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**The COGITO Study:
Overview of Research Design, Past Work, and Data Access**

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The COGITO Study: Funding and Principal Investigators

Collection of the core data of the COGITO Study, consisting of 100 daily assessments of 12 cognitive tasks in 101 younger and 103 older adults, started in 2006. The study was made possible by a grant from the Innovation Fund of the President of the Max Planck Society (to UL). Additional sources of funding for data analysis and later data collections include the Sofja Kovalevskaja Award administered by the Alexander von Humboldt Foundation and donated by the German Federal Ministry for Education and Research (to ML), and the Gottfried Wilhelm Leibniz Award 2010 of the German Research Foundation (to UL).

The principal investigators of the original COGITO Study are Ulman Lindenberger, Martin Lövdén, and Florian Schmiedek. For the purpose of making the data set available to other researchers, a Steering Committee of the COGITO Study has been formed. Currently, this committee consists of Annette Brose, Ulman Lindenberger, Martin Lövdén, and Florian Schmiedek.

Major Scientific Objective

One of the central goals in designing the COGITO Study was the comparative analysis of between-person versus within-person structures of cognitive abilities. Between-person structures have been at the heart of research on the structure of human intelligence for over a century. Within-person structures capture changes and fluctuations within individuals and have been investigated less often (and, if so, more in relation to affect and motivation than in relation to cognitive performance). There is no strong reason to expect a close correspondence of between-person and within-person structures (e.g., Borsboom et al., 2003; Molenaar, 2004; Nesselroade, 1991; Voelkle et al., 2014). Hence, it was deemed of fundamental importance to examine within-person structures, assess their heterogeneity, and compare them to between-person structures.

Study Design and Overview of Past Work (Selection)

The core data set of the COGITO Study comprises two Cattellian data cubes with 100 repeated daily assessments of twelve cognitive tasks, one cube representing data from 101 younger adults aged 20 to 31 years, and another cube representing data from 103 older adults aged 65 to 80 years. The cognitive task battery includes computerized versions of three tasks of working memory, three tasks of episodic memory, and six tasks of perceptual speed (three two-choice decisions and three perceptual comparison tasks), with contents balanced across verbal, numerical, and figural-spatial domains. The twelve tasks were also assessed before and after the 100 daily assessments along with a large battery of standardized tests of cognitive abilities. To avoid ceiling and floor effects, the presentation times of the three working memory tasks and the three episodic memory tasks were individually adapted to individuals' performance levels and then kept constant across the 100 daily assessments. A close description of the twelve practiced tasks can be found in Schmiedek et al. (2010). Florian Schmiedek is the scientist primarily responsible for the cognitive battery of the COGITO Study.

The design of the COGITO Study allows researchers to model individual within-person structures based on the same tasks and the same number of observations as the corresponding between-person structures, and to compare them to each other (Schmiedek, Lövdén, von Oertzen, & Lindenberger, 2016). Given that each task has been measured with at least two blocks of trials in each session, systematic fluctuations in performance across sessions can be separated from short-term fluctuations across blocks, which allows, for example, comparing the amount of systematic fluctuations across age groups (Schmiedek, Lövdén, & Lindenberger, 2013).

The assessment of daily within-person fluctuations is not restricted to cognition but also includes other psychological constructs such as task-related motivation, positive and negative

affect, stressful events, and various aspects of coping, as well as physical health. Annette Brose is the scientist primarily responsible for this part of the study. The non-cognitive constructs in the COGITO Study have been analyzed in their own right (e.g., Brose et al., 2011), as possible antecedents of daily cognitive performance (e.g., Brose et al., 2010, 2012, 2014), or in the context of structural between- versus within-person comparisons (Brose et al., 2015; Voelkle et al., 2014).

With 100 sessions of practice on a broad battery of challenging cognitive tasks, the COGITO Study also qualifies as a cognitive training study of unusually high dosage and long extension. Hence, the study was designed with an eye on assessing transfer effects. A comprehensive battery of broad cognitive abilities based on measures not included in the daily assessments was administered before and after the practice sessions. The broad cognitive abilities represented in this transfer assessment battery include reasoning, episodic memory, and perceptual speed, assessed with nine tasks each from the Berlin Intelligence Structure Test (Jäger, Süß, & Beauducel, 1997), as well as three basic and three more complex measures of working memory. In combination with the relatively large samples, this broad psychometric representation of cognitive abilities allows for the investigation of training and transfer effects (as well as individual differences therein) at the level of latent ability factors (Schmiedek, Lövdén, & Lindenberger, 2010). Members of the COGITO group have scrutinized the nature and assessment of cognitive plasticity (Lindenberger, 2014; Lövdén et al., 2010; Noack et al., 2014), and these discussions have contributed to a critical appraisal of the available evidence on transfer of training in cognitive intervention studies (e.g., Makin, 2016).

