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► **To cite this version:**

Nounagnon Frutueux Agbangla, Michel Audiffren, Jean Pylouster, Cédric T. Albinet. Effect of age on behavioral performance and metabolic brain activity during dual-task. Hasan Ayaz; Frédéric Dehais. Neuroergonomics - The Brain at Work and in Everyday Life, Oct 2016, Paris, France. Elsevier, pp.235-236, 2018, Neuroergonomics - The Brain at Work and in Everyday Life. hal-02904160

HAL Id: hal-02904160

<https://hal.science/hal-02904160v1>

Submitted on 21 Jul 2020

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Effect of age on behavioral performance and metabolic brain activity during dual-task.

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Introduction

It is well documented in the literature that the attentional cost of gross motor dual-task increases with advancing age [1]. Recently, it has been demonstrated that the metabolic activity of the prefrontal cortex (PFC) decreased during walking while performing a cognitive visual task in older adults [2]. But very little works have examined the attentional cost of fine motor dual-task [3] and those few studies have not explored metabolic activity of the PFC. The objective of this study was to examine age-related effects on behavioral performance and metabolic activity of the PFC in a dual-task paradigm involving fine motor control and executive-function control.

Method

Procedure: Thirty-one adults and 33 older adults (see characteristic in table 1) performed separately and then concurrently a modified Fitts task on targets of different sizes (Index of Difficulty: IDs = 3; 4; 5 bits) and the random number generation task (RNG). Movement time (MT) and count score (CS) were the dependent variables for the modified Fitts task and the RNG task, respectively.

fNIRS data: Relative changes in concentrations of oxyhemoglobin [O₂Hb] and deoxyhemoglobin [HHb] 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. The fNIRS signals were filtered with a gaussian average filter of 1 s. To determine the level of activation, the area under the curve (AUC) [4] was calculated for [O₂Hb] and [HHb] for each experimental condition. **Statistical analysis:** Repeated measures ANOVAs were conducted on behavioral and hemodynamic data to examine age-related effects.

Table 1. Characteristic of participants

	Young	Older
Age (years)	20±1.1	70.7±5.1*
Gender (M/F)	14/17	15/18
Education (years)	14.7±0.7	11.9±3.3*
Perdue Pegboard	44.3±6.1	41.9±4.6
MMSE	-	28.9±1.2
GDS	-	6.3±4.3

*: significant difference between the two groups.

Results

Behavioral data

Single task: At the sensorimotor level, there was a main effect of ID ($p < 0.01$; $\eta^2 = .71$) and older participants' MT was consistently longer than younger participants' MT ($p = 0.05$; $\eta^2 = .06$). At the cognitive level, older participants showed greater CS (lower cognitive performance) than the young participants ($p < .05$).

Dual-task: At the sensorimotor level, the significant group \times condition interaction ($p < 0.01$; $\eta^2 = .35$) on MT (see figure 1) indicated that, compared to the single-task condition, the young participants were faster ($\approx -5\%$) in the dual-task condition, whereas the older participants increased their MT ($\approx +15\%$). Thus, the difference between young and older participants' MT increased in the dual-task condition ($p < 0.01$).

At the cognitive level, the main effect of group on CS ($p = 0.01$; $\eta^2 = .10$) indicated that, regardless of sensorimotor difficulty, the older participants showed higher CS than the young participants. The Difference in Cs comparatively to the single-task condition was not significant in any group (see figure 2).

