Integrative Analysis of Longitudinal Studies on Aging

CENTRE ON AGING COLLOQUIUM SERIES
Optimizing Aging & Health: Methods & Applications

Introductions

Scott M. Hofer

Andrea Piccinin, Graciela Muniz, Jeffrey Kaye, Diana Kuh, Sean Clouston, Daniel Mroczek and many IALSA/Maelstrom colleagues

The Integrative Analysis of Longitudinal Studies of Aging (IALSA; www.ialsa.org) research network is supported by a grant from the National Institutes of Health/NIA: 1P01AG043362; and previously by NIH/NIA 1R01AG026453 and the Canadian Institutes of Health Research: 200910MPA Canada-UK Aging Initiative.

Types of Large-Scale Data Resources

- Integrative Data Analysis
  - Collaborative/Coordinated analysis of existing data resources
  - Biobanks (P3G; BioSHARE), longitudinal cohort studies (IALSA; HALCYON, CLOSER, DYNOPTA, COSMIC, etc.)
- Embedded within Healthcare Infrastructure
  - Integrated Electronic Health Record as a platform for sustainable longitudinal and frequent measurements
  - Basis for learning health care system / precision medicine
- E-Epi Research/Remote Objective Measurement
  - Optimize data acquisition across laboratory, clinical, and in-home settings
  - Longitudinal, detailed, and minimally obtrusive assessments

Integrative Analysis of Longitudinal Studies of Aging

www.ialsa.org

- The IALSA network (NIH/NIA 1P01AG043362) is comprised of over 100 longitudinal studies on aging, health and dementia.
  - Mix of samples aged from birth to 100 years, with birth cohorts ranging from 1880 to 1980.
  - Assessed from 1921 to the present.
  - Time between assessments ranges from 6 months to 17 years (the majority 1-5 years), with up to 32 (typically 3-5) measurement occasions spanning 4 to 48 years of monitoring within each individual.
- Collaboration with UK Healthy Ageing across the Life Course (HALCyon) and the Quebec Network for Research on Aging.
- Reproducibility of results (i.e., direction and pattern of effects) across populations, historical periods, measurements, designs, and statistical models.

Hofer & Piccinin, 2009; 2010; Piccinin & Hofer, 2008

Major research aim: To maintain and enhance cognitive and physical health and well-being throughout the lifespan

Detecting within-person change:

- Why do these changes occur (e.g., health)? Can these changes be prevented, delayed, or treated?
- Is this individual changing more rapidly than they have in the past?

Contextual and lifespan factors:

- What is the impact of early life characteristics (e.g., childhood cognition; early life distress) and changing cohort contexts (e.g., SES, education, nutrition) on later life outcomes?

Within-person dynamics:

- Improvements in within-person measurement and design to better predict future outcomes (e.g., frailty; dementia)

“Most Published Research Findings are False”

