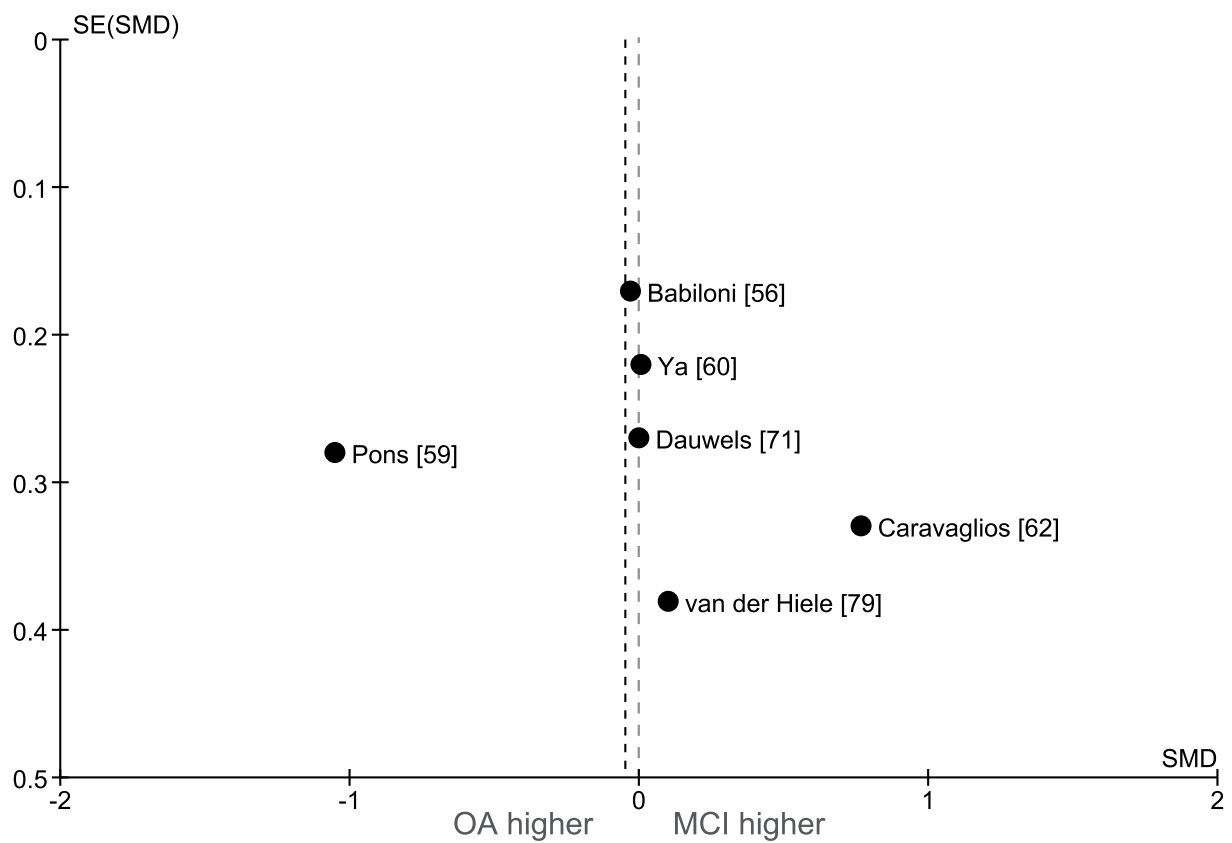
**Supplementary Figure 1.** Funnel plot for the meta-analysis comparing resting state alpha power in cognitively healthy older adults and people with MCI. Black dashed line marks the pooled standardized mean difference (SMD = -1.49, random-effects model).



**Supplementary Figure 2.** Funnel plot for the meta-analysis comparing resting state alpha power in people with MCI and people with AD. Black dashed line marks the pooled standardized mean difference (SMD = -0.30, random-effects model).

