

Disentangling broad-band EEG microstates into frequency-specific features of aging

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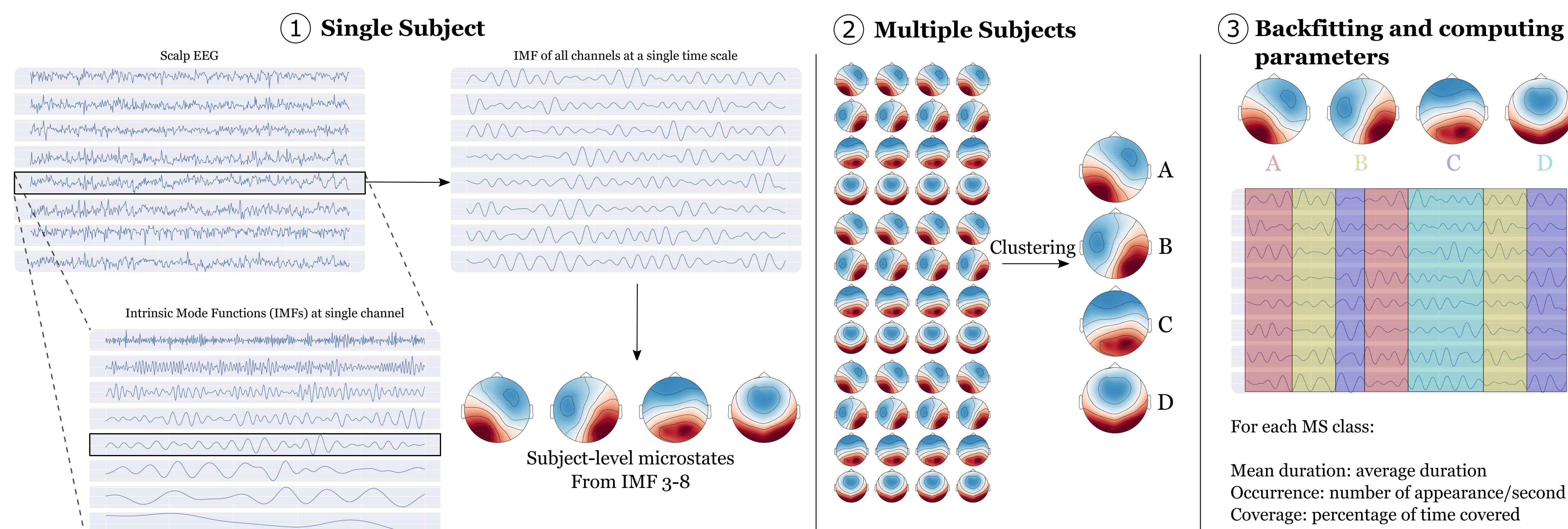
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BACKGROUND AND MOTIVATION

- Multichannel EEG signals can be represented by a few topographical maps, with each spanning **60-150 ms**, these maps are referred to as EEG microstates (MSs).
- EEG MS were segmented from 2-20 Hz or 1-40 Hz bandpass-filtered EEG, thus described as a **broadband** phenomenon. The feasibility of MS analysis in other frequency bands has not been explored.
- EEG microstates have been studied in a wide range of neuropsychiatric diseases such as ADHD, depression, schizophrenia, but **findings in ageing were inconsistent** in previous studies.
- The present study aims to (1) examine the age-related modulation on MS parameters with two broad-band settings; (2) explore the existence of EEG MSs in narrowband signals; and (3) examine if frequency-specific MS parameters provide new insights on age-related modulation.

MICROSTATES SEGMENTATION AND PARAMETERS COMPUTATION



PRIMER ON DISCUSSION

- The connections between MS and RSNs were studied. Class A and B were found to correlate with **auditory** and **visual** network respectively, C had been related to **saliency and default mode network**, D had been related to **cognitive control and attention network** [2].
- Broadband EEG MSs were dominated by alpha oscillations and **reflected inhibitory activities** [3].
- Spontaneous thoughts are proposed to be supported by the **interactions between brain networks** (sensorimotor areas, dorsal attention network, frontoparietal control network, default-mode network and salience network) [4].

