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Testing the behavioral and neurohemodynamic compensation effects of cardiorespiratory fitness on the aging of working memory updating

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Introduction

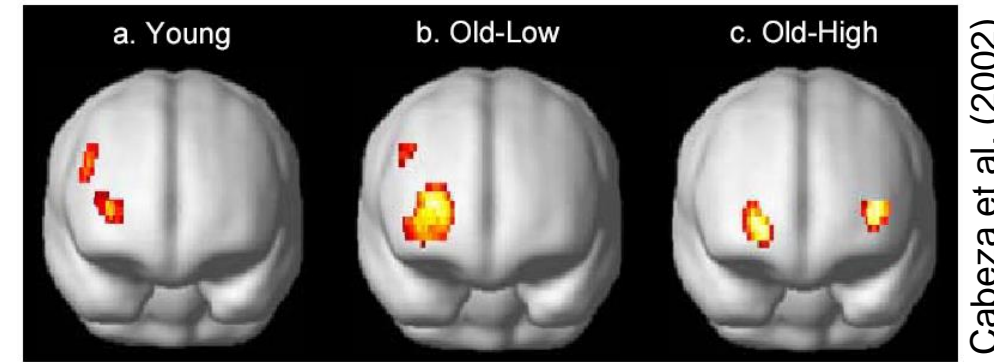
Physical exercise and cardiorespiratory fitness (CRF) → Better cognitive performance
Improved brain functioning

Albinet et al. (2014); Hyodo et al. (2016)

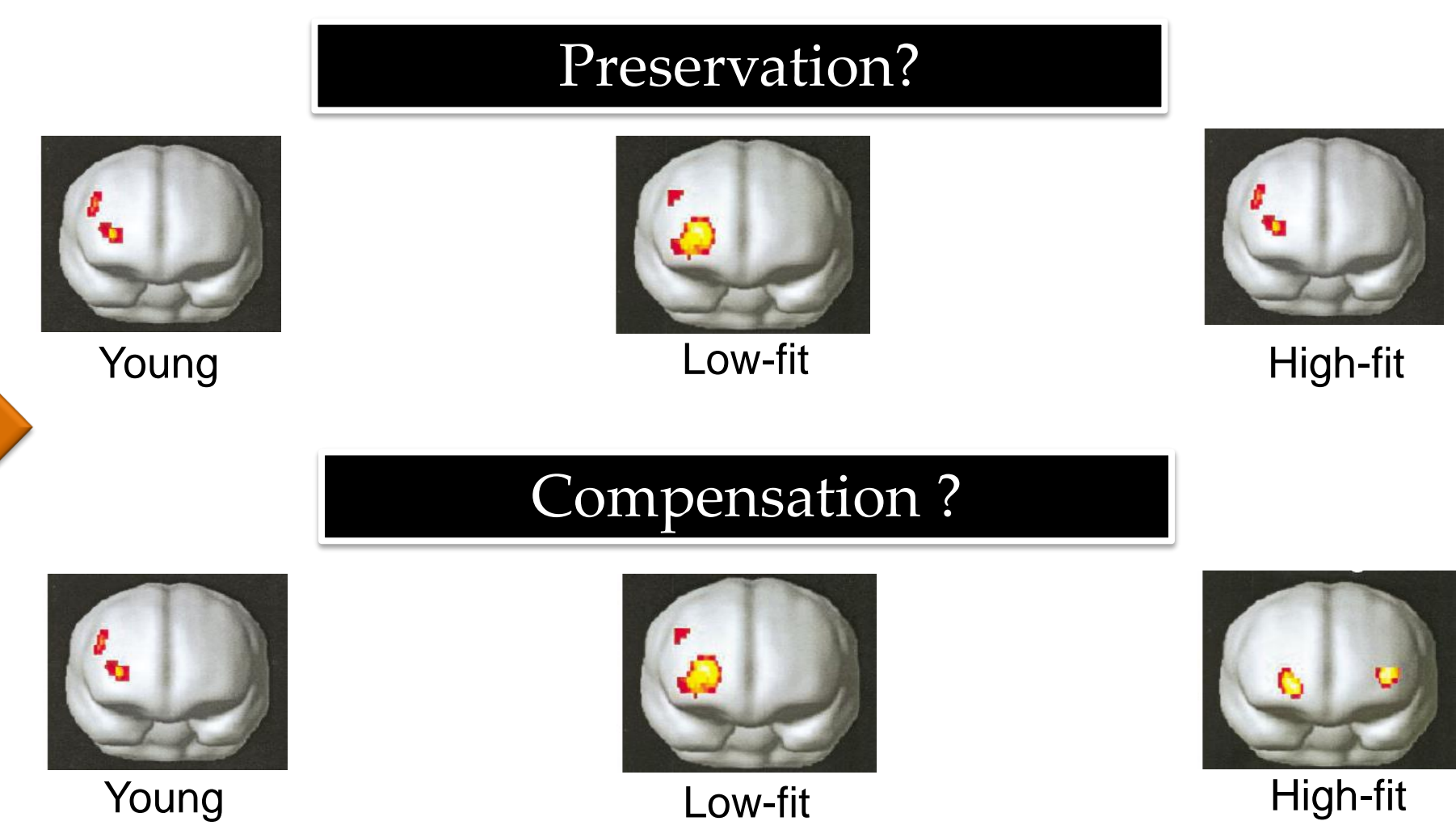
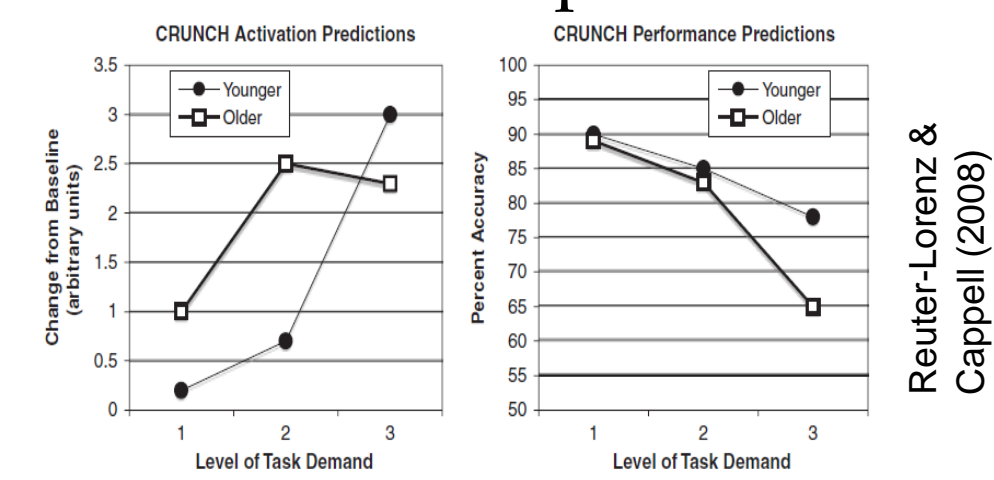
To sustain better cognitive performance :

