Whole-Body Networks
A Holistic Approach for Studying Aging

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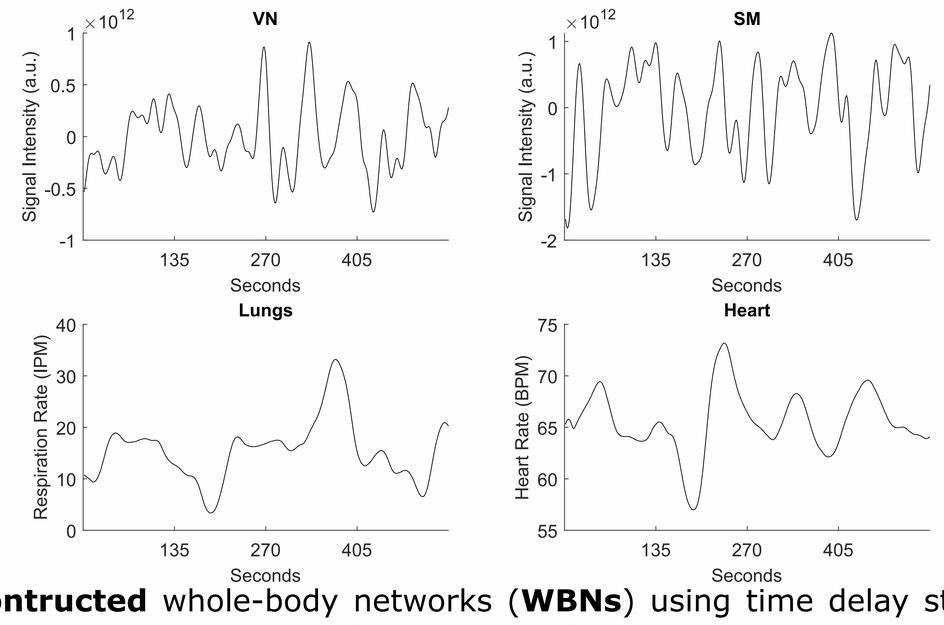
Abstract

We constructed **whole-body networks (WBNs)** using fMRI-BOLD, respiratory rate and heart rate time series of a young and an elderly group during eyes-open resting-state. Our methodology identified **regional differences**. The comparison of the WBNs revealed a **complex relationship** where some connections were stronger and some weaker in the elderly. The **WBN architecture** negatively **correlated** with the **short-term memory** and **verbal learning** of the **young** group.

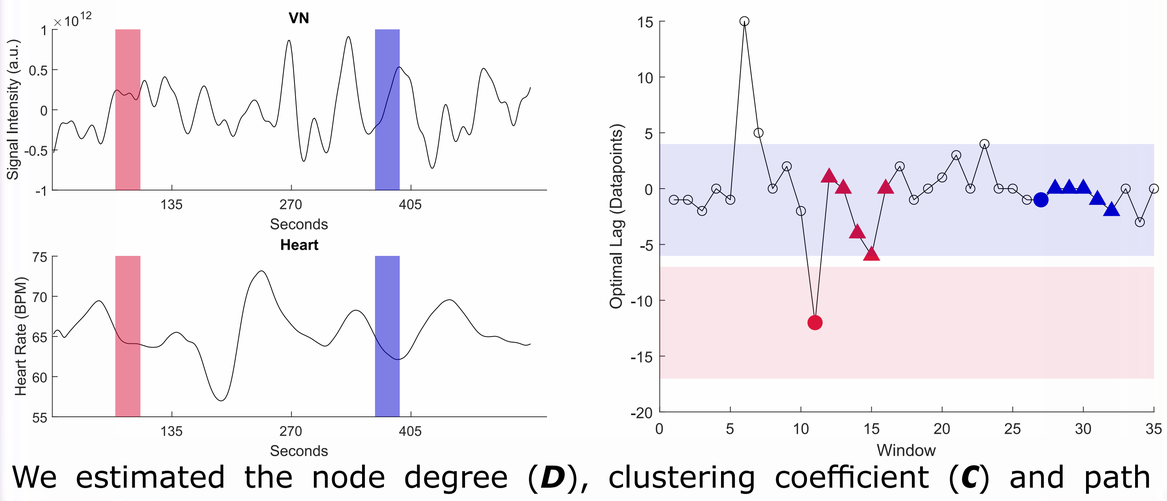
Introduction & Methods

LEMON dataset (Babayan et al., 2019): **34 elderly** (≥60 years old, 12 female) and **42 young** ≤25 years old, 10 female) subjects, 9 min preprocessed eyes-open resting-state **fMRI-BOLD** time series (TR=1.4s) and simultaneous recording of **blood pressure** and **respiration**, California Verbal Learning Task (**CVLT**) for estimating **verbal learning** and **short-term memory**