Ioannidis (2005); Young, Ioannidis, Al-Ubaydli (2008), www.PloSmedicine.org

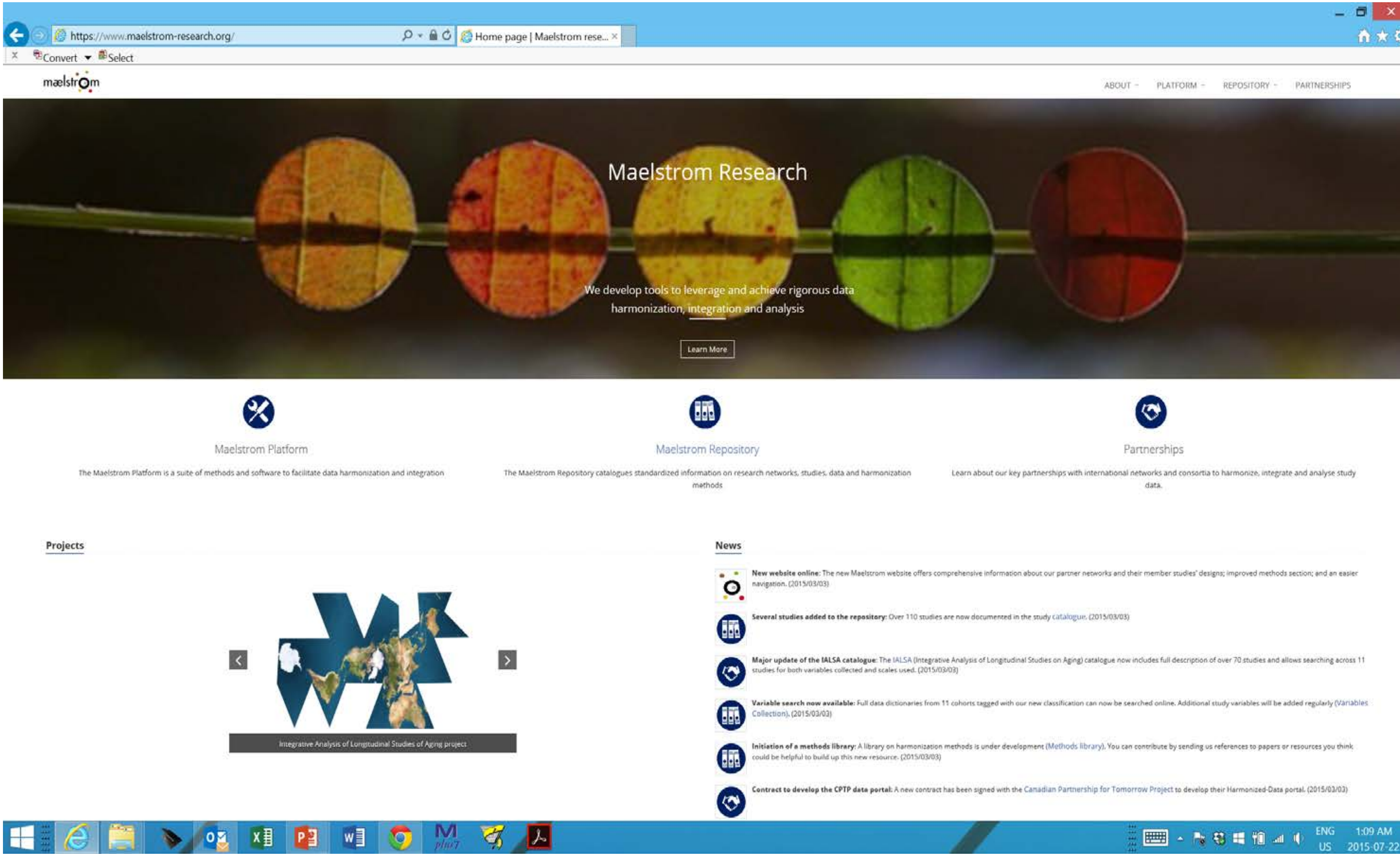
- Dramatic results are more likely to be false
  - Less dramatic results unpublished or in less prestigious journals
- Why?
  - Competition for “original” contributions: Highly selected studies are overvalued and unrepresentative of true outcomes
  - Bias towards publishing positive results
  - Artificial scarcity; Best journals publish “most dramatic” research; excuse for rejection
- **Solution: Provide basis for demonstrating replicability**
  - **Science as an objective and open process**
  - **Data sharing and availability for re-analysis / extension of results**
  - **Availability of full results and methods, reasons for selective findings given**
  - **Publish all research that meets quality threshold**

Longitudinal Observational Studies

- Sources of Variation in Results
  - Measures and Measurement Models
  - Populations and samples (country, cohort)
  - Design Factors
    - Number, Spacing, and Duration of Observation
    - Age / Cohort / Period (i.e., baseline heterogeneity)
  - Selectivity / Incomplete Data
  - Retest Effects
  - Statistical Models (change, covariate adjustment)
- Emphasis on pattern of results (directionality)
  - Maxwell (2012); West & Thoemmes (2010): “This variation may typically be of only minimal scientific or policy interest, except when the reversal or the elimination of a causal effect occurs.”