To separate training from retest effects, the COGITO study includes control groups of 44 younger and 40 older adults who completed the pretest, posttest, and follow-up assessments at comparable time delays as the training group samples. Given that these participants were not invited to the daily assessments, they qualify as a passive control group. Note, however, that the pretest and posttest assessments in the COGITO Study lasted for ten sessions each, regardless whether individuals belonged to the treatment or to the control group. To estimate long-term effects of the cognitive intervention (Schmiedek, Lövdén, & Lindenberger, 2014) and to link individual differences in processes that operate on a day-to-day level to individual differences in longer-term development, the cognitive battery of transfer tests was administered again two years after the termination of the posttest assessment. The two-year follow-up also included a ten-day repeat of the original 100-day daily assessments. On the initiative of Julia Wolff, scales of social support and health behaviors were added to the daily protocol (Wolff et al., 2012, 2013, 2016).

The pretest, posttest, and follow-up assessments of the COGITO Study also include a large number of trait measures from the domains of personality (e.g., NEO-PI-R), well-being (e.g., the PANAS), stress, and coping. These measures were included to relate individual differences in within-person fluctuations (as measures in the course of the 100 days) to individual differences in well-established trait markers of psychological constructs, and to evaluate possible effects of cognitive training beyond cognition (Sander et al., 2017).

Furthermore, the COGITO Study seeks to link individual differences in behavior to neural levels of analysis. At pretest and posttest, subsamples of younger and older individuals underwent structural magnetic resonance imaging (MRI; 1.5-T GE Signa), functional MRI (3-T Siemens Trio and 1.5-T GE Signa), and electroencephalography (EEG).

Martin Lövdén is primarily responsible for the MRI data of the COGITO Study. The structural MRI protocol consists of a T1-weighted sagittal 3-D spoiled gradient-echo (SPGR) image and a diffusion-weighted spin-echo-refocused echoplanar imaging sequence (12 gradient orientations; 4 averages). Adaptations of the two-choice decision tasks (3-T Siemens Trio), the numerical working memory task (3-T Siemens Trio), and the numerical episodic memory task (1.5-T GE

Signa) were the functional protocols. Group (treatment versus control) by time (pretest vs. posttest) interactions indicate that reliable cognitive intervention effects on white matter were restricted to the genu of the corpus callosum (Lövdén et al., 2010), and that reliable effects on grey matter were confined to cerebellar volumes (Raz et al., 2013). In another series of analyses, individual differences drawn from the 100 daily assessments were related to structural or functional MRI-based parameters. Examples concern neural correlates of perceptual decision-making (Kühn et al., 2011) and intrusive thoughts (Kühn et al., 2013) as well as associations between frontal brain volume and cognitive variability (Lövdén et al., 2013).

The EEG assessment battery was originally assembled by Christian Chicherio, who is now at the University of Geneva. At present, Markus Werkle-Bergner is primarily responsible for the EEG data of the COGITO Study. EEG was recorded from 60 scalp and three EOG channels (1000 Hz sampling rate, 0.01-250 Hz analog filter). Data is available for two resting state conditions (eyes-closed and eyes-open; 3 min each), as well as three perceptual speed task with verbal, figural, and numerical content. Analyses of EEG data thus far have focused on the temporal stability and cognitive ability correlates of individual alpha peak frequency (Grandy et al., 2013a, 2013b), as well as on the within-trial coordination of rhythmic neural activity during perceptual decision making (Werkle-Bergner et al., 2014).

The COGITO Study also has established direct links to two other longitudinal studies. First, subsamples of the COGITO Study were successfully recruited into the Berlin Aging Study II (BASE-II; Bertram et al., 2014). In addition to cognitive testing, BASE-II also comprises in-depth medical exams and GWAS genotyping. Hence, individual differences in practice gains were examined as a function of allelic differences in candidate genes (Bellander et al., 2015). Second, a sizable proportion of the COGITO Study participants, including those who joined BASE-II, were added to the German Socioeconomic Panel Study (SOEP; Wagner, Frick, & Schupp, 2007).¹

The series of figures, COGITO Data Description, provides a schematic rendition of the overall design of the COGITO Study, including the main variables that can be made available for data analysis to other researchers (see below).

COGITO Conference

The Max Planck Institute for Human Development was proud to host the COGITO Conference 2016, entitled "The COGITO Study: Looking at 100 Days Ten Years After" in October. The aim of the conference was to discuss methodological and conceptual implications of the COGITO Study from 2006. To this end, world leading behavioral scientists with a strong interest and expertise in methodology, individual differences, and adult development were invited to take a fresh look at the COGITO Study. As a result, a selection of articles will soon be published in the journal *Multivariate Behavioral Research* (Boker & Martin, 2018; Bulteel et al., 2018; Ghisletta et al., 2018; Hamaker et al., 2018).