Preprocessing: **parcelation** of fMRI-BOLD into the seven **resting-state networks** (DMN, FPN, LN, VAN, DAN, SMN, VN), estimation of **heart rate** and **respiratory rate**



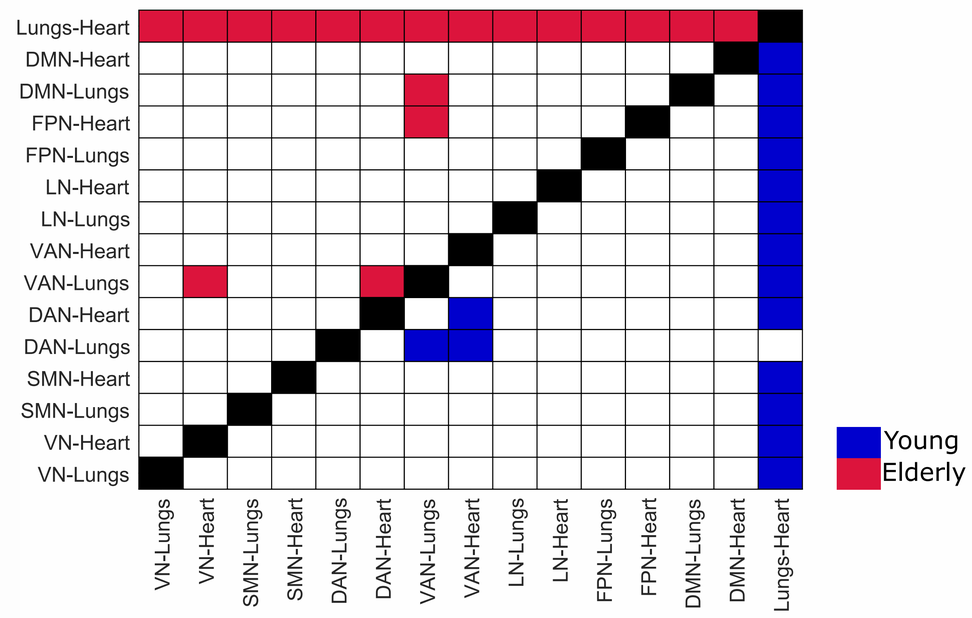
We **contructed** whole-body networks (**WBNs**) using time delay stability (Bashan et al., 2012) - i.e. **time-lagged coupling** - between the different organs



We estimated the node degree (***D***), clustering coefficient (***C***) and path length (***L***)

Regional Variability

Question: Can our analytical pipeline capture **regional differences**?



Answer:

i) **Lungs-Heart higher** than most other connections
   -> Agrees with **previous WBN studies**
   (Zanetti et al., 2019; Antonacci et al., 2020, 2021; Pernice et al., 2021)
   -> Already-known strong iinteractions of cardiorespiratory system

