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Age Differences in Cognitive Demands of Walking: From Dual-Task Research to Assisted Cognition

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Whole-body Motion in Dual-tasked Walking

When cognitive and sensorimotor tasks are performed simultaneously, older adults usually show greater dual-task costs than younger adults in either or both domains. Studying postural control while standing, Huxhold et al. (2006) proposed a dual-process account for sensorimotor-cognitive interactions:

- **internal versus external attentional focus (age-general):** sensorimotor performance benefits from a simple concurrent cognitive task
- **cross-domain resource competition (age-specific):** elderly require more attentional resources for "automatized" motor activities; increasing cognitive load challenges them more than younger adults.

Here, we parametrically manipulated cognitive task difficulty (WM load in the *n*-back task), and assessed walking performance using a novel measure of regularity in whole-body coordination.

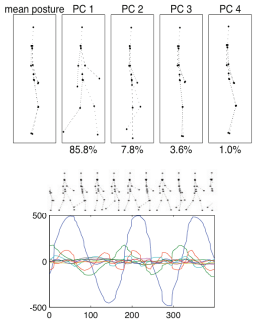
Methods

Participants. 96 healthy adults (20-30, 60-70, and 70-80 years), 16 women and men per group.

Procedure. Working memory task varying in load while sitting versus treadmill-walking at preferred speed. Whole-body motion recorded in 3D (VICON).

Dependent variable in motor domain. Whole-body motion quantified by *residual variance* (PCA).

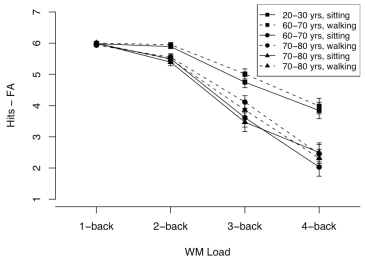
Dependent variable in cognitive domain. Hits minus false alarms in working memory task (1-, 2-, 3-, and 4-back).



Results

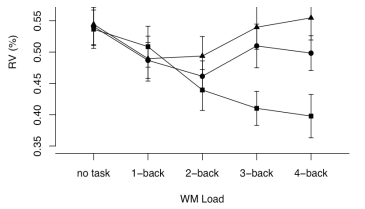
Cognitive Performance

- lower performance in older adults, in particular with higher load
- no adverse effects of walking on cognition
- hence, age differences in walking performance are easily interpretable



Residual Whole-body Variance

- no task vs 1-back: main task effect
- 1-/2-/3-/4-back: age-group by WM-load interaction
- trends for WM load: negative for 20-30, positive for 70-80 year-olds
- corresponding effects are less pronounced or absent for step-related variability measures



Discussion

Results support the dual-process account proposed by Huxhold et al. (2006). Residual variance (RV), as a whole-body measure, efficiently captured subtle differences in walking regularity. In on-going work, we attempt to separate adaptive and dysfunctional forms of postural variability.

References

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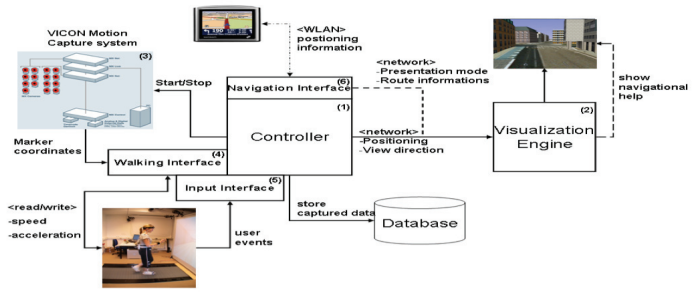
A Laboratory Evaluation Framework for Pedestrian Navigation Systems in Old Age

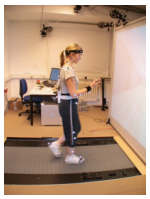
By continuously adjusting the balance between "environmental support" and "self-initiated processing" in person-specific and aging-sensitive ways, intelligent assistive technology can promote successful aging by enhancing cognitive resource allocation. (Lindenberger & Lövdén, 2006; Lindenberger, Lövdén, Schellenbach, Li, & Krüger, in press)

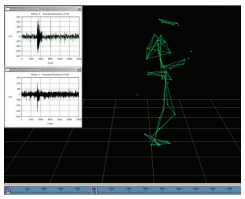
Experimental Setup



Equipment

- Floor-based treadmill
- Power wall for visualization
- Vicon Motion Capture System with 11 infrared cameras and synchronisation to other sensor technology (e.g. EMG/EEG)





Experiment on "Net Resource Release"

- Older adults use up cognitive resources for walking that are therefore not available for navigation (Lövdén et al., 2005)
- To be helpful, navigation aids need to release more cognitive resources than are required for its operation.
- If navigation aids are too complex, they will decrease gait stability in older adults

Methods

Participants

- 18 younger men (21-28 yrs.), 18 older men (68-77 yrs.)

Procedure

- Balance and cognitive tests; familiarization to treadmill walking in virtual environments (e.g., Schellenbach et al., in prep.)
- Navigational tasks in virtual environments at preferred walking speed (2 sessions). Variation in navigation aid: no support, virtual guide, and map. Whole-body motion recording in 3D (VICON)

Measures

- navigation performance; motor performance: gait patterns and regularity of whole-body motion

Preliminary Results

Both age groups benefit most by the virtual guide. Older adults perform better with with the virtual guide than with a map. Analyses of gait patterns to delineate the relation between navigation performance and walking are in progress. Preliminary results suggest similar effects of support on walking as for navigation performance.

Conclusions

Our results demonstrate that the effectiveness of different kinds of navigational assistance vary by context and individuals' sensorimotor and cognitive resources. Better knowledge about the interaction between walking stability and cognitive load in old age may serve to improve the usability of mobile navigation systems in old age.

These studies are part of the **Sensorimotor-Cognitive Couplings** project (scientific investigators: **Sabine Schaefer**, **Martin Lövdén**, **Ulman Lindenberger**; predocs: **Michael Schellenbach** & **Julius Verrel**). The project investigates lifespan changes in the interactions between sensorimotor and cognitive aspects of behavior, using multiple-task settings with a high degree of everyday validity. A related goal is to propose and test criteria for effective technological assistance in old age.