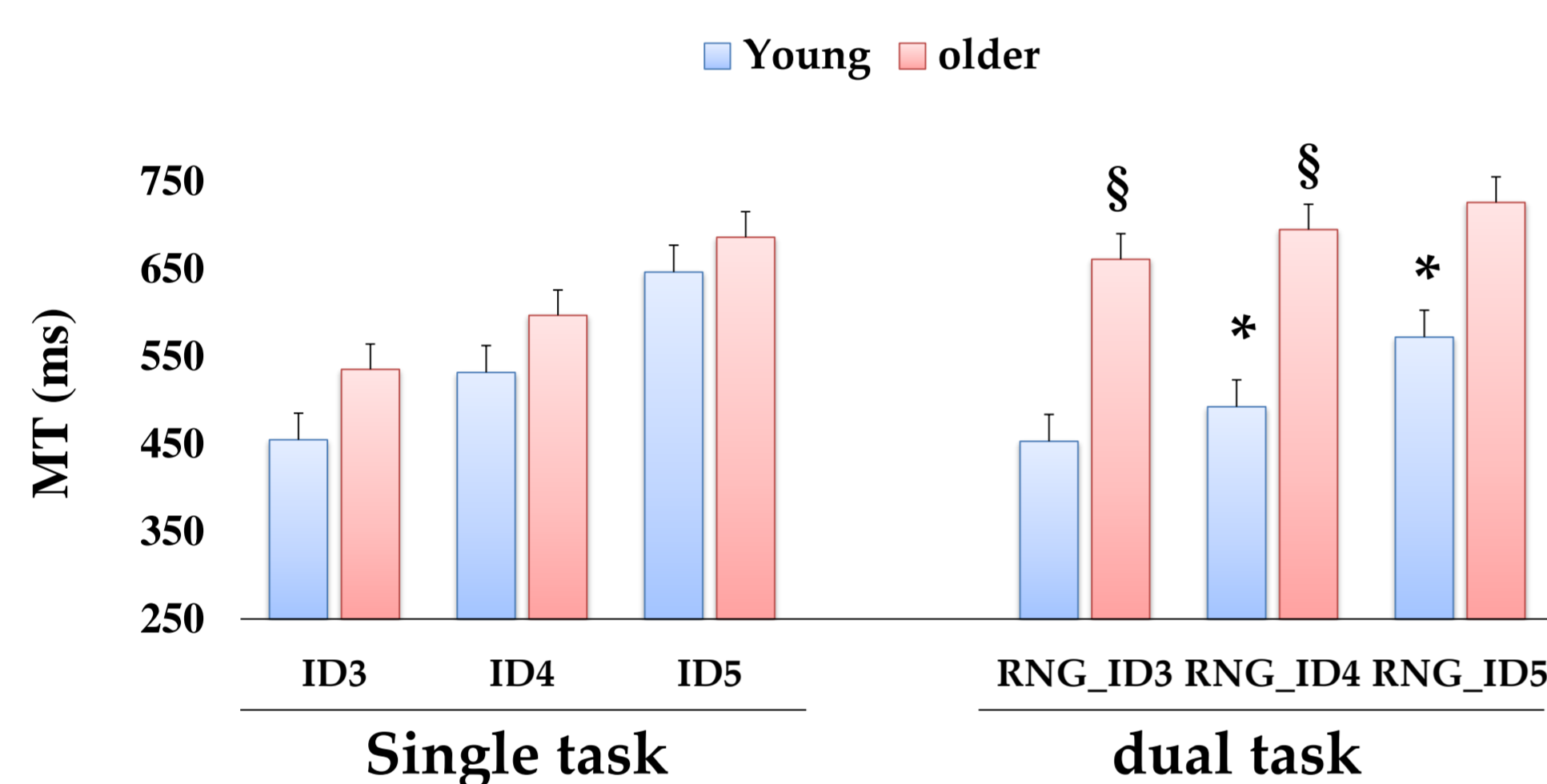


Figure 1. Evolution of MT as a function of group, ID and condition. * significantly shorter compared to single task; § significantly longer compared to single task