Does CRF elicit:
❖ a Preservation ?
❖ a Compensation ?
of brain activation patterns

The HAROLD model

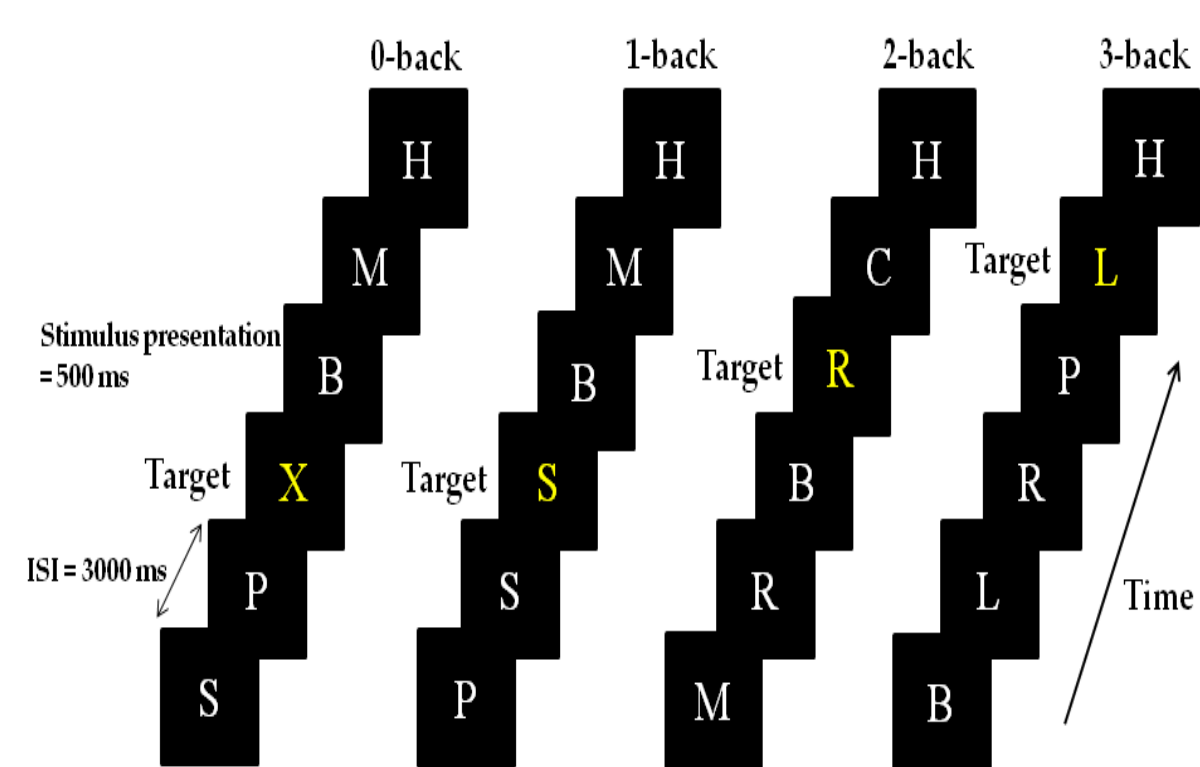


The CRUNCH predictions



Method

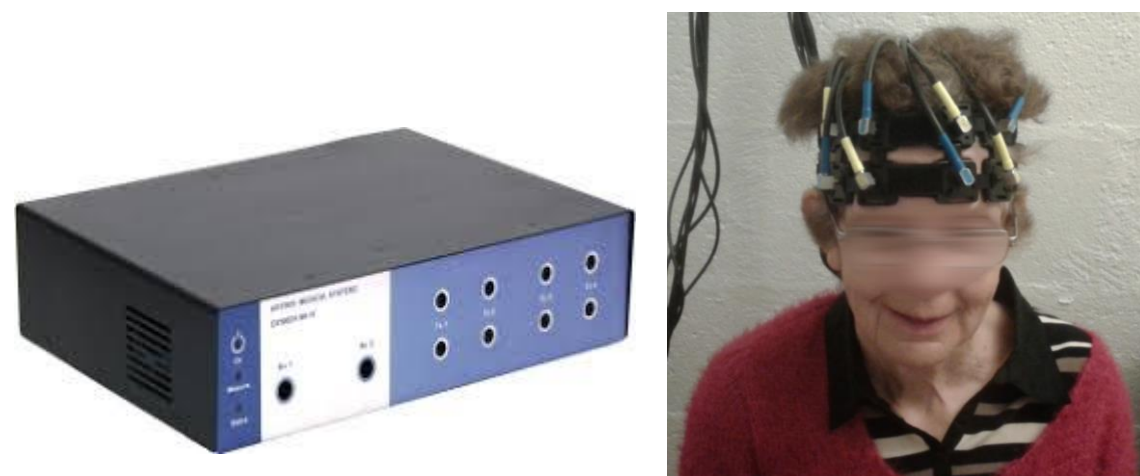
N-back task:



Dependent Variable:
Accuracy score: A'

fNIRS data:

Relative changes in concentrations of oxyhemoglobin [O₂Hb] and deoxyhemoglobin [HHb] in $\mu\text{mol}/\text{cm}$ were recorded continuously on the **left** and **right** PFCs in each condition, with near-infrared spectroscopy (Oxymon MkIII-Artinis) with an acquisition rate of 10 Hz.



Characteristics of the participants

	Young adults (N = 19)	Older adults (N = 37)	Older High-fit (N = 21)	Older Low-fit (N = 16)
Age (years)	19.7±1	69±4.7*	67.9±4.9	70.3±4.3
Gender (M/F)	17/2	15/22	8/13	7/9
Education (years)	14	13.4±3.8	14.5±3.6	11.8±3.7†
VO ₂ max (mL/Kg/min)	54.8±7.21	22.3±7.9*	26.1±6.7	17.4±6.6†
MMSE	-	29.2±0.9	29±1	29±0.9
GDS	-	5.8±4.2	6±4.9	6±3.4