Integrative Data Analysis: Systematic Study of Testable Hypotheses

- Cross-Method
  - Sensitivity of results to design (e.g., different confounds) and analysis (e.g., different models of change)
- Cross-Cohort (Between-Group)
  - Changing outcomes and influences, critical periods
- Cross-Country (Between-Group)
  - Natural experiments: diffs in secular trends and policies
- Long-term longitudinal (Within-Person)
  - Cognitive reserve (childhood IQ; educ), impact of early and middle life predictors, detection of indiv. change-points
- Prediction
  - Extrapolation to prospective studies / recent birth cohorts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Maelstrom Research
We develop tools to leverage and achieve rigorous data harmonization, integration and analysis
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Maelstrom Platform
The Maelstrom Platform is a suite of methods and software to facilitate data harmonization and integration
Maelstrom Repository
The Maelstrom Repository catalogues standardized information on research networks, studies, data and harmonization methods
Partnerships
Learn about our key partnerships with international networks and consortia to harmonize, integrate and analyse study data.
Projects
Integrative Analysis of Longitudinal Studies of Aging project
News
New website online: The new Maelstrom website offers comprehensive information about our partner networks and their member studies' designs; improved methods section; and an easier navigation. (2015/03/03)
Several studies added to the repository: Over 110 studies are now documented in the study catalogue. (2015/03/03)
Major update of the IALSA catalogue: The IALSA (Integrative Analysis of Longitudinal Studies on Aging) catalogue now includes full description of over 70 studies and allows searching across 11 studies for both variables collected and scales used. (2015/03/03)
Variable search now available: Full data dictionaries from 11 cohorts tagged with our new classification can now be searched online. Additional study variables will be added regularly (Variables Collection). (2015/03/03)
Initiation of a methods library: A library on harmonization methods is under development (Methods library). You can contribute by sending us references to papers or resources you think could be helpful to build up this new resource. (2015/03/03)
Contract to develop the CPTP data portal: A new contract has been signed with the Canadian Partnership for Tomorrow Project to develop their Harmonized-Data portal. (2015/03/03)
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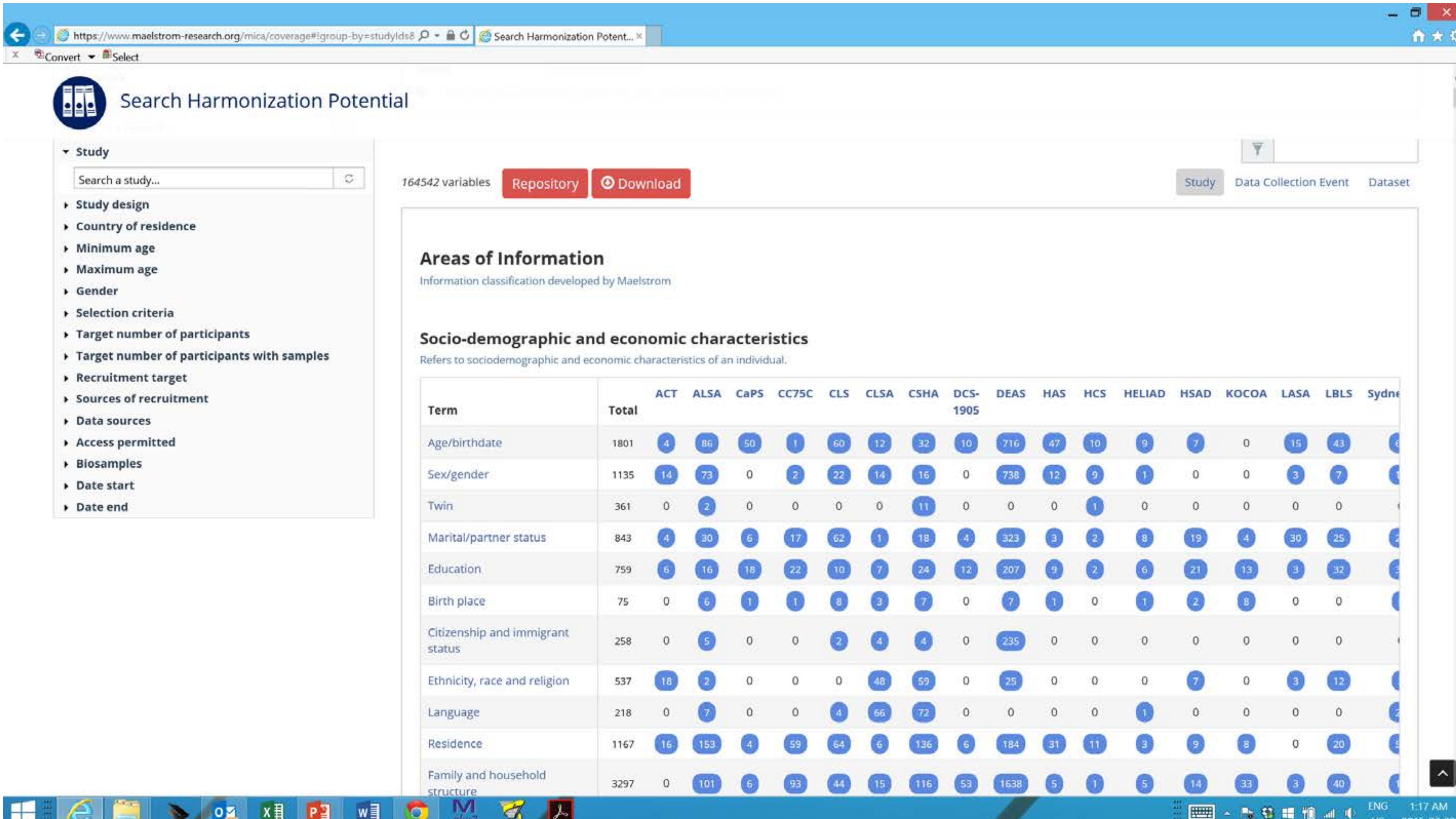
Maelstrom-IALSA Metadata Catalogue and Harmonization Platform