How to Access Data of the COGITO Study

The collection, storage, use, and disclosure of personal data are strictly regulated in Germany.² For this reason, the COGITO Study data set cannot be put in the public domain. However, parts of the data set can be made available for specific analysis projects under the condition that the relevant data protection rules are met.

¹ Specifically, the BASE-II sample includes 43 and 13 younger as well as 70 and 26 older participants from the COGITO training and control groups, respectively. The SOEP sample includes 42 and 16 younger as well as 81 and 29 older participants from the training and control groups, respectively. There is considerable overlap among the participants included in the two studies.

² For more information, see https://en.wikipedia.org/wiki/Informational_self-determination.

We encourage colleagues to come up with specific data analysis projects of the COGITO Study data set and invite them to contact us for data transfer requests. **Please fill out the form, “COGITO Data Transfer Request,” and send the form as an email attachment to Charles Driver via COGITO@mpib-berlin.mpg.de.**

The transfer of data to your institution will require some paperwork, including a formal contract between the Max Planck Institute for Human Development and your research institution. Charles Driver will assist you with this work.

Documentary of the COGITO Study

A documentary of the COGITO study, produced by filmmaker Joachim Lühning, is available for streaming at the Institute’s website: <https://www.mpib-berlin.mpg.de/en/media/mediathek>. In addition, you can also watch it on YouTube: <https://youtu.be/ijbHF2Pe7Lo>.

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³ As of January 2019.

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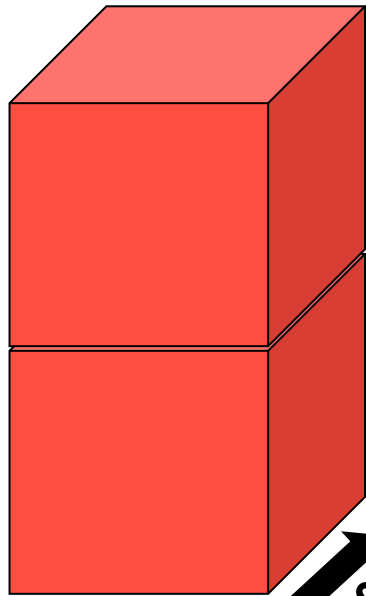
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COGITO's Cognitive Cubes

101 Younger & 103 older adults



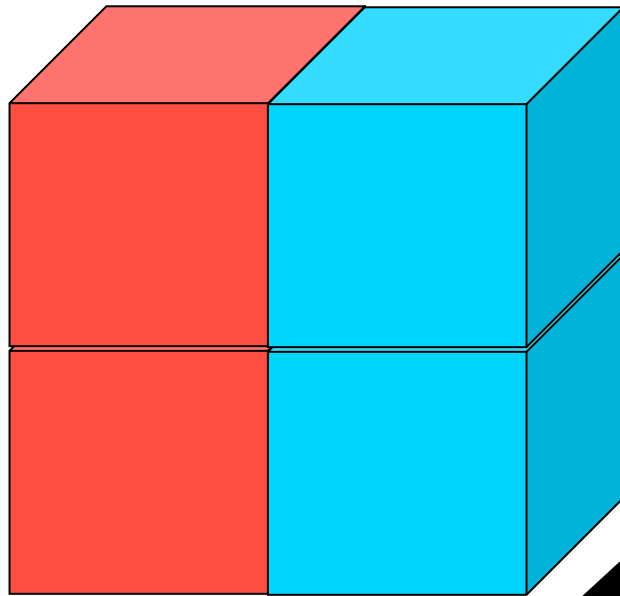
12 cognitive tasks

100 daily sessions

	Verbal	Numerical	Figural/ Spatial
Perceptual Speed	Comparison tasks		
	Choice reaction tasks		
Episodic Memory	Word memory	Number memory	Object position memory
	Alpha Span	Memory Updating	N-Back

COGITO's Self-report Cubes

101 Younger & 103 older adults



Self-report
items/scales

100
daily
sessions

Before cognitive tasks:

Mood/Affect: PANAS & Happiness
Sleep: quality & quantity
Health: constraints of daily activities
Events: 8 event categories (DISE) + others
Stress: perceived stress & control
Coping: rumination, self-regulation, distraction, reappraisal, suppression, avoidance, planning
Task-related motivation