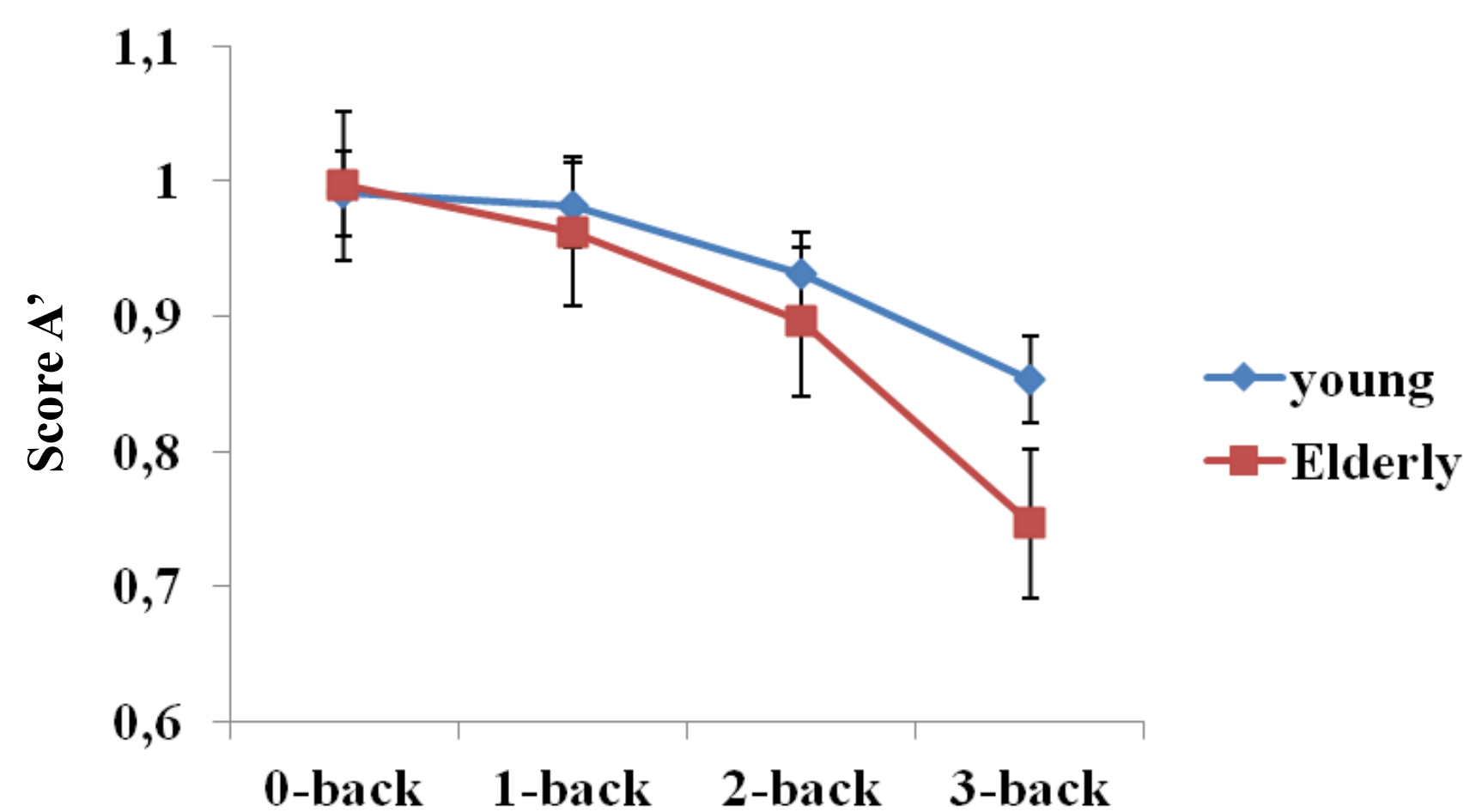
*: significant difference between Young and Older adults.

†: significant difference between High-fit and Low-fit.