https://www.maelstrom-research.org/mica/network/ialsa



Term	Total	ACT	ALSA	CaPS	CC75C	CLS	CLSA	CSHA	DCS-1905	DEAS	HAS	HCS	HELIAD	HSAD	KOCOA	LASA	LBLS	Sydne
Age/birthdate	1801	4	86	50	1	60	12	32	10	716	47	10	9	7	0	15	43	[illegible]
Sex/gender	1135	14	73	0	2	22	14	16	0	738	12	9	1	0	0	3	7	[illegible]
Twin	361	0	2	0	0	0	0	11	0	0	0	1	0	0	0	0	0	[illegible]
Marital/partner status	843	4	30	6	17	62	1	18	4	323	3	2	8	19	4	30	25	[illegible]
Education	759	6	16	18	22	10	7	24	12	207	9	2	6	21	13	3	32	[illegible]
Birth place	75	0	6	1	1	8	3	7	0	7	1	0	1	2	8	0	0	[illegible]
Citizenship and immigrant status	258	0	5	0	0	2	4	4	0	235	0	0	0	0	0	0	0	[illegible]
Ethnicity, race and religion	537	18	2	0	0	0	48	59	0	25	0	0	0	7	0	3	12	[illegible]
Language	218	0	7	0	0	4	66	72	0	0	0	0	1	0	0	0	0	[illegible]
Residence	1167	16	153	4	59	64	6	136	6	184	31	11	3	9	8	0	20	[illegible]
Family and household structure	3297	0	101	6	93	44	15	116	53	1638	5	1	5	14	33	3	40	[illegible]

IALSA Approach: Reproducibility

- Coordinated/Parallel analysis
  - Aim: To maximize the data value from each study while making results as comparable as possible
  - Expect similar *conclusions* regardless of the exact variables used.
    - Construct-level comparison
    - Common statistical models
    - Emphasis on cross-culture, cross-study comparisons
  - Evaluation of sensitivity to statistical model
  - Meta-Analysis / Meta-Regression
    - Evaluation of subgroup interactions (e.g., age) across studies

Hofer & Piccinin, 2009, Psychological Methods

IALSA Portland Workshop
Feb. 23-25, 2015

- Primary aim: To examine associations between changes in **physical functioning** (i.e., grip strength, pulmonary function, chair stands, walking speed) and **cognitive functioning** (i.e., measures of speed, memory, reasoning, executive functioning) in multiple-study comparative framework.
  - Pulmonary function – Cognition
  - Grip Strength – Cognition
  - Gait – Cognition
  - Cognition: Within and across cognitive domains
  - Physical functioning: Across pulmonary, grip, gait
- Bivariate linear growth curve models
- Adjustment for age, sex, education, height, health behaviors, and health outcomes in block sets.