DISCUSSION: BROADBAND MS

- Ageing is related to **reduced MSs duration and increased occurrence**.
- Increased coverage in A and decreased coverage in D** with increasing age observed from 2-20 Hz broadband MS: older adults **exerted more control** and had **less inner language** types of thoughts during rest (**Table 1**).
- Broadband MS parameters **revealed different age-related results** depending on the selected bandpass filters. E.g. the decreased mean duration of classes B, C and D were consistent across settings while occurrence and coverage yielded different results (**Table 1**).
- Higher class D duration: **longer inhibitory period of the cognitive control** network and thus led to poorer performance in picture naming task.
- EEG MSs likely reflect communications between networks that maintain spontaneous thoughts in sub-second timescales.

DISCUSSION: NARROWBAND MS

- The same four canonical maps **can be segmented from narrowband IMFs** (**Fig. 1**).
- Narrowband MS parameters **revealed differences that were masked in broadband MS**. E.g., duration of MS A decreased in IMF6 MS but not broadband MS (**Table 1**).
- Narrowband MS parameters significantly correlated with picture naming reaction time in frequency ranges except the alpha, the divergent findings between broadband and narrowband MS **lead to a new research direction** (**Fig. 2**).

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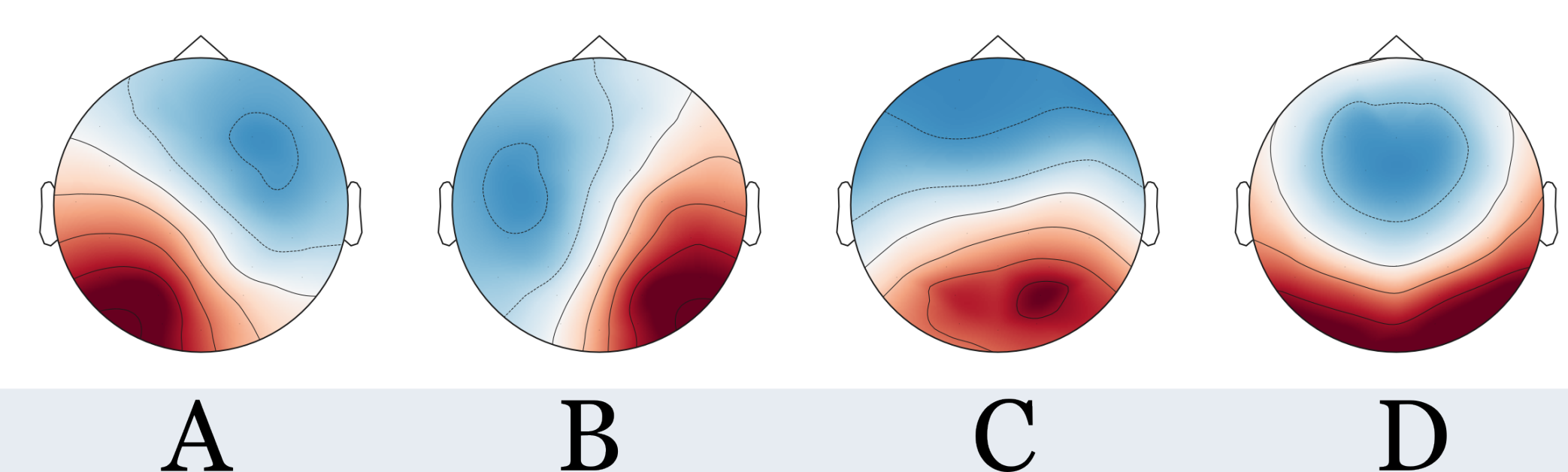
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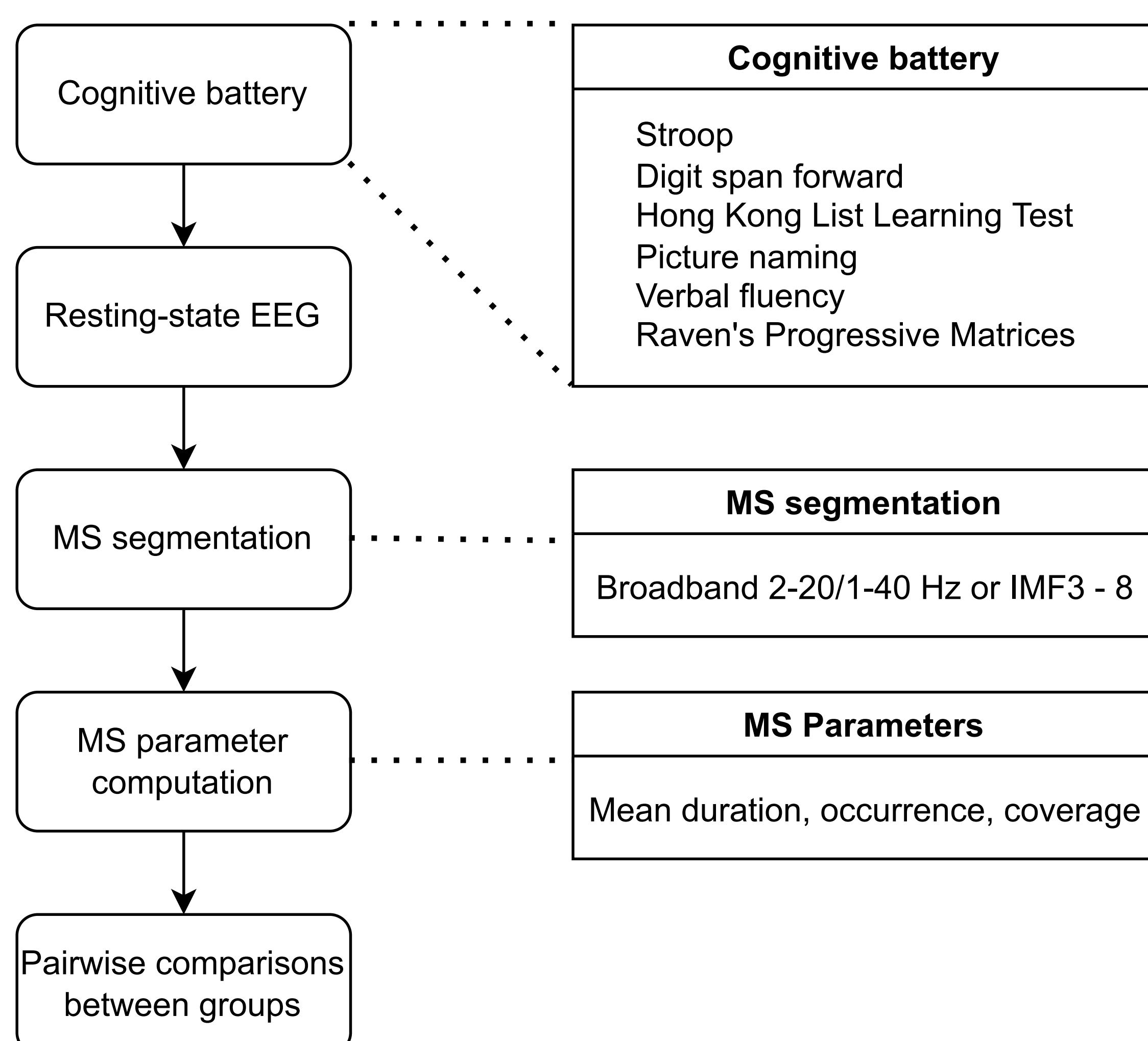
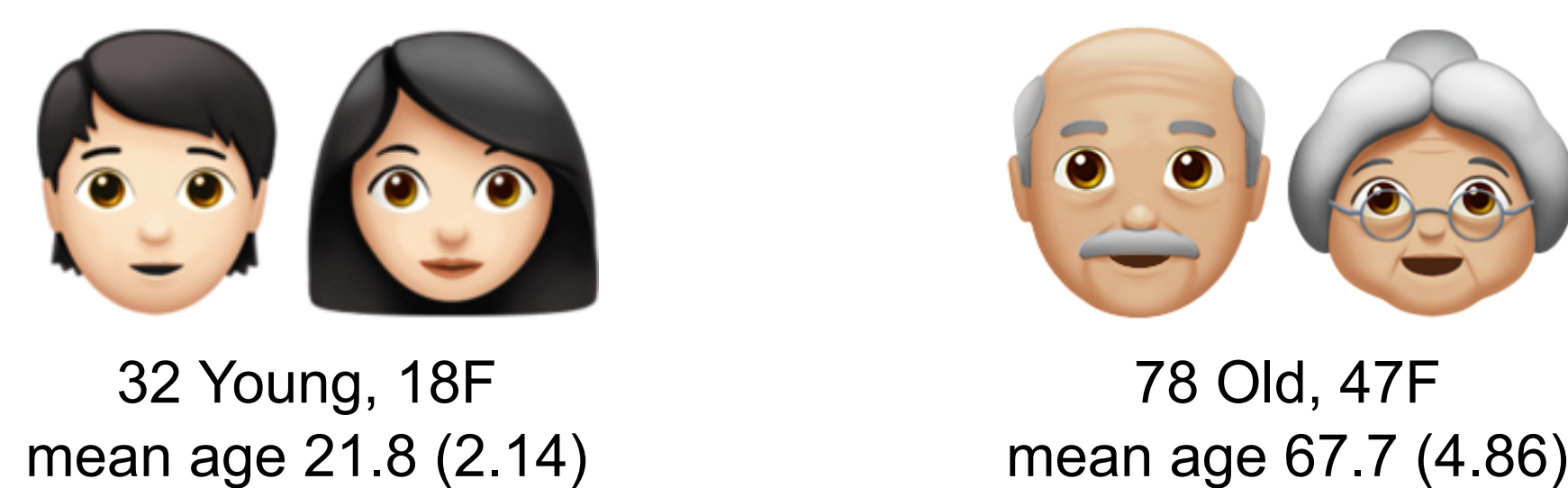
CANONICAL MICROSTATES