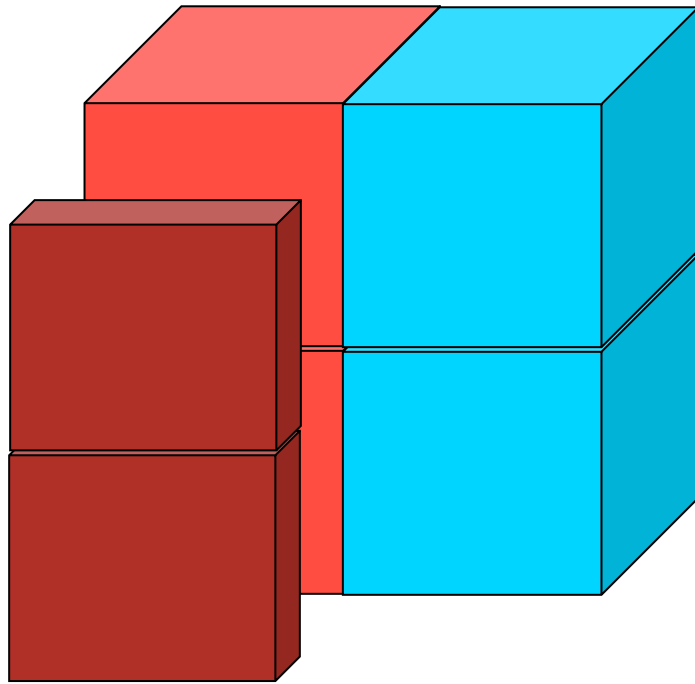
After cognitive tasks:

Evaluation of performance
Distraction
Enjoyment & effort

Brose, Schmiedek, Lövdén, Molenaar & Lindenberger (2010)
Brose, Schmiedek, Lövdén, & Lindenberger (2011, 2012)

COGITO's Cognitive Baseline Measures

101 Younger & 103 older adults



Cognitive
pretest

Intensive assessment of 12 daily tasks:

→ Varying presentation times for working/episodic memory

Transfer tasks:

Reasoning (13)

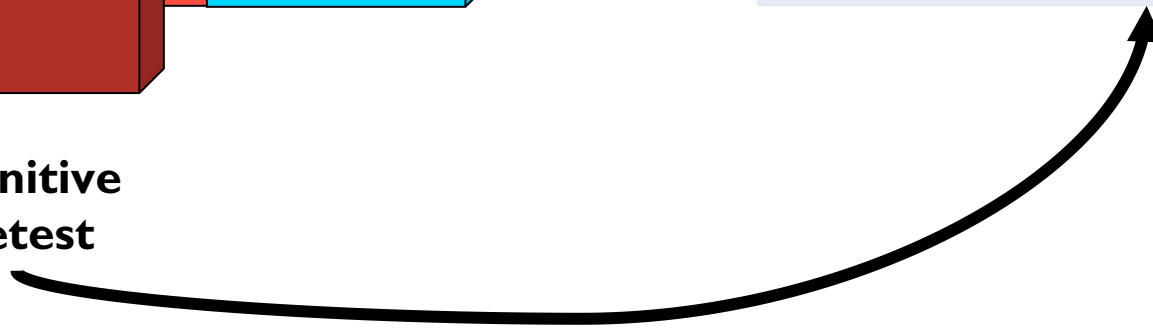
Episodic memory (10)

Working memory updating (3)

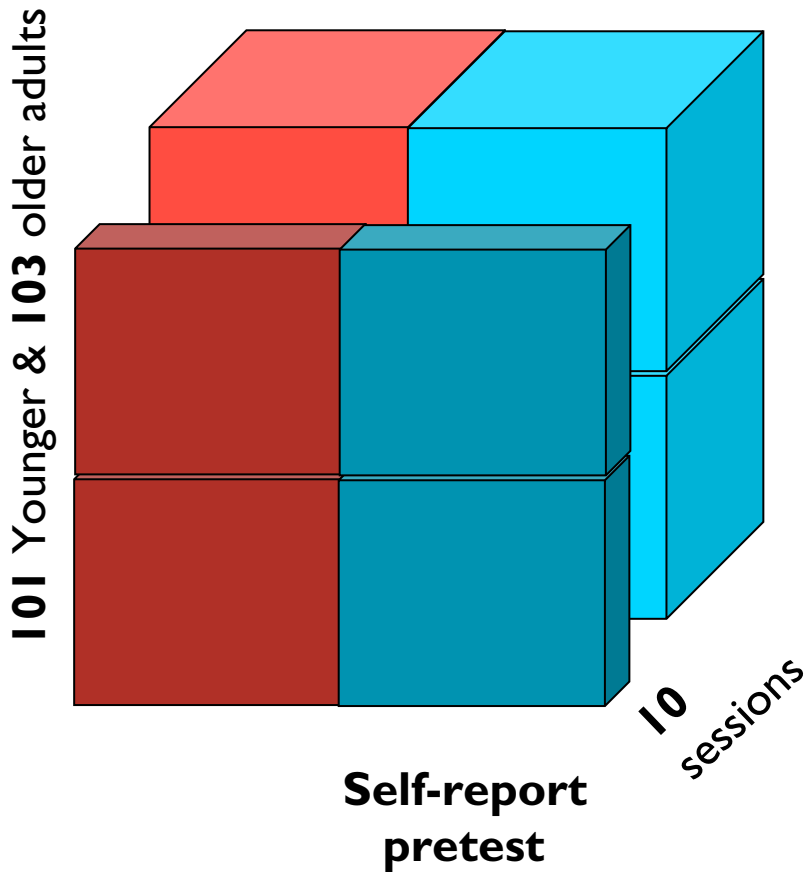
Working memory complex span (3)