Coordinated Analysis: Studies

Study	**Contact**
Einstein Aging Study	Andrea Zammit
English Longitudinal Study of Aging	Annie Robitaille
HRS	Chenkai Wu
Interdisciplinary Longitudinal Study	Philipp Handschuh
Normative Aging Study	Lewina Lee
NuAge	Valerie Jarry
OCTO-Twin	Marcus Praetorius
Rush Memory and Aging Project	Cassandra Brown
SATSA	Deborah Finkel

IALSA Analysis Workshops

- NACC/IALSA Methodological issues in analysis of natural history cohorts (Sept 2015)
- Harmonization Summit (Spring 2016; June 2017)
- IALSA Analysis Workshops (Fall 2015/Spring 2016)
  - Selection into retirement and impact of retirement on cognitive and physical functioning and health (Gothenburg, October 2015)
  - Impact of secular changes (i.e., Flynn effect) on age-based estimates of cognitive and physical level and change in functioning
  - Predictive models for use in prospective studies: Dynamic risk profiles and joint modeling of dementia and death
  - Incorporating terminal decline in models of aging
  - Evaluation of models for successful/healthy/active aging

Integrative Analysis of Longitudinal Studies on Aging

Visual tools for big analyses: Cross-study replication of bivariate growth models

Andriy Koval (UVic)
Cassandra Brown (UVic)
William Beasley (OU)

CENTRE ON AGING COLLOQUIUM SERIES
Optimizing Aging & Health: Methods & Applications

13-October-2015

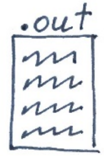
University of Victoria | Centre on Aging

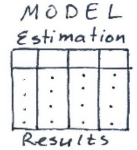
Sequence of speakers

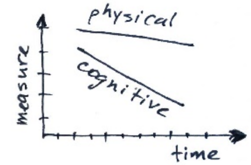
The speakers will each address the following questions in their pairs (approximate number of minutes in parenths)

- Scott (5-7)
  - Big picture of Portland. Why many studies?
- Andrey(10-15)
  - How can we organize the workflow?
- Will (5-10)
  - How can we optimize the workflow?
- Andrey(5-7)
  - What can we learn so far? 5D, BISER, Forrest
- Cassandra (30-40)
  - How can we explore questions in this framework: varying wave count (RADC) study

$${}_m y_i = {}_m\beta_{0i} + {}_m\beta_{1i}\,Time_i + {}_m\varepsilon_i$$







$${}_{o=\text{Physical}}\beta_{0i} = {}_p\gamma_{00} + {}_p\Gamma_{0k}(CovSet) + {}_p u_{0i}$$

$${}_{o=\text{Physical}}\beta_{1i} = {}_p\gamma_{10} + {}_p\Gamma_{1k}(CovSet) + {}_p u_{1i}$$

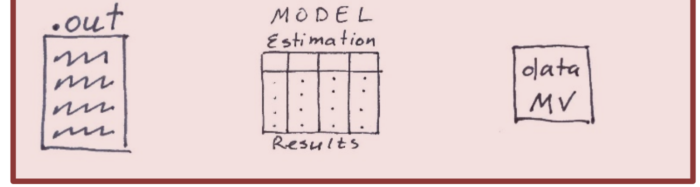
$${}_o y_{ti} = {}_o\beta_{0i} + {}_o\beta_{1i}(Time_{ti}) + {}_o\varepsilon_{ti}$$

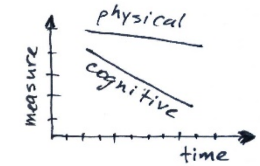
$${}_{o=\text{Cognitive}}\beta_{1i} = {}_c\gamma_{10} + {}_c\Gamma_{1k}(CovSet) + {}_c u_{1i}$$

$${}_{o=\text{Cognitive}}\beta_{0i} = {}_c\gamma_{00} + {}_c\Gamma_{0k}(CovSet) + {}_c u_{0i}$$