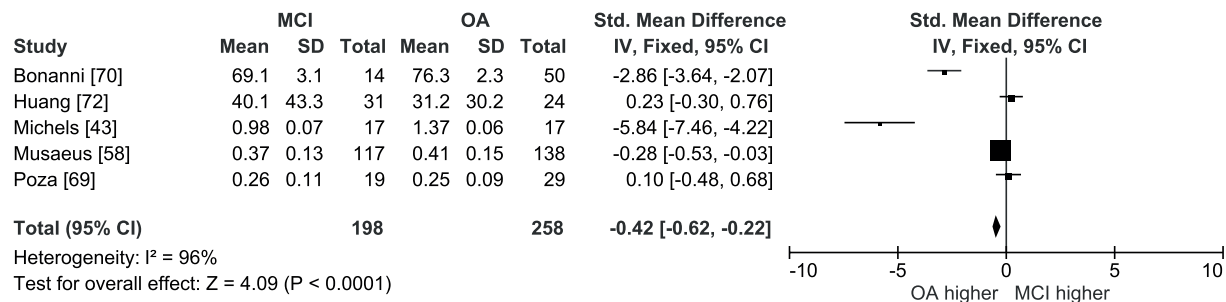


**Supplementary Figure 3.** Funnel plot for the meta-analysis comparing lower resting state alpha power in cognitively healthy older adults and people with MCI. Black dashed line marks the pooled standardized mean difference (SMD = 0.23, random-effects model).

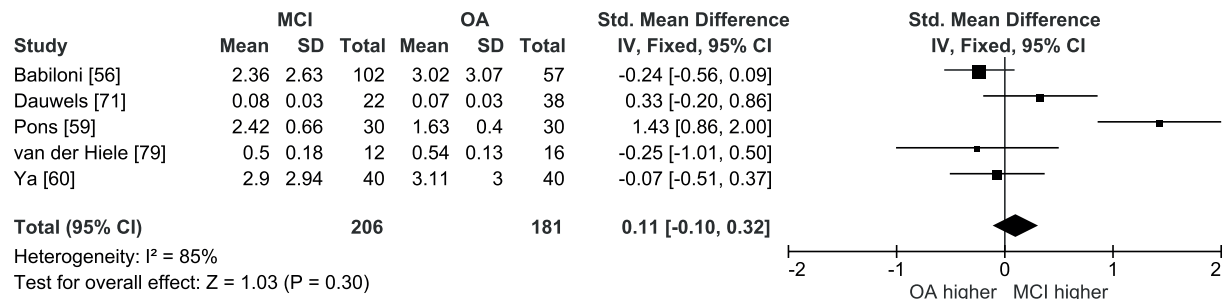


**Supplementary Figure 4.** Funnel plot for the meta-analysis comparing upper resting state alpha power in cognitively healthy older adults and people with MCI. Black dashed line marks the pooled standardized mean difference (SMD = -0.05, random-effects model).

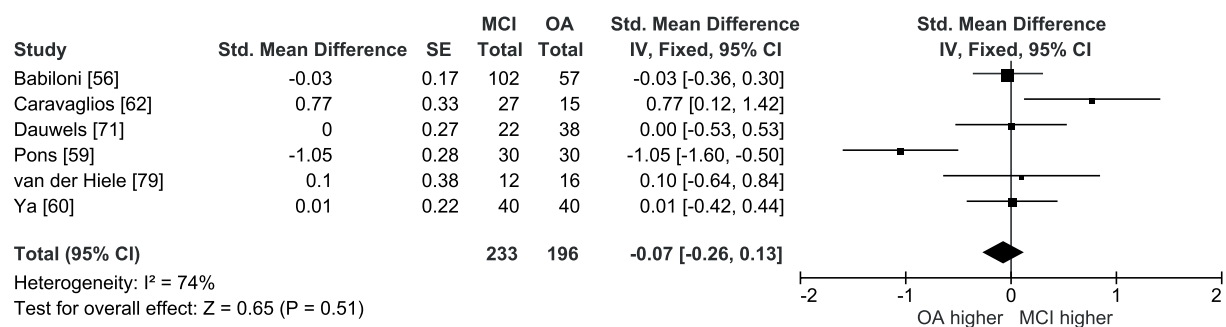
## Supplementary Material 4: Fixed-Effects Meta-Analyses



**Supplementary Figure 5.** Table and forest plot of effect sizes for power in awake resting state in the full alpha band in people with MCI versus cognitively healthy older adults (OA).



**Supplementary Figure 6.** Table and forest plot of effect sizes for power in awake resting state in the lower alpha band in people with MCI versus cognitively healthy older adults (OA).



**Supplementary Figure 7.** Table and forest plot of effect sizes for power in awake resting state in the upper alpha band in people with MCI versus cognitively healthy older adults (OA).