Results

Young vs. Older adults

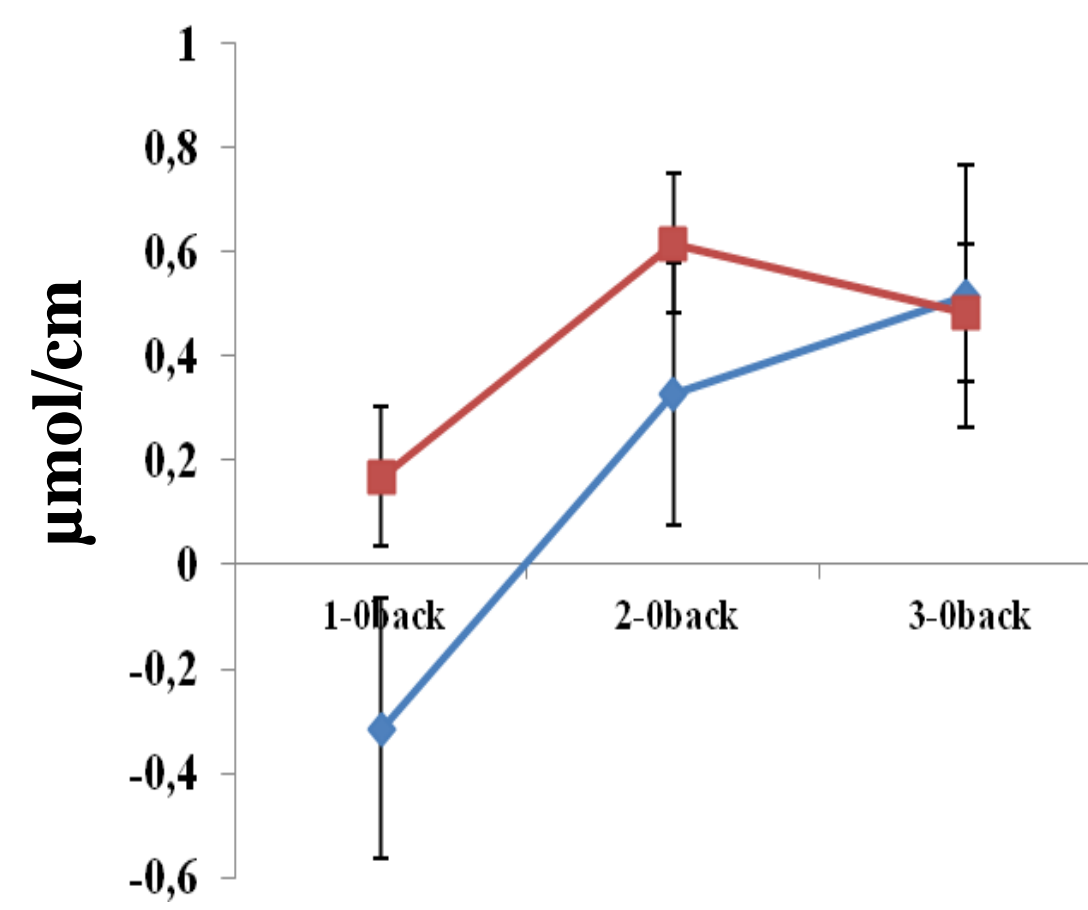
Behavioral data



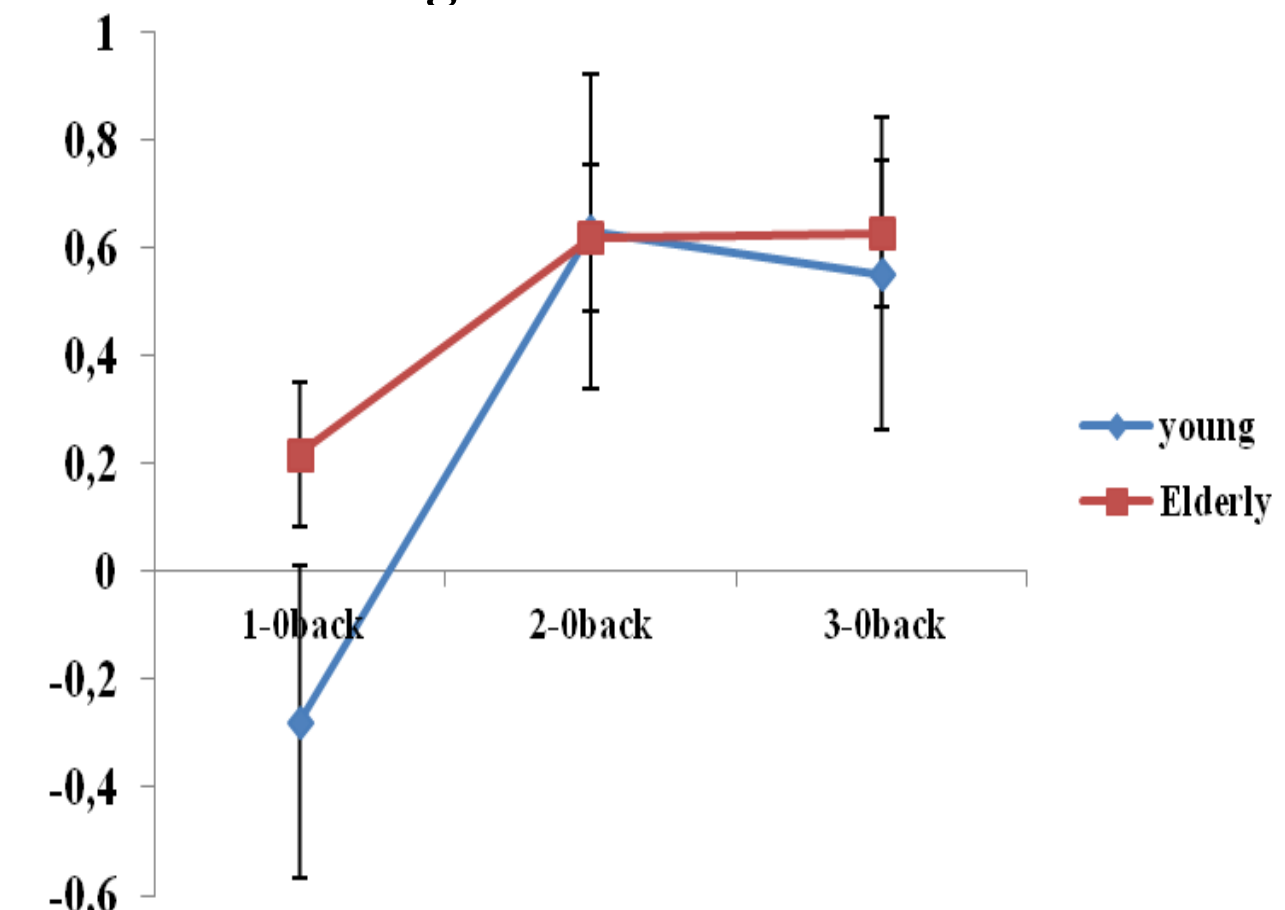
Significant impaired behavioral performance for the Elderly at the most complex 3-back condition.

