Neural Variability of Crosstalk Effects in Dual-Tasking and Its Modulation by Age

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Introduction

- Difficulties in **dual-tasking** arise from several sources and usually increase in **advanced age** [1,2].
- Dual-tasking has been associated with increased fronto-parietal activity [3], but output-related interference, e.g., **opposing response codes,** has remained understudied.

➢ **Aim 1:** To study the neural correlates of **response-related dual-task crosstalk** and their age-related differences by implementing a **spatial auditory-manual, single-stimulus onset, dual-response paradigm** [4-6] (see Fig. 1).

➢ **Aim 2:** To investigate how we can explain crosstalk-related brain activity with **other facets of dual-task performance** in young and older adults.

Methods

➢ Participants:

43 young adults (22 ♀, Ø 25.6 ± 3.4 years old)
36 older adults (15 ♀, Ø 61.9 ± 5.5 years old)

➢ Behavioral Analysis:

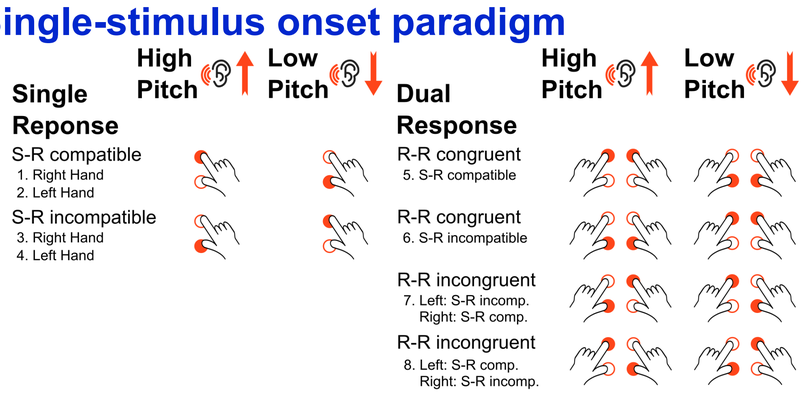
- **Dual-task costs [DTC]** on **speed**, **accuracy**, and the **Balanced Integration Score [BIS]** (combined measure of standardized accuracy and speed with higher values indicating better performance, [7]).
- 2(Age) × 2(S-R compatibility) × 2(R-R congruency) mixed ANOVA.
- Tasks used as covariates:
  - Audio-visual crossmodal **selective and focused attention tasks**
  - Forward and backward **Corsi block-tapping test** (Vienna Test System)
  - **Task-switching paradigm**

➢ fMRI Data Analysis:

- 3.0 T Siemens • Whole–brain EPI • 36 slices • TR = 2.2 s, TE = 30 ms, 3.1 mm^3 voxels ➜ Standard preprocessing with SPM12: Realignment & unwarping, slice time correction, normalization to MNI space, smoothing (FWHM 8 mm).
- **Single-subject GLM:** Event-related model with sum contrasts for **5 experimental conditions (ST_{SRC}, ST_{SRI}, DT_{SRC}, DT_{SRI}, DT_{RRI}).**
- **Group-level GLM: 10 regressors** ➜ 5 experimental conditions for each age group (YA, OA).
- **Covariance analysis models:**
  (A) BIS for S-R compatible hand in R-R incongruent trials
  (B) Selective attention compound mean reaction time
  (C) Working memory compound number of achieved sequences
  (D) Global task-switching reaction time costs (repeat vs. single)