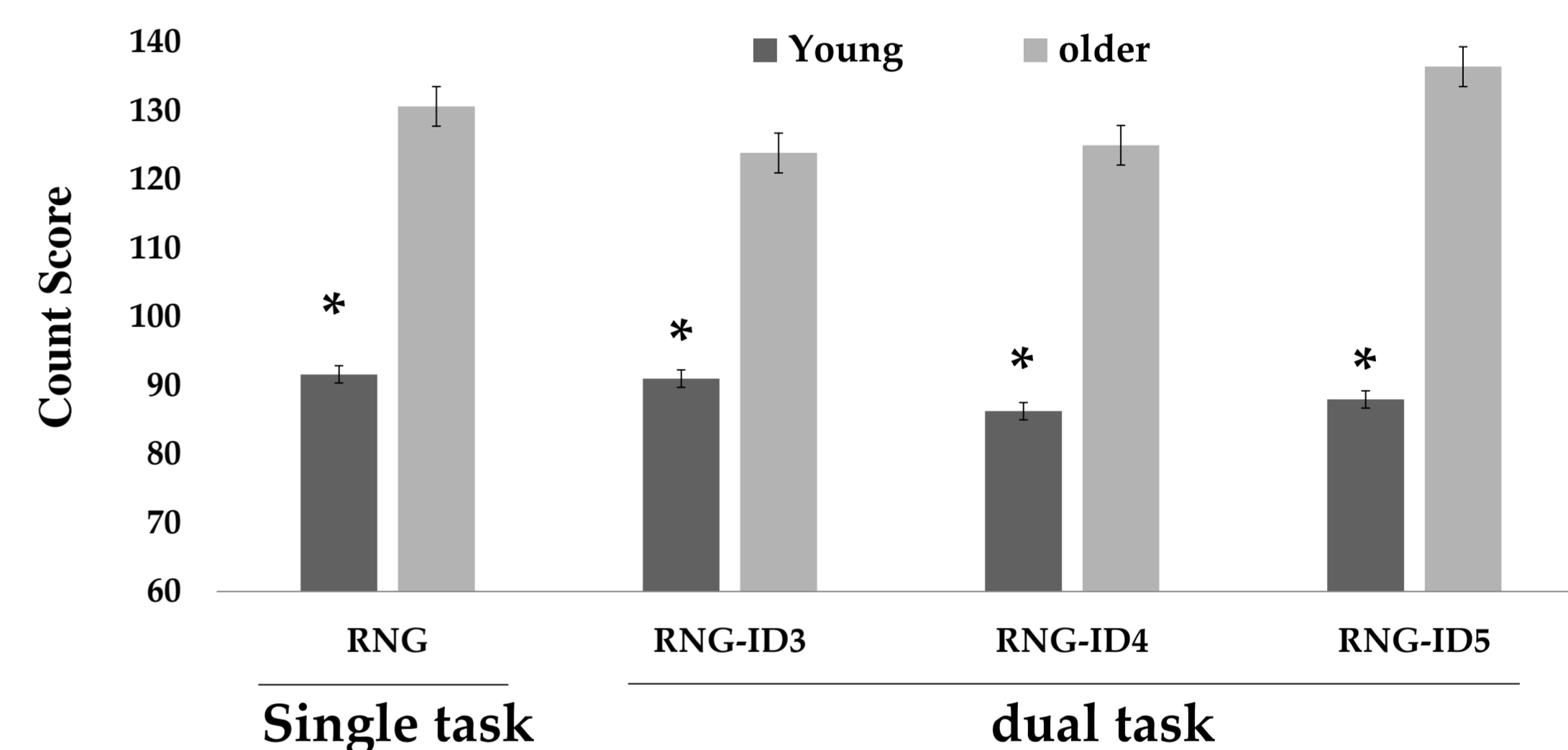
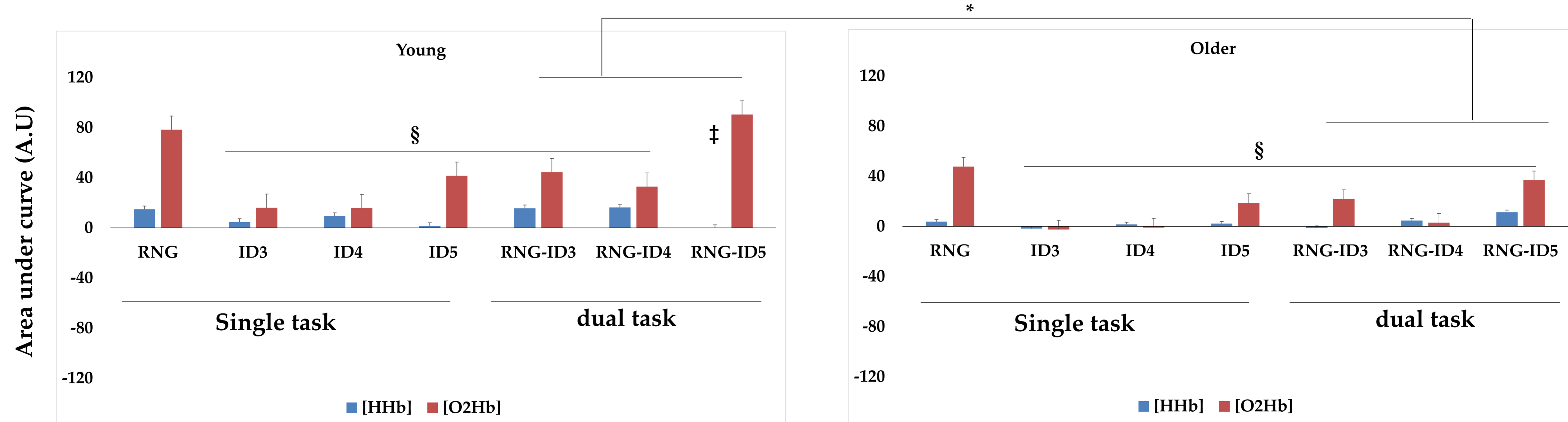


Figure 2. Evolution of CS as a function of group, ID and condition. *: significant difference between young and older adults during dual task

Hemodynamic data

The analyses of the hemodynamic parameters showed a main effect of group on [O₂Hb] ($p = 0.04$; $\eta^2 = .06$) only during the dual-task condition. In addition, the significant condition \times ID \times group interaction ($p = 0.002$; $\eta^2 = .09$) was significant. Indeed, [O₂Hb] decreased during dual-task in both groups except for RNG + ID5 in the young adults, where [O₂Hb] significantly increased (see figure 3).



*: significant difference between the young and the older participants groups during the dual-task condition; ‡: significantly more [O₂Hb] than in single RNG; §: significantly less [O₂Hb] than in single RNG.

Figure 3. Evolution of the hemodynamic parameter as a function of group, ID and condition.

Discussion

This study showed large motor dual-task cost in seniors compared to young adults, but no clear dual-task cost in the cognitive domain, neither for the young nor for the older adults. These results contradict somewhat with previous results using a similar procedure [3]. They may reflect that the seniors in the present study prioritized the cognitive performance, but consequently they did not have enough resources to perform the sensorimotor task correctly. At the hemodynamic level, our results showed a prominent activation of the PFC in the young adults compared to the seniors during the dual-task condition, particularly in the most difficult condition (RNG+ID5). This result partly agrees with those of Beurskens and collaborators [2], who showed that gross-motor dual-task (walking + visual checking task) was accompanied by lower PFC activity in seniors, and extend them to fine-motor dual-task. In sum, our results showed the involvement of the PFC in the management of two tasks and depicted age-related effects on this involvement.

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