fNIRS data

Left Prefrontal Cortex



Right Prefrontal Cortex

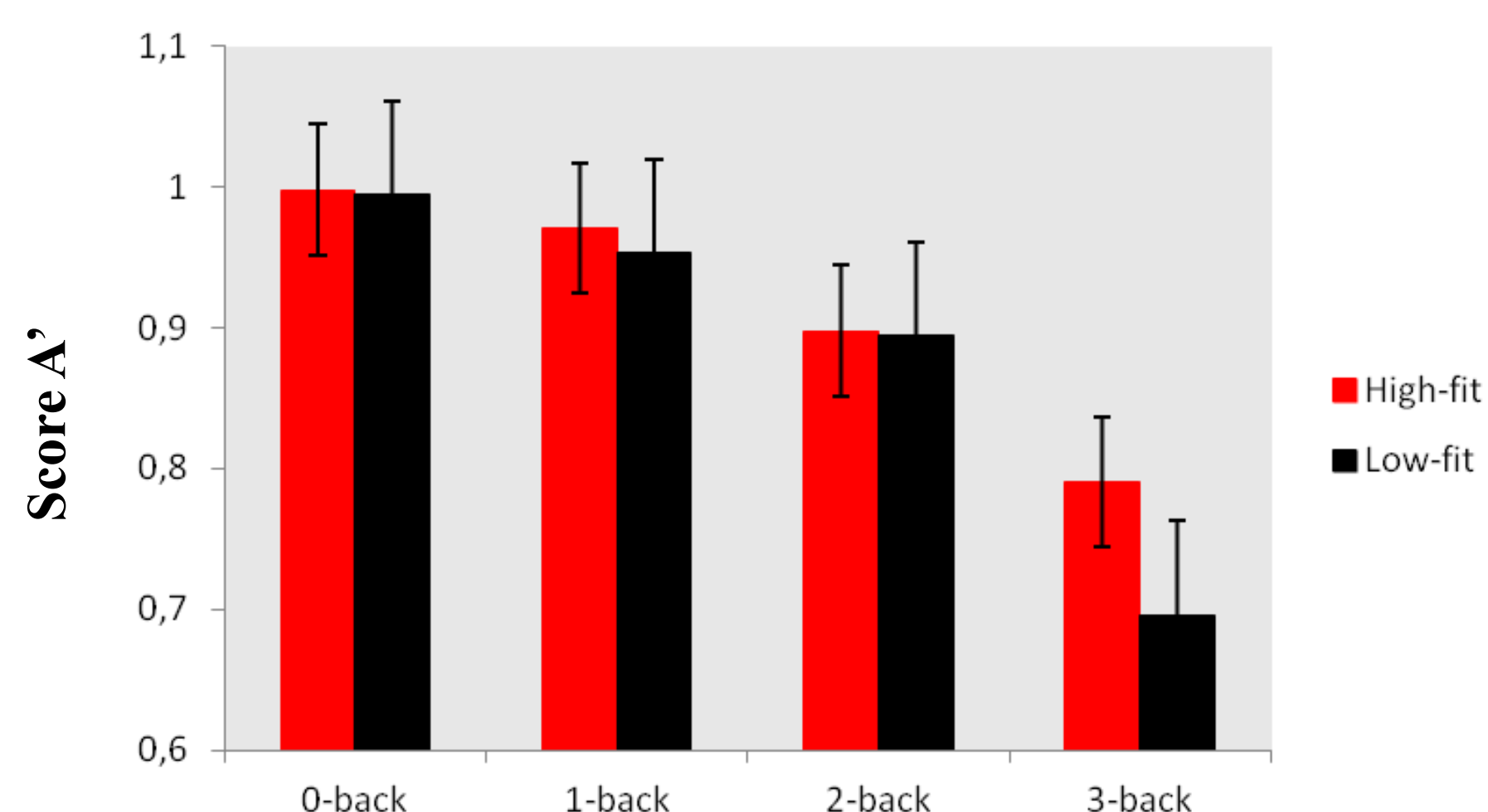


For Young adults, activation increased more in the right PFC from 1-back to 2-back, and bilaterally for the 3-back condition.