	Fixed Effects				Random Effects				Residuals	
Physical Intercept	${}_p\gamma_{00}$	${}_p\gamma_{01}$	${}_p\gamma_{02}\ \cdots$	${}_p\gamma_{0k}$	${}_{pp}\tau_{00}$	${}_{pp}\tau_{01}$	${}_{pc}\tau_{01}$	${}_{pc}\tau_{00}$	${}_p\sigma^2$	${}_{pc}\sigma^2$
Physical Slope	${}_p\gamma_{10}$	${}_p\gamma_{11}$	${}_p\gamma_{12}\ \cdots$	${}_p\gamma_{1k}$		${}_{pp}\tau_{11}$	${}_{pc}\tau_{11}$	${}_{pc}\tau_{10}$		
Cognitive Slope	${}_c\gamma_{10}$	${}_c\gamma_{11}$	${}_c\gamma_{12}\ \cdots$	${}_c\gamma_{1k}$			${}_{cc}\tau_{11}$	${}_{cc}\tau_{10}$		${}_c\sigma^2$
Cognitive Intercept	${}_c\gamma_{00}$	${}_c\gamma_{01}$	${}_c\gamma_{02}\ \cdots$	${}_c\gamma_{0k}$				${}_{cc}\tau_{00}$		

$$m y_i = m\beta_{0i} + m\beta_{1i}\, Time_i + m\varepsilon_i$$



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MODEL FIT INFORMATION

Number of Free Parameters                       21

Loglikelihood

          H0 Value                      -26546.355
          H0 Scaling Correction Factor      1.2776
            for MLR

Information Criteria

          Akaike (AIC)                   53134.711
          Bayesian (BIC)                 53236.917
          Sample-Size Adjusted BIC       53170.221
            (n* = (n + 2) / 24)



MODEL RESULTS

                                                    Two-Tailed
                    Estimate       S.E.  Est./S.E.    P-Value

 IP         ON
    BAGE              -0.670      0.050    -13.282      0.000

 SP         ON
    BAGE              -0.018      0.007     -2.484      0.013

 IC         ON
    BAGE              -0.210      0.030     -6.932      0.000

 SC         ON
    BAGE              -0.025      0.004     -5.965      0.000

 IP       WITH
    SP                -2.438      0.729     -3.345      0.001
    IC                 7.968      2.716      2.933      0.003
    SC                 0.449      0.353      1.273      0.203

 SP       WITH
    IC                -0.310      0.385     -0.805      0.421
    SC                 0.104      0.043      2.449      0.014

 IC       WITH
    SC                 0.204      0.227      0.895      0.371
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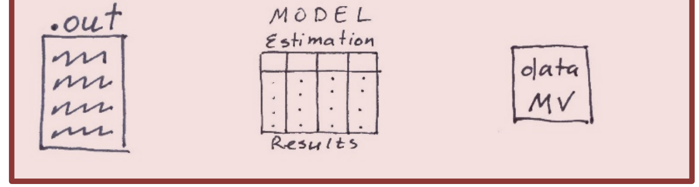
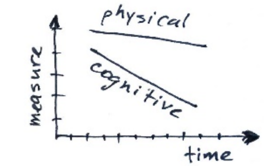
$$m y_i = m\beta_{0i} + m\beta_{1i} Time_i + m\varepsilon_i$$