Processing speed (13)

Vocabulary (1)



COGITO's Self-report Baseline Measures



Personality:

- Big Five
- Self efficacy
- Control beliefs
- Self regulation
- Emotion regulation
- Affect intensity

Well-being/Health:

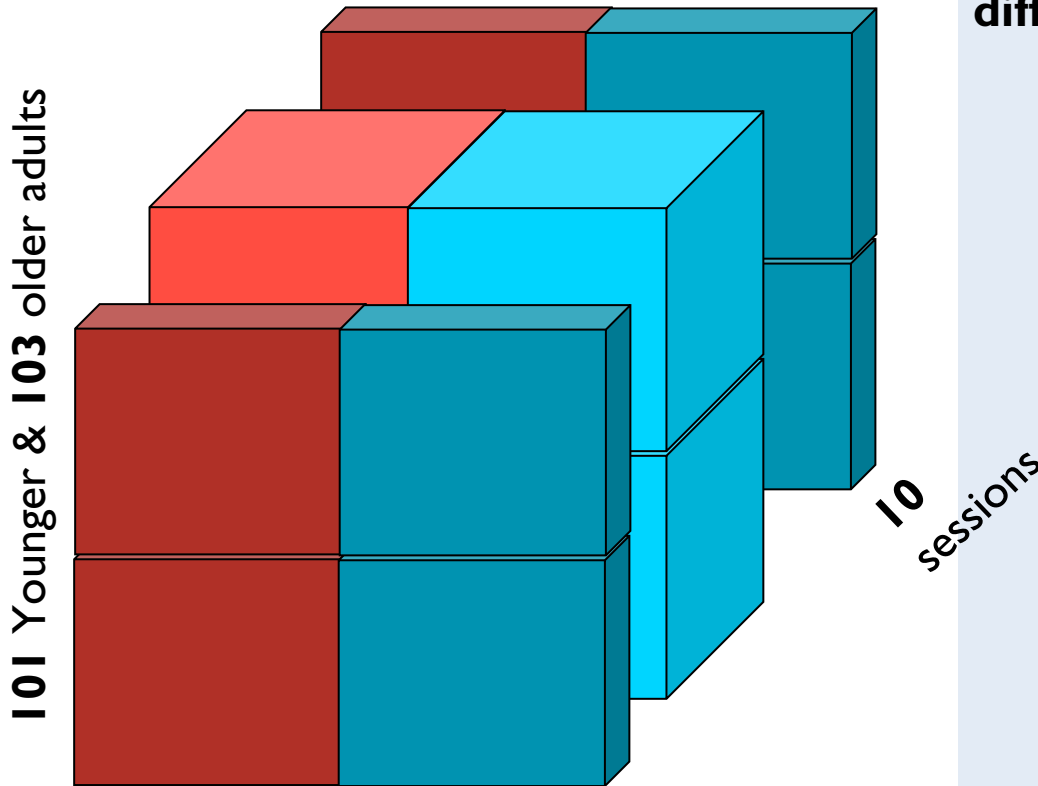
- Life satisfaction
- Affective well-being
- Psychological well-being
- Depressive symptoms
- Physical symptoms
- Major illnesses
- Alcohol consumption
- Information on chronotype, seasonality

Stress:

- Major life events
- Perceived stress
- Chronic stress
- Coping



COGITO's Posttest



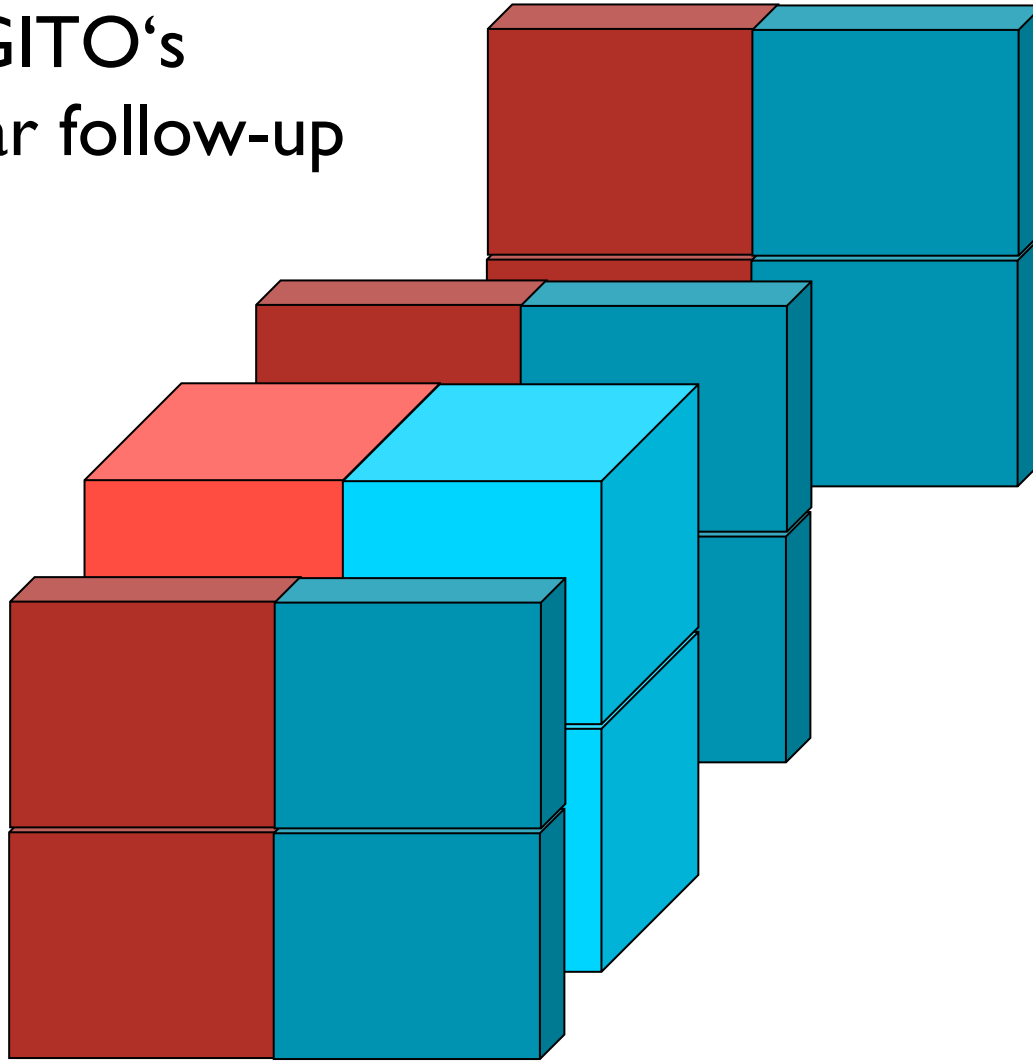
Posttest:
**Repetition of cognitive pretest +
different self-report scales:**

- Physical activity
- Social and cultural engagement
- Personal interests
- Social support
- Goal pursuit & adjustment
- Screening of psychopathological symptoms
- Typical intellectual engagement
- Beliefs about memory