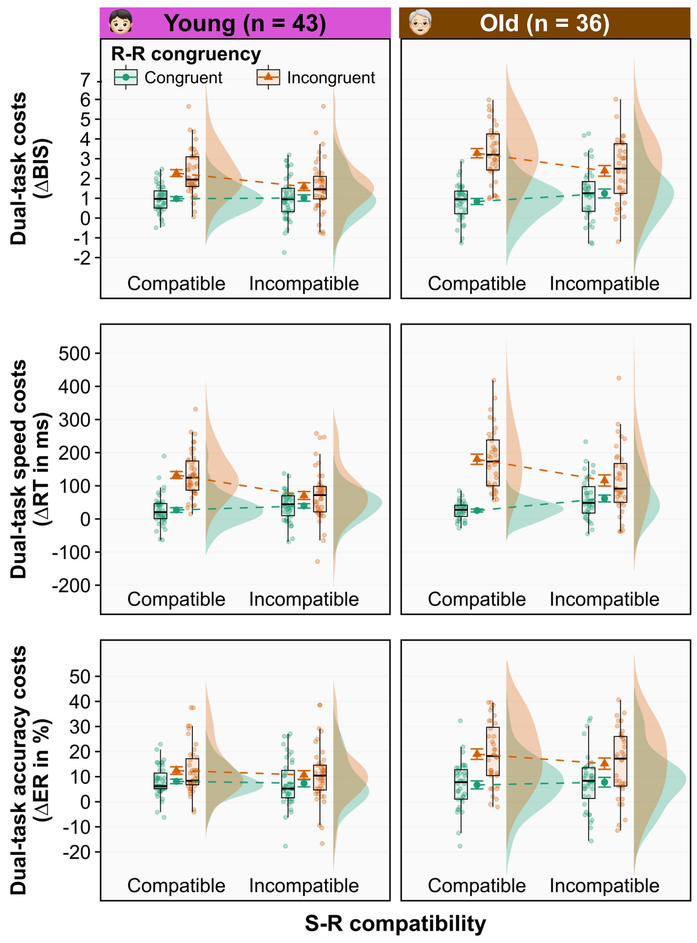
Results

Single-stimulus onset paradigm



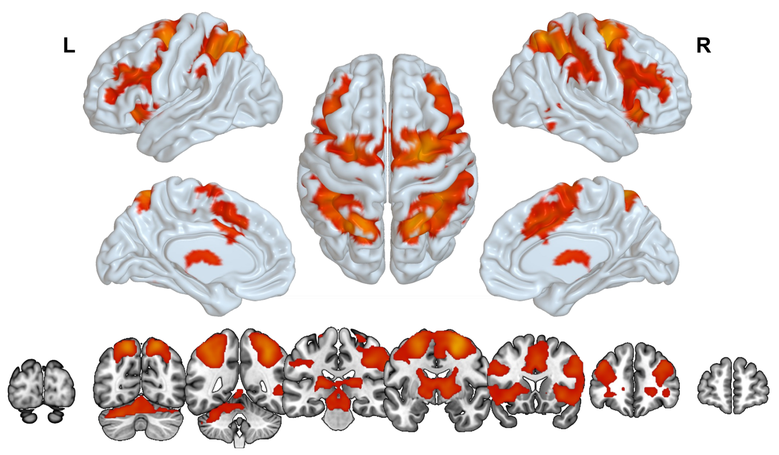
▲ **Figure 1.** Speeded choice responses to **high- or low-pitched tones** via pressing **upper or lower** response buttons with one hand (single-tasking) or both hands simultaneously (dual-tasking).

Behavioral results

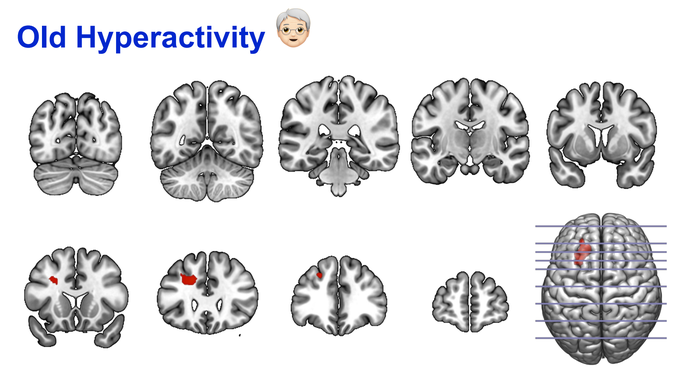


▲ **Figure 2.** Mean **dual-task costs on BIS, speed, and accuracy** according to age, stimulus–response (S-R) compatibility and response–response (R-R) congruency. Error bars represent SEM.

(A) $Dual_{RRI} \gtrless Single$



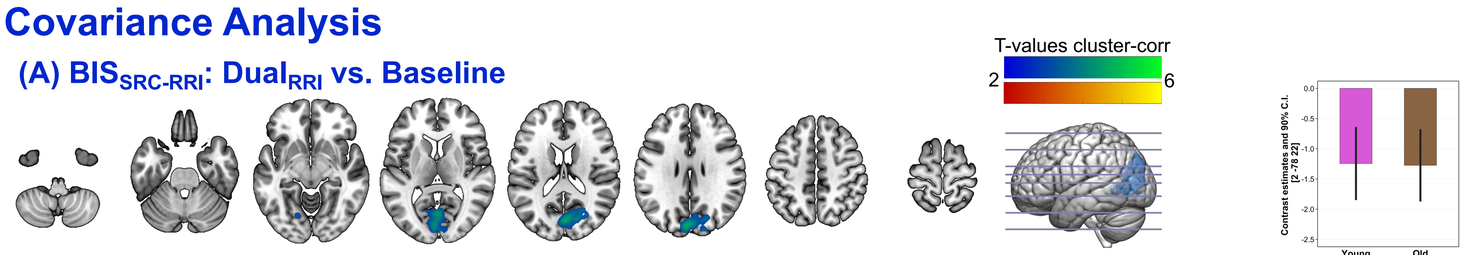
(B) $(Dual_{RRI} \gtrless Dual_{RRC}) \times Age$



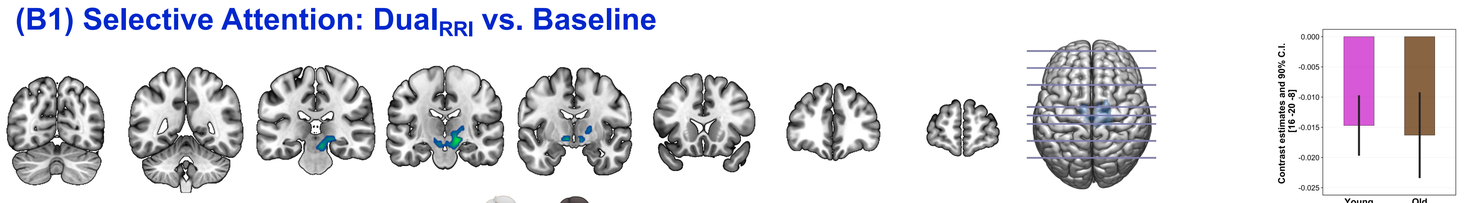
▲ **Figure 3. (A) Brain activations** associated with **response-code conflict in dual-tasking**. **(B)** Greater brain activation associated with **dual-task cross-talk in older** healthy adults. All activations significant at cluster-level FWE-corrected $p \leq .05$ (voxel-level inclusion threshold: $p < .001$).