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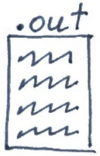
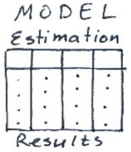
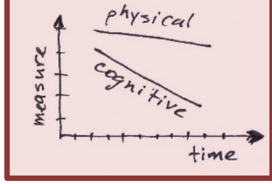
-26546.355	53134.71	53236.92	53170.22	53135.70	b1_female_a_grip_numbercomp_10.out	radcMAP_wide.dat	7.968	2.716	2.933	0.003
-27187.063	54416.13	54518.33	54451.64	54417.11	b1_female_a_grip_numbercomp_11.out	radcMAP_wide.dat	8.088	2.683	3.015	0.003
-27508.875	55059.75	55161.96	55095.26	55060.74	b1_female_a_grip_numbercomp_12.out	radcMAP_wide.dat	7.949	2.688	2.957	0.003
-27672.245	55386.49	55488.69	55422.00	55387.48	b1_female_a_grip_numbercomp_13.out	radcMAP_wide.dat	8.165	2.699	3.026	0.002
-27820.126	55682.25	55784.46	55717.76	55683.24	b1_female_a_grip_numbercomp_14.out	radcMAP_wide.dat	8.406	2.697	3.116	0.002
-27916.349	55874.70	55976.90	55910.21	55875.68	b1_female_a_grip_numbercomp_15.out	radcMAP_wide.dat	8.391	2.684	3.126	0.002
-27980.516	56003.03	56105.24	56038.54	56004.02	b1_female_a_grip_numbercomp_16.out	radcMAP_wide.dat	8.461	2.683	3.153	0.002
-27991.037	56024.07	56126.28	56059.58	56025.06	b1_female_a_grip_numbercomp_17.out	radcMAP_wide.dat	8.490	2.684	3.163	0.002
NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
-17473.371	34988.74	35090.95	35024.25	34989.73	b1_female_a_grip_numbercomp_4.out	radcMAP_wide.dat	8.798	2.893	3.041	0.002
-19720.004	39482.01	39584.21	39517.52	39482.99	b1_female_a_grip_numbercomp_5.out	radcMAP_wide.dat	8.633	2.867	3.012	0.003
-21361.544	42765.09	42867.29	42800.60	42766.07	b1_female_a_grip_numbercomp_6.out	radcMAP_wide.dat	8.398	2.821	2.976	0.003
-22829.189	45700.38	45802.58	45735.89	45701.36	b1_female_a_grip_numbercomp_7.out	radcMAP_wide.dat	8.516	2.772	3.072	0.002
-24218.898	48479.80	48582.00	48515.31	48480.78	b1_female_a_grip_numbercomp_8.out	radcMAP_wide.dat	8.237	2.741	3.005	0.003
-25545.071	51132.14	51234.35	51167.65	51133.13	b1_female_a_grip_numbercomp_9.out	radcMAP_wide.dat	7.979	2.712	2.942	0.003
-9224.294	18490.59	18570.75	18504.13	18493.53	b1_male_a_grip_numbercomp_10.out	radcMAP_wide.dat	21.322	6.690	3.187	0.001
-9450.667	18943.33	19023.49	18956.88	18946.28	b1_male_a_grip_numbercomp_11.out	radcMAP_wide.dat	21.688	6.719	3.228	0.001
-9558.270	19158.54	19238.70	19172.08	19161.48	b1_male_a_grip_numbercomp_12.out	radcMAP_wide.dat	21.786	6.737	3.234	0.001
-9585.752	19213.50	19293.66	19227.05	19216.45	b1_male_a_grip_numbercomp_13.out	radcMAP_wide.dat	22.072	6.750	3.270	0.001
-9607.758	19257.51	19337.67	19271.06	19260.46	b1_male_a_grip_numbercomp_14.out	radcMAP_wide.dat	22.066	6.751	3.268	0.001
-9618.519	19279.04	19359.20	19292.58	19281.98	b1_male_a_grip_numbercomp_15.out	radcMAP_wide.dat	22.047	6.750	3.266	0.001
-9632.474	19306.95	19387.11	19320.49	19309.89	b1_male_a_grip_numbercomp_16.out	radcMAP_wide.dat	22.191	6.759	3.283	0.001