For the Elderly, activation was overall equivalent for both hemispheres and greater than the one of the Young only during the 1-back

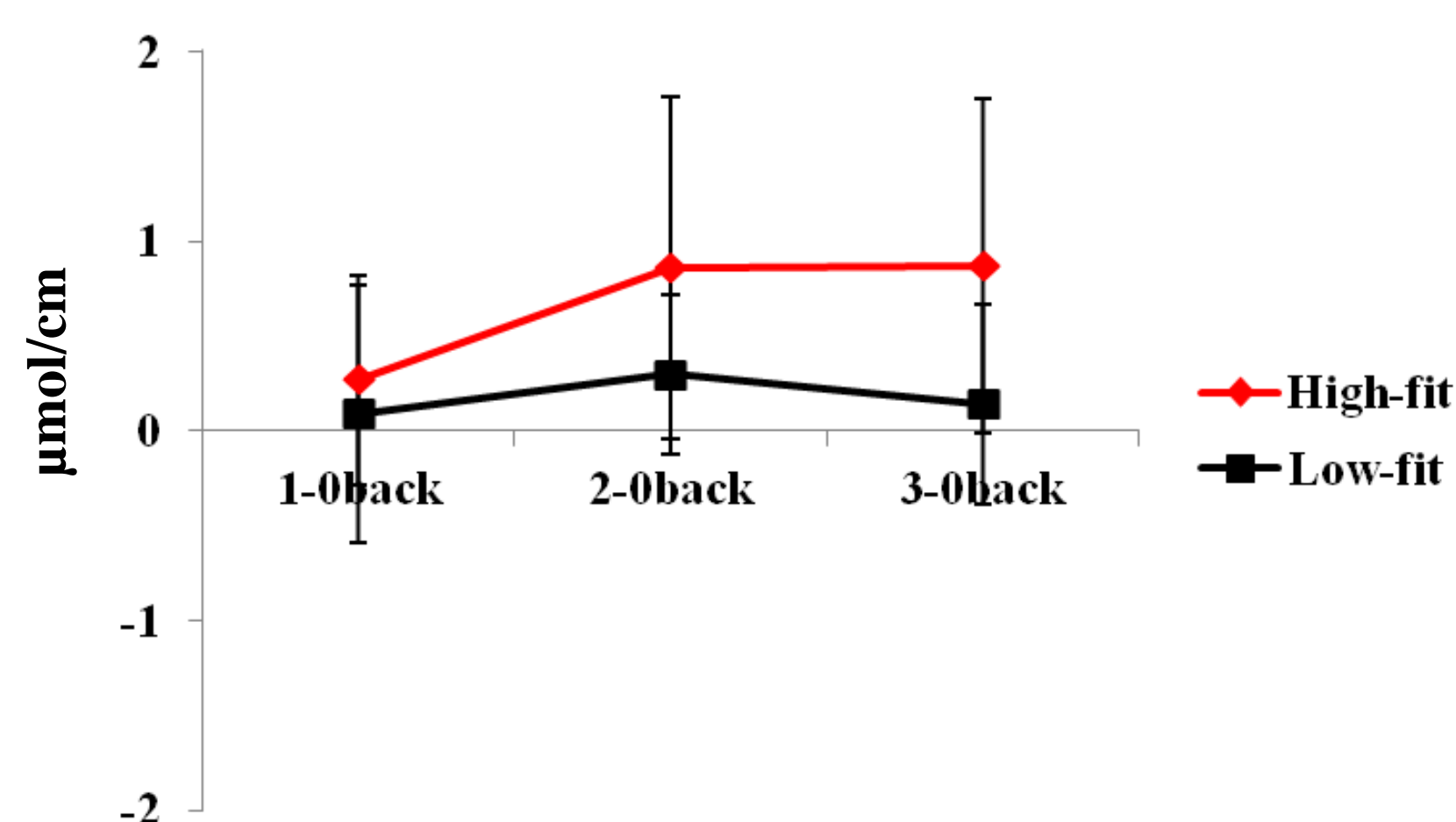
High-fit vs. Low-fit Older adults

Behavioral data



Significant greater behavioral performance for the High-fit at the most complex 3-back condition.