Covariance Analysis

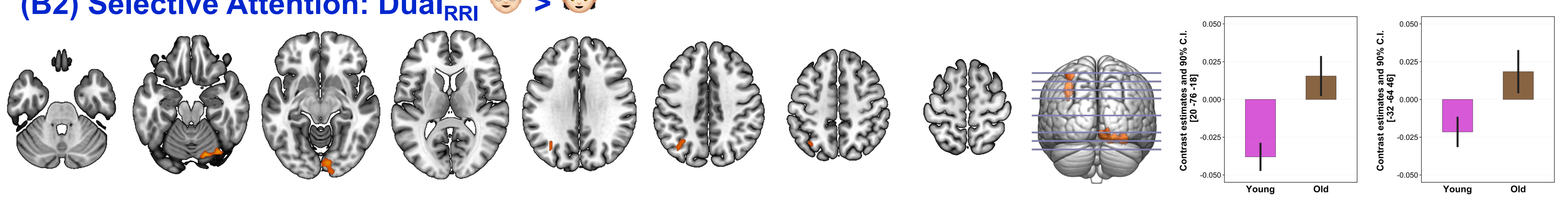
(A) $BIS_{SRC-RRI}$: $Dual_{RRI}$ vs. Baseline



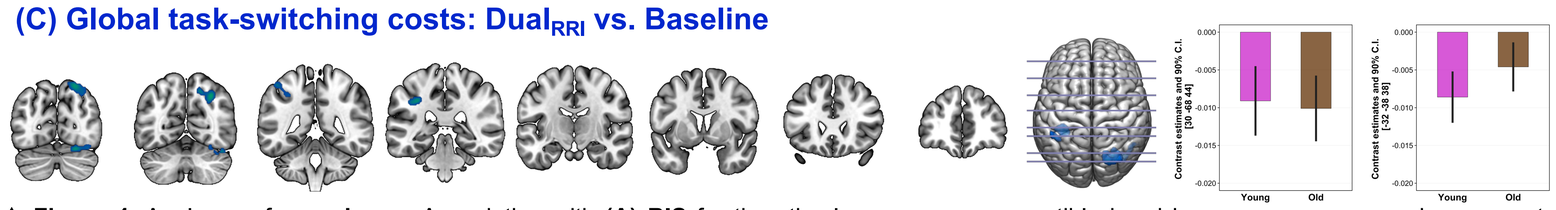
(B1) Selective Attention: $Dual_{RRI}$ vs. Baseline



(B2) Selective Attention: $Dual_{RRI}$ >



(C) Global task-switching costs: $Dual_{RRI}$ vs. Baseline



▲ **Figure 4.** Analyses of **covariance**: Association with **(A) BIS** for the stimulus–response compatible hand in response–response incongruent trials, **(B)** mean reaction time of two tasks assessing **selective attention**, and **(C) global task-switching costs**. **Working memory** did not show any significant results. All activations significant at cluster-level FWE-corrected $p \leq .05$ (voxel-level inclusion threshold: $p < .001$).

Discussion

- Dual-tasking is impeded by **opposing response codes [5,6].**
  → Fits action focus of task with motor-parietal areas involved in **sensory-to-motor coordinate transformations** [8].
  → **Extensive multiple demand network (eMDN) [3,9,10]** activity is associated with solving **response-code crosstalk** and **flexibly allocating attention to response selection**.
- Increased **response-code confusability** in **older adults** is accompanied by hyperactivity in **medial precentral gyrus** and **frontal pole**.
- **Task-specific eMDN** is linked to **divided attention** and **global switch performance** in **"low-order" motor-parietal areas.**
- **Left IPS** and **right occipito-cerebellar** areas are involved differently in **age**, and this is associated with **divided attention**.

Conclusions

➢ **Age differences** point towards a **dedifferentiation** pattern or **inter-individual variability in attentional strategies**.

➢ **DT performance (BIS)** is only related to **task-irrelevant visual cortex** activity, but **some task-activated regions** are associated with **other facets of dual-tasking** ➜ Individual activity patterns linked to dual-task performance differences?

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Acknowledgments: This study was supported by the Deutsche Forschungsgemeinschaft (DFG, LA 3071/3-1), the National Institute of Mental Health (R01-MH074457), the Helmholtz Portfolio Theme Supercomputing and Modeling for the Human Brain, and the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreements 720270 (HBP SGA1), 785907 (HBP SGA2).