$$my_i = m\beta_{0i} + m\beta_{1i}\,Time_i + m\varepsilon_i$$

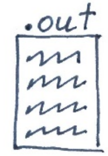


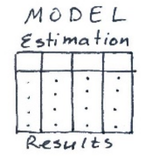


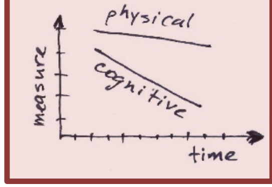


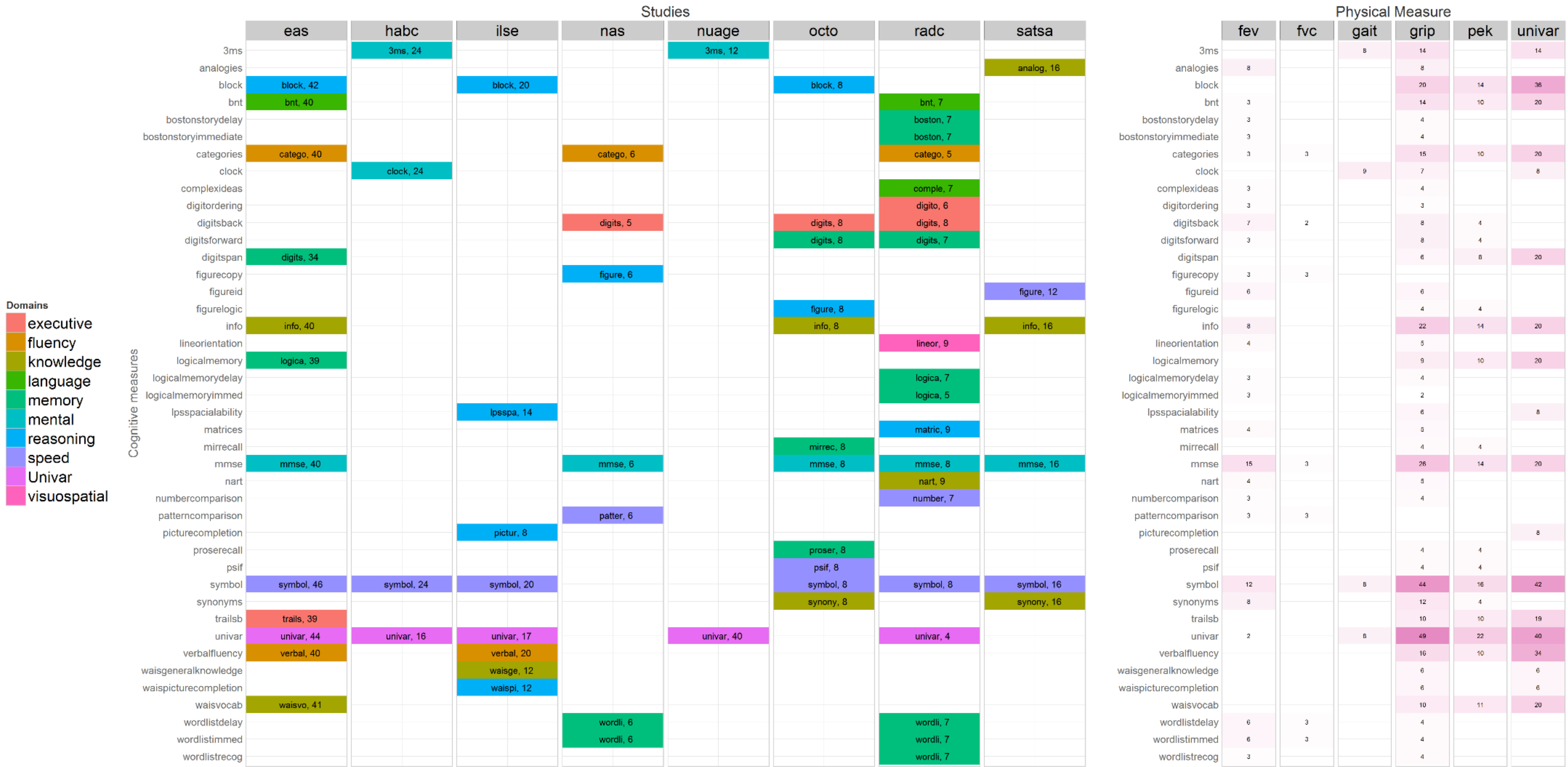
- Exploratory Graphical Devices

$$m y_i = m\beta_{0i} + m\beta_{1i}\, Time_i + m\varepsilon_i$$