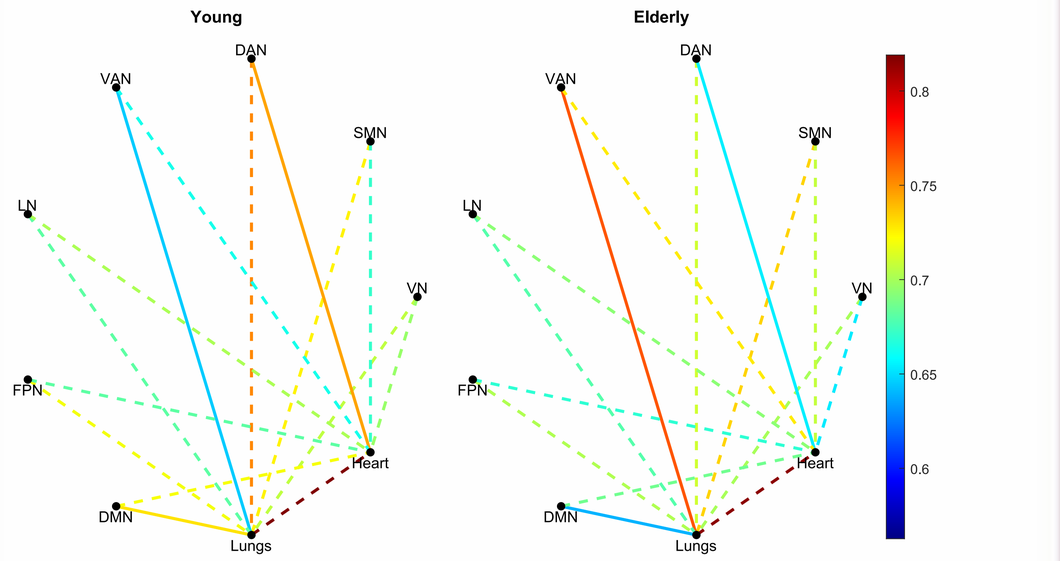
ii) **Strong DAN-Lungs in young** and **VAN-Lungs in elderly** connections
   -> Agrees with **previous WBN studies** (Kluger et al., 2021)

Conclusion:

Validation of our methodology by agreeing with previous studies and known physiology

Group Differences

Question: Are there **differences** in the WBN of **young** and **elderly** group?



Answer:

i) **DAN-Heart** and **DMN-Lungs** connections **higher** in the **young**

ii) **VAN-Lungs** connection **higher** in the **elderly**

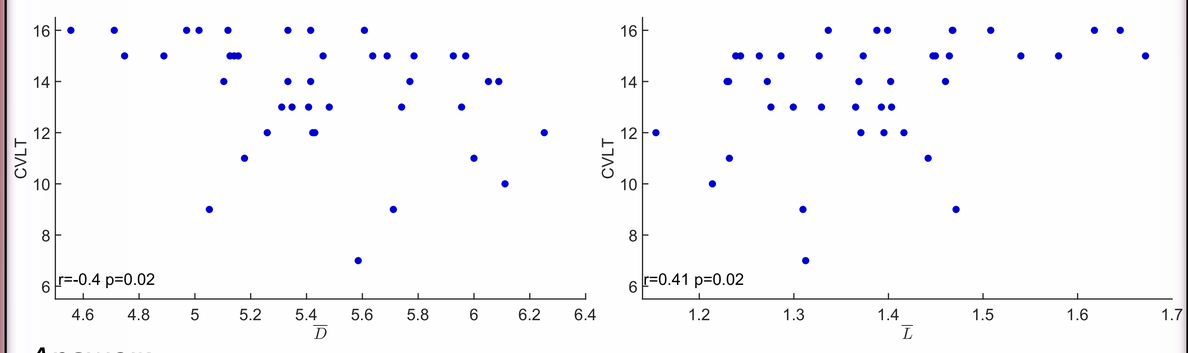
Conclusion:

i) **Decrease** with aging could indicate **functional decoupling** of the organs

ii) Both **decreased** and **increased** connectivity indicates a **complex WBN restructuring**

Correlation with CVLT

Question: Does the **WBN architecture** correlate with **verbal learning** and **short-term memory**?



Answer:

i) **Young** people with **lower interconnectivity** and **integration** tend to have **better short-term memory** and **verbal learning**
   -> Agrees with **previous studies** (Kaposzta et al., 2023; Czoch et al., 2024)

ii) **No** correlations in the **elderly**

Conclusion:

i) The groups had **similar network metrics**, but their **CVLT** scores **differed**. Thus, the **lack of correlations** in the elderly is mainly **influenced** by the **task** and not by the underlying WBN structure.

ii) We hypothesize that in the **young** group, participants who **pruned** efficiently **redundant connections** in **rest** can invest more into **rebuilding task-specific** connections and **perform better**.

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Acknowledgments: C.M.K. acknowledges support by DERAS-II Survey Update