Study evaluation: enjoyment,
motivation, strategy use

COGITO's 2-year follow-up

101 Younger & 103 older adults



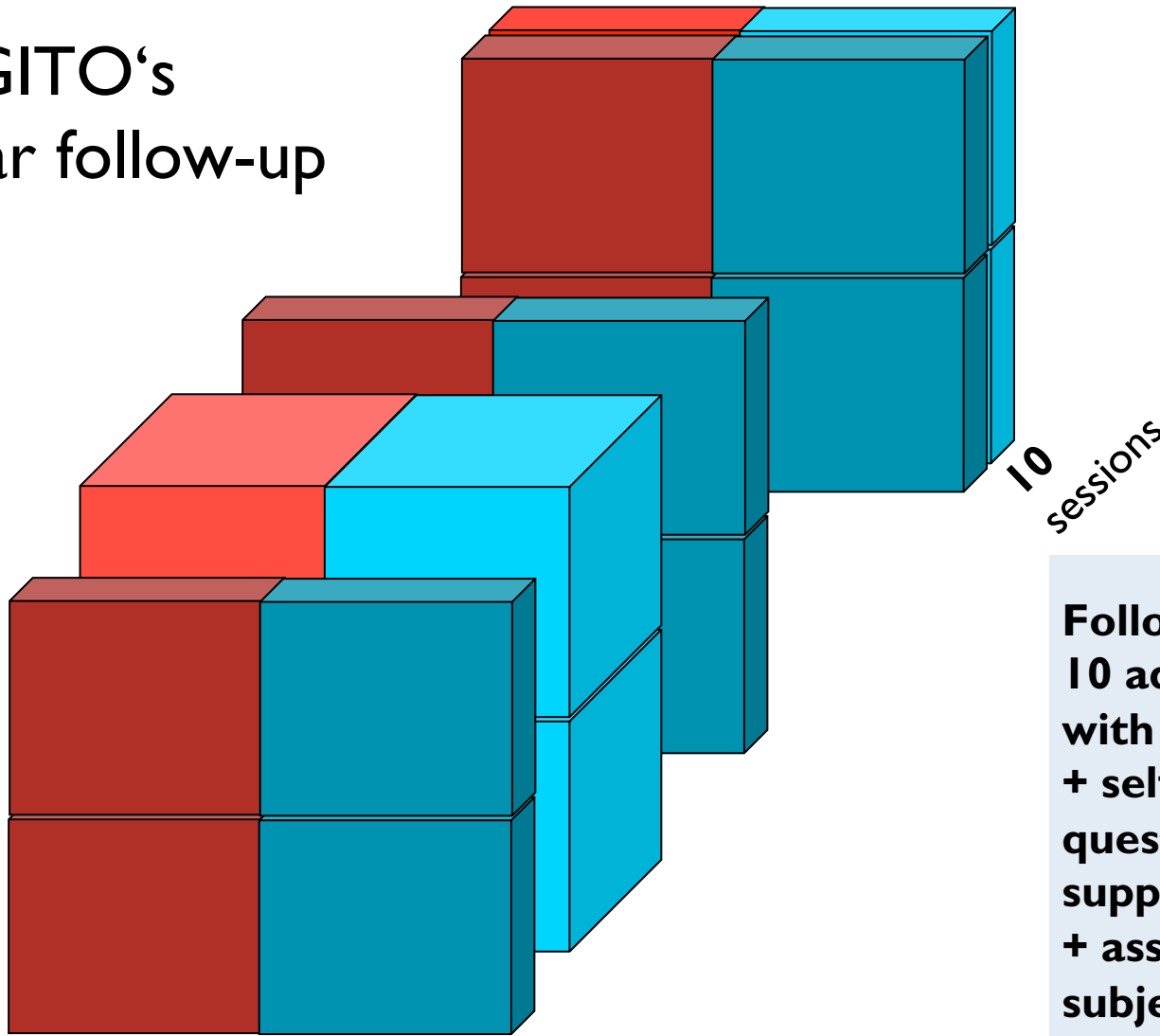
10
sessions

**Follow-up:
Repetition of
cognitive pretest +
partly different self-
report scales:**

- Self-esteem
- Social support & integration
- Health behaviors

COGITO's 2-year follow-up

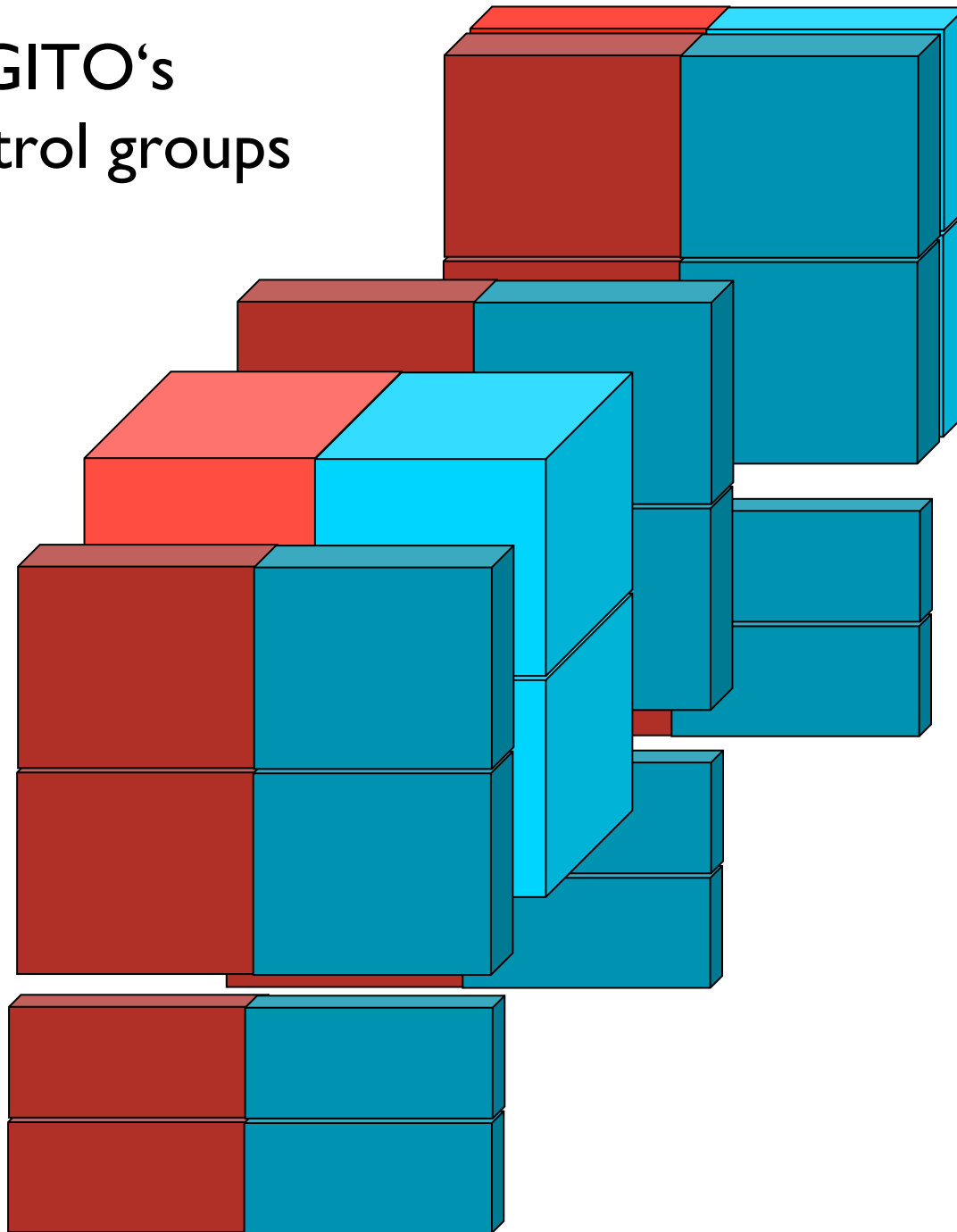
101 Younger & 103 older adults



Follow-up:
10 additional sessions
with daily protocol