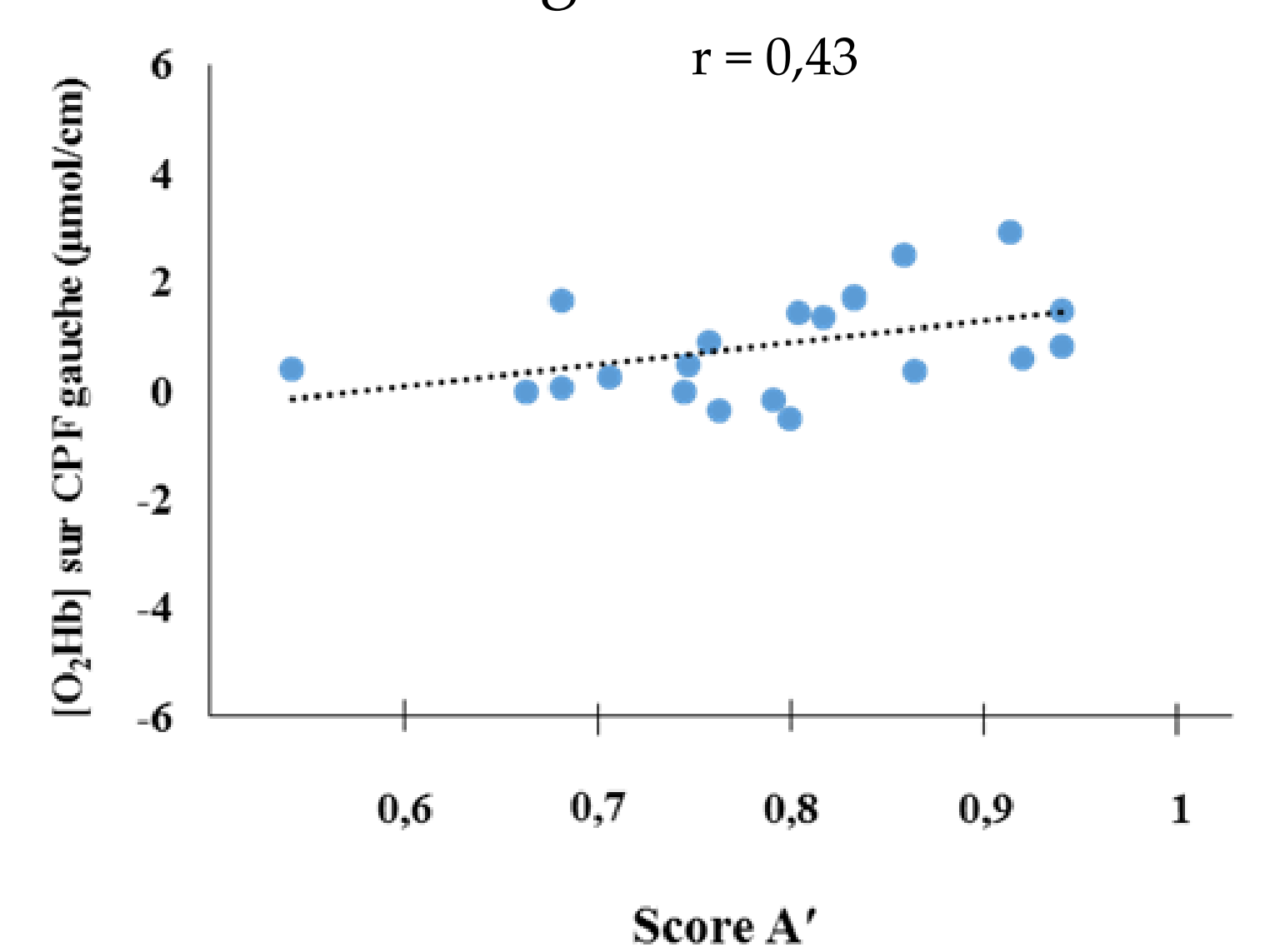
fNIRS data



For High-fit, activation significantly increased bilaterally from 1-back to 3-back.

Low-fit showed overall less activation and no significant differences between the 3 cognitive load conditions.

High-fit older adults



Significant relationship between behavioral performance and left PFC activation during the most complex 3-back condition for the High-fit.

Discussion

When comparing Young and Older participants, behavioral data fully support CRUNCH predictions (Reuter-Lorenz et Cappell, 2008), but hemodynamics data only partly. Although there was a clear bilateral overactivation under the lower levels of cognitive load for the elderly, the predicted brain activity reduction at the 3-back condition was not really observed.

This may be due, consistent with our results, to differences in CRF levels in the elderly. High-fit older adults exhibited a significant and bilateral increase in PFC activation as a function of cognitive load, whereas the corresponding response in the low-fit older adults was compromised. Although they do not completely validate the strong predictions of the CRUNCH model, these results do lend some support to the compensation hypothesis whereby overactivation or bilateral recruitment of brain regions is functionally related to better cognitive performances.

References

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