Response-Related Crosstalk in Dual-Tasking and Its Modulation by Age

Lya K. Paas Oliveros[1,2 *], Aleks Pieczykolan[3,4], Rachel N. Pläschke[2], Edna C. Cieslik[1,2], Simon B. Eickhoff[1,2], & Robert Langner[1,2]

[1] Institute of Systems Neuroscience, Heinrich Heine University Düsseldorf, Düsseldorf, Germany;
[2] Institute of Neuroscience and Medicine (INM-7: Brain and Behaviour), Research Centre Jülich, Jülich, Germany
[3] Institute of Psychology, University of Würzburg, Germany
[4] Human Technology Center, RWTH Aachen University, Aachen, Germany

* l.paas.oliveros@fz-juelich.de

63 .
TAGUNG EXPERIMENTELL
ARBEITENDER PSYCHOLOGEN
ULM / 14-17 March 2021

TeaP @Home

ULM 2021

Dual-tasking

- Dual-tasking:
  - Requires parallel activation and maintenance of two task sets
    - ➢Susceptible to mutual interference (i.e., **crosstalk**) (Koch et al., 2018; Pashler, 1994; Pieczykolan & Huestegge, 2019)

- Central capacity-sharing model within parallel processing perspective (Navon & Miller, 2002; Tombu & Jolicœur, 2003)
  - Cross-modal studies: Asymmetrical cost allocation in dual-tasking (Huestegge & Koch, 2009, 2010; Pieczykolan & Huestegge, 2014)
    → Spatial response-related crosstalk is a major determinant for dual-task costs
  - **Flexible and strategic resource allocation** to shield tasks and avoid response crosstalk
    (Fischer & Plessow, 2015; Hazeltine et al., 2006; Huestegge et al., 2018; Koch et al., 2018; Lehle & Hübner, 2009; Pieczykolan & Huestegge, 2019)

Dual-tasking and Aging

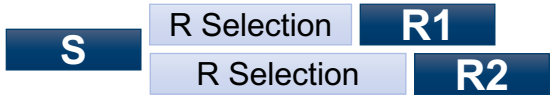
- Healthy aging:
  - ➢ Deterioration in processing speed and various cognitive domains
  - ➢ Detrimental effects of dual-tasking are pronounced with a decline in speed and accuracy

    (Koch et al., 2018; Verhaeghen, 2011; Verhaeghen et al., 2003)
  - ➢ However, studies often ignore the response-related interference

1. Investigate how spatially incongruent mapping selection processes affect dual-task performance and examine whether and how these effects are modulated by age