+ self-report
questions on social
support
+ assessment of
subjective and
objective physical
fitness

COGITO's Control groups

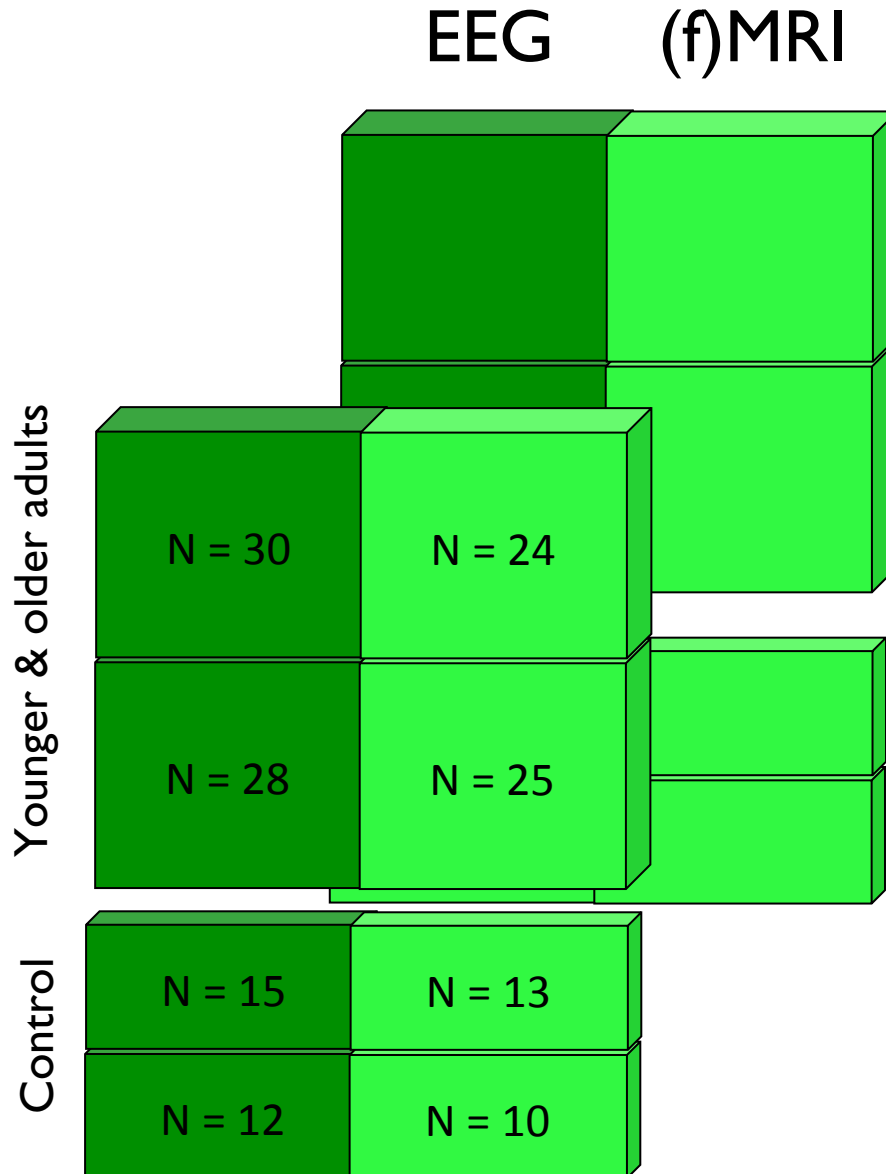
44 Younger &
40 older adults



Control groups:

**Same pretest/
posttest/follow-up
with comparable time
delays between
occasions**

COGITO's Neuroscience



EEG:

- Resting state
- Two-choice tasks

MRI:

hand-traced regions

DTI

fMRI:

- Memory updating
- Paired associated
- Two-choice decision