Below are the four canonical MSs that have been repeatedly replicated in the last 30 years of studies:



- Only **one MS** is assumed to be active at a moment.
- No constraints** on the frequency of the underlying oscillators.

DATA AND METHODS



RESULTS

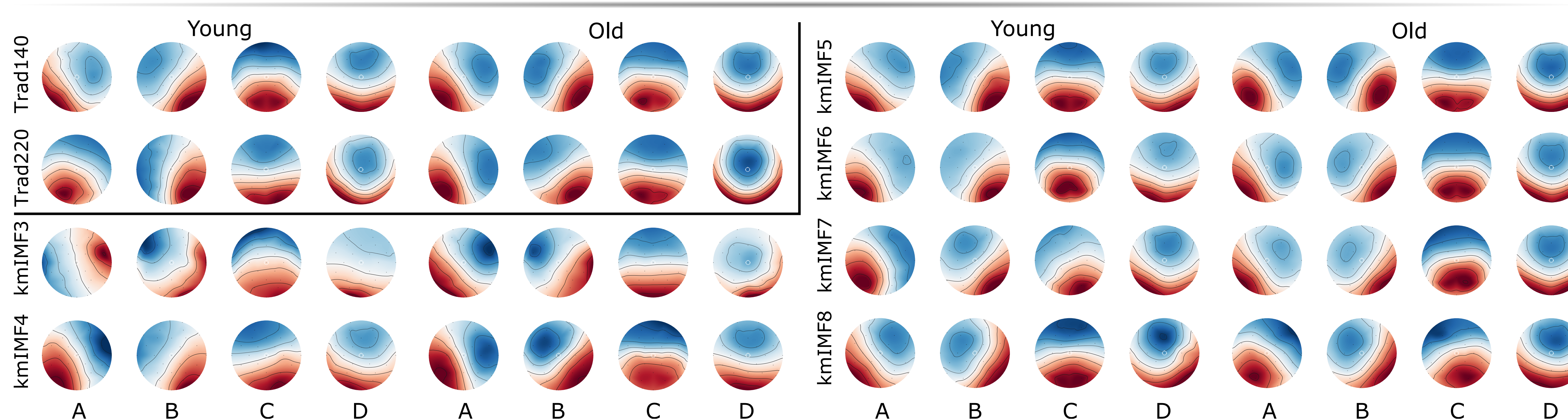


Figure 1: EEG MSs segmented from different frequency configurations.