2. Assess the replicability of the effects in the MRI scanner (Experiment 2)

Single-Stimulus Onset Paradigm



High Pitch Low Pitch

Single Task

1. Right Hand
(2. Left Hand)
S-R compatible

3. Right Hand
(4. Left Hand)
S-R incompatible

Dual Task

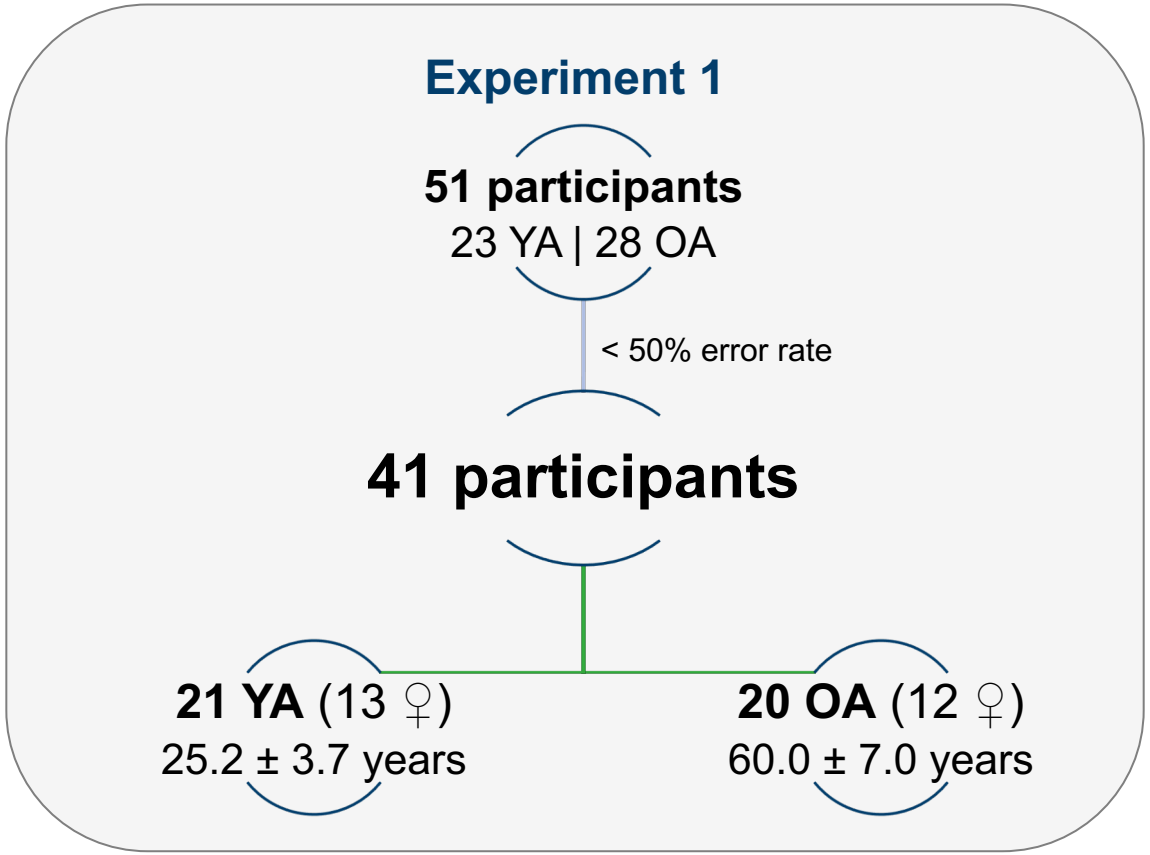
5. Both Hands
S-R compatible

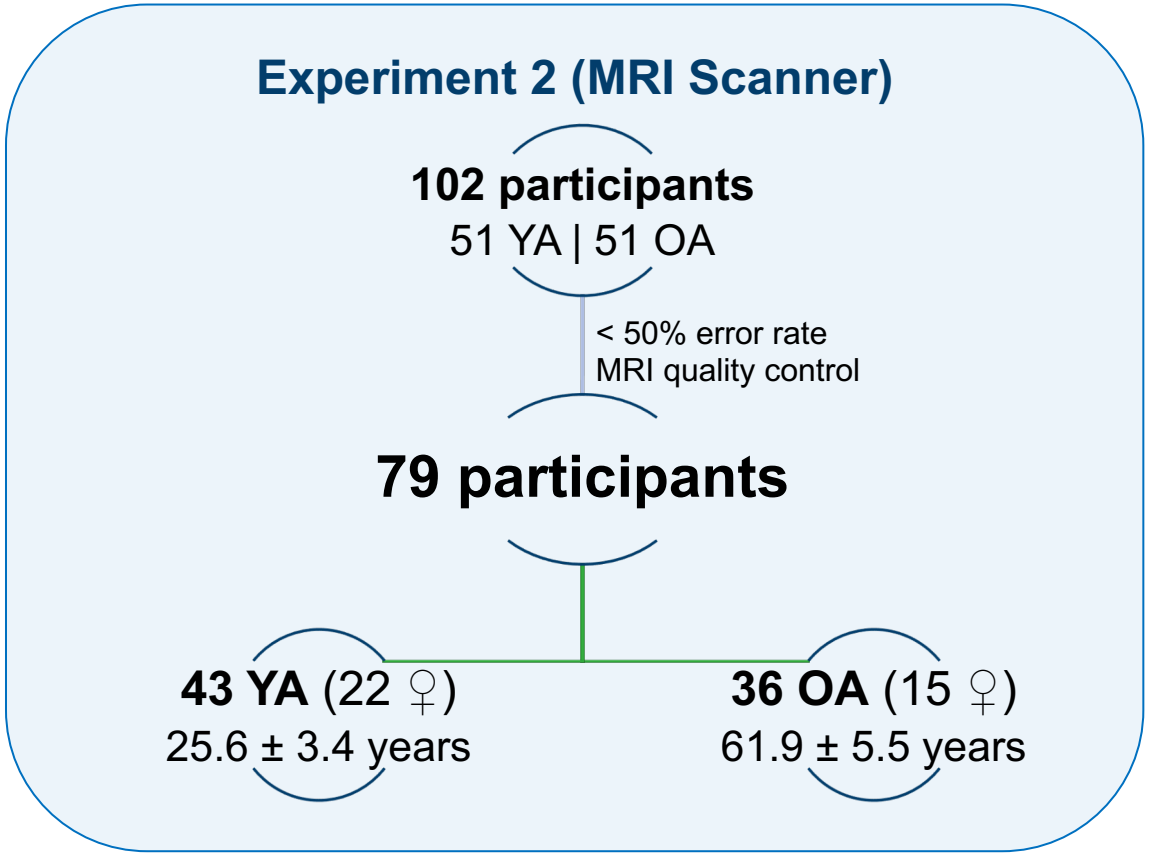
6. Both Hands
S-R incompatible

7. Both Hands
Left S-R incompatible
Right S-R compatible
R-R incongruency

8. Both Hands
Left S-R compatible
Right S-R incompatible
R-R incongruency

Sample


Experiment 1
51 participants
23 YA | 28 OA
< 50% error rate
41 participants
21 YA (13 ♀)
25.2 ± 3.7 years
20 OA (12 ♀)
60.0 ± 7.0 years


Experiment 2 (MRI Scanner)
102 participants
51 YA | 51 OA
< 50% error rate
MRI quality control
79 participants
43 YA (22 ♀)
25.6 ± 3.4 years
36 OA (15 ♀)
61.9 ± 5.5 years

Statistical Analysis

Behavioral assessment

- Dual-task costs
  - RT (dual) – RT (single)
  - ER (dual) – ER (single)
- BIS costs (speed and accuracy)

2 × 2 × 2

Mixed repeated-measures ANOVA

Stimulus–response [S-R] compatibility

Response–response [R-R] congruency

Age

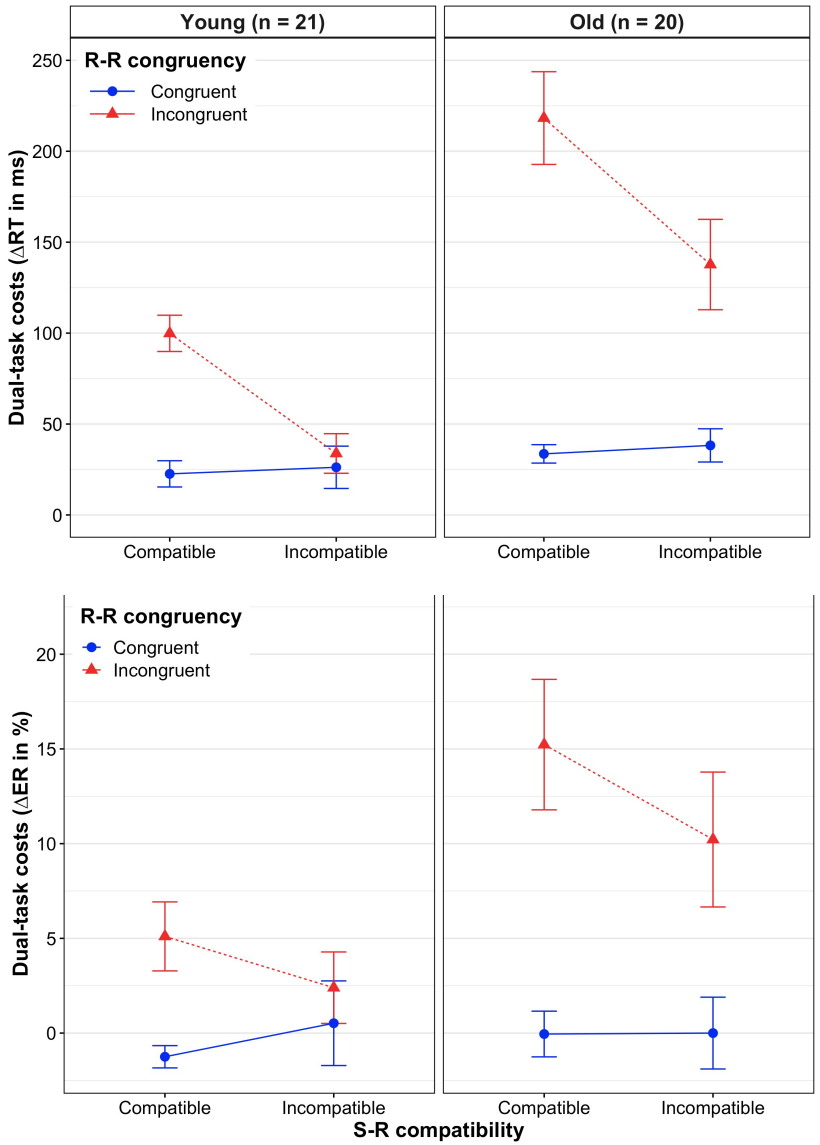
Balanced integration score (BIS)