Table 1: Eyes-closed condition: significant ($p < .05$) age-related difference patterns on MS parameters in all frequency configurations. \uparrow and \downarrow indicates increase or decrease with ageing. Not all IMFs are shown here.

Type	Frequency range	Mean duration				Occurrence				Coverage			
		A	B	C	D	A	B	C	D	A	B	C	D
Broadband	1-40 Hz		\downarrow	\downarrow	\downarrow				\uparrow				
	2-20 Hz		\downarrow	\downarrow	\downarrow	\uparrow	\uparrow	\uparrow		\uparrow			\downarrow
IMFs	IMF5 (13.72 - 23.67 Hz)			\downarrow					\uparrow				
	IMF6 (8.2 - 14.94 Hz)	\downarrow	\downarrow		\downarrow	\uparrow	\uparrow	\uparrow		\uparrow		\uparrow	\downarrow

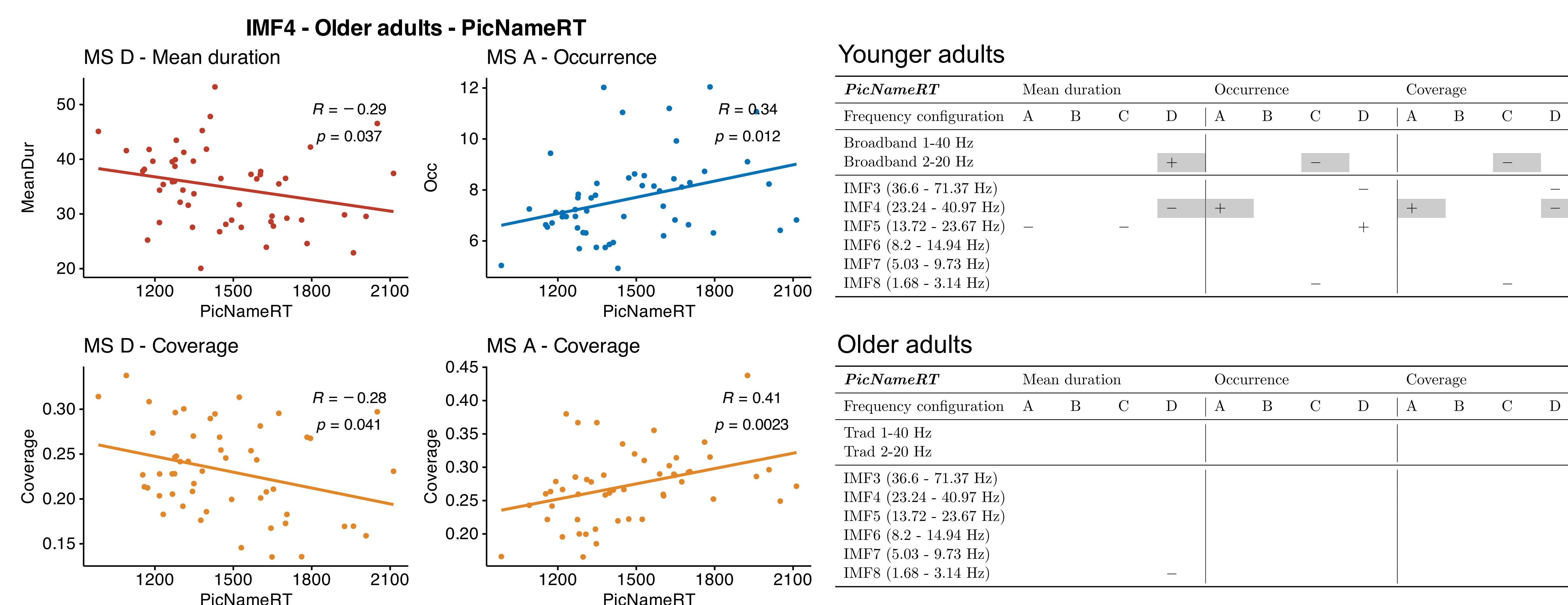


Figure 2: Correlation between MS parameters and reaction time of the picture naming task.