(Liesefeld et al., 2019)

$$BIS_{i,j} = z_{PC_{i,j}} - z_{\overline{RT_{i,j}}}$$

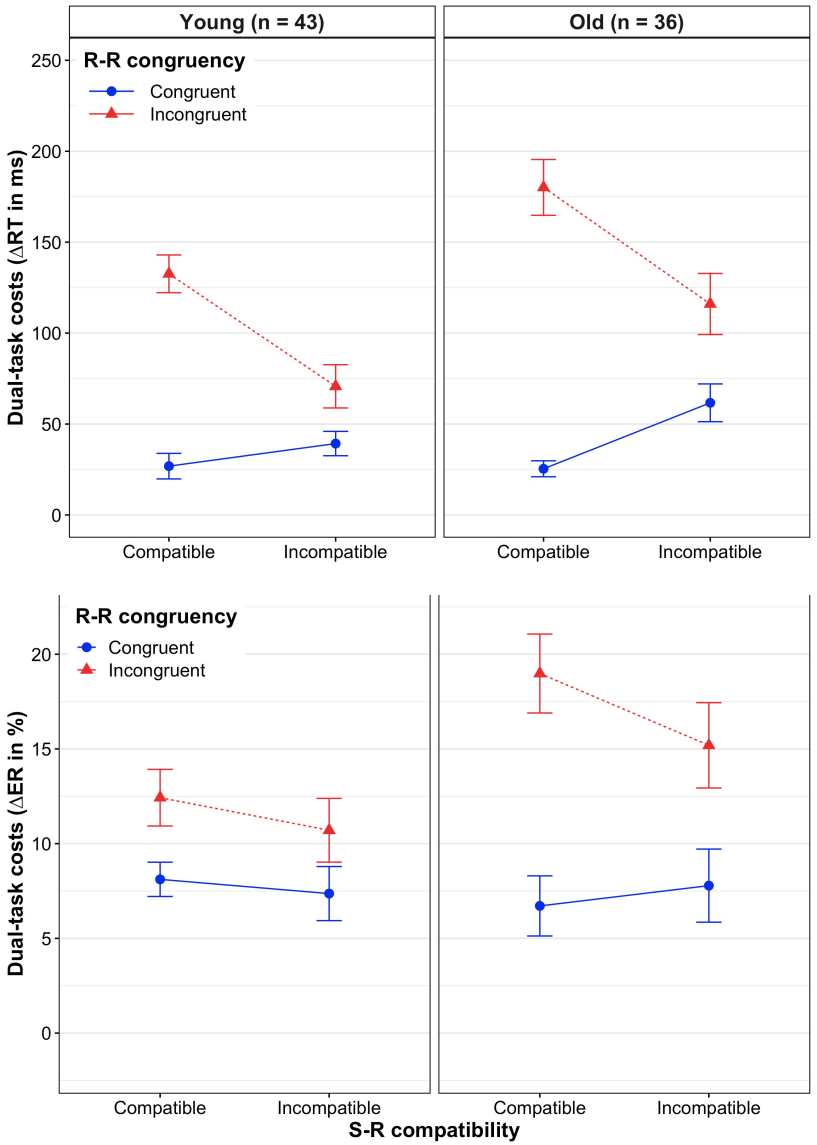
$$\text{with } z_{x_{i,j}} = \frac{x_{i,j} - \bar{x}}{S_x}.$$

Dual-task speed and accuracy costs

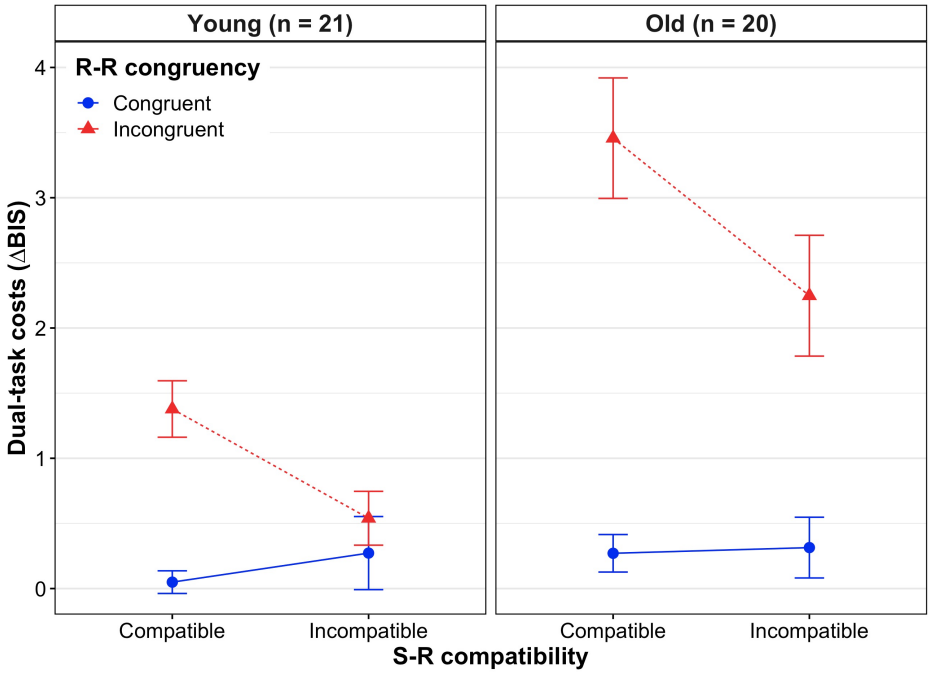


Experiment 1

Experiment 2

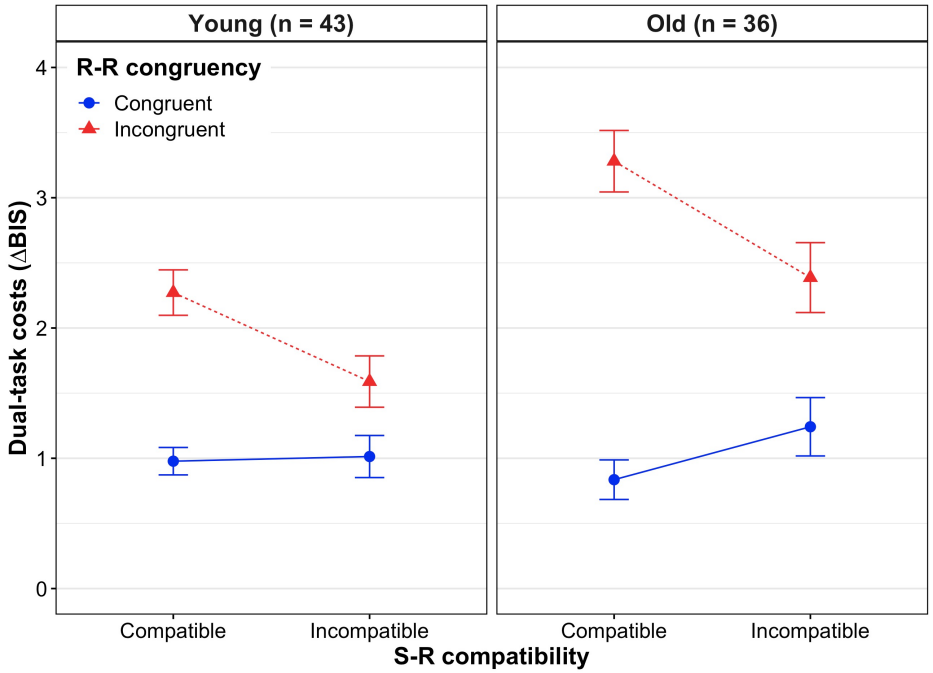


Dual-task performance costs (BIS: Accuracy and speed)

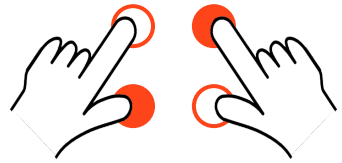


Experiment 1

Experiment 2



Conclusions



- Two spatially conflicting manual tasks → Response-related conflict
  - Asymmetric cost allocation: The more demanding task is prioritized over the easier one
    - **Strategic prioritization** of limited processing capacity
    - **Flexible allocation of attentional resources**

- Crosstalk effect is accentuated by **age**
  - Age-related increased **susceptibility to response-code confusability**
  - Deficits shielding tasks within the context of multiple-action control

- Effects can be **reproduced** inside the MRI scanner

THANK YOU FOR YOUR ATTENTION

References

Fischer, R., & Plessow, F. (2015). Efficient multitasking: parallel versus serial processing of multiple tasks. Frontiers in Psychology, 6(September), 1–11.

Hazeltine, E., Ruthruff, E., & Remington, R. W. (2006). The role of input and output modality pairings in dual-task performance: Evidence for content-dependent central interference. Cognitive Psychology, 52(4), 291–345.

Huestegge, L., & Koch, I. (2009). Dual-task crosstalk between saccades and manual responses. *Journal of Experimental Psychology: Human Perception and Performance*, *35*(2), 352–362.

Huestegge, L., & Koch, I. (2009). Dual-task crosstalk between saccades and manual responses. *Journal of Experimental Psychology: Human Perception and Performance*, *35*(2), 352–362.

Huestegge, L., Pieczykolan, A., & Janczyk, M. (2018). Backward crosstalk and the role of dimensional overlap within and between tasks. Acta Psychologica, 188(June), 139–147.

Koch, I., Poljac, E., Müller, H., & Kiesel, A. (2018). Cognitive structure, flexibility, and plasticity in human multitasking—An integrative review of dual-task and task-switching research. *Psychological Bulletin, 144*(6), 557–583.

Lehle, C., & Hübner, R. (2009). Strategic capacity sharing between two tasks: evidence from tasks with the same and with different task sets. Psychological Research, 73(5), 707–726.

Liesefeld, H. R., & Janczyk, M. (2019). Combining speed and accuracy to control for speed-accuracy trade-offs(?). *Behavior Research Methods*, *51*(1), 40–60.

Navon, D., & Miller, J. (2002). Queuing or Sharing? A Critical Evaluation of the Single-Bottleneck Notion. *Cognitive Psychology*, *44*(3), 193–251.

Pashler, H. (1994). Dual-task interference in simple tasks: Data and theory. *Psychological Bulletin, 116*(2), 220–244.

Pieczykolan, A., & Huestegge, L. (2014). Oculomotor dominance in multitasking: Mechanisms of conflict resolution in cross-modal action. *Journal of Vision*, *14*(13), 1–17.

Pieczykolan, A., & Huestegge, L. (2019). Action scheduling in multitasking: A multi-phase framework of response-order control. Attention, Perception, and Psychophysics.

Tombu, M., & Jolicœur, P. (2003). A central capacity sharing model of dual-task performance. *Journal of Experimental Psychology: Human Perception and Performance*, *29*(1), 3–18.

Verhaeghen, P. (2011). Aging and Executive Control: Reports of a Demise Greatly Exaggerated. *Current Directions in Psychological Science, 20*(3), 174–180.

Verhaeghen, P., Steitz, D. W., Sliwinski, M. J., & Cerella, J. (2003). Aging and dual-task performance: A meta-analysis. *Psychology and Aging, 18*(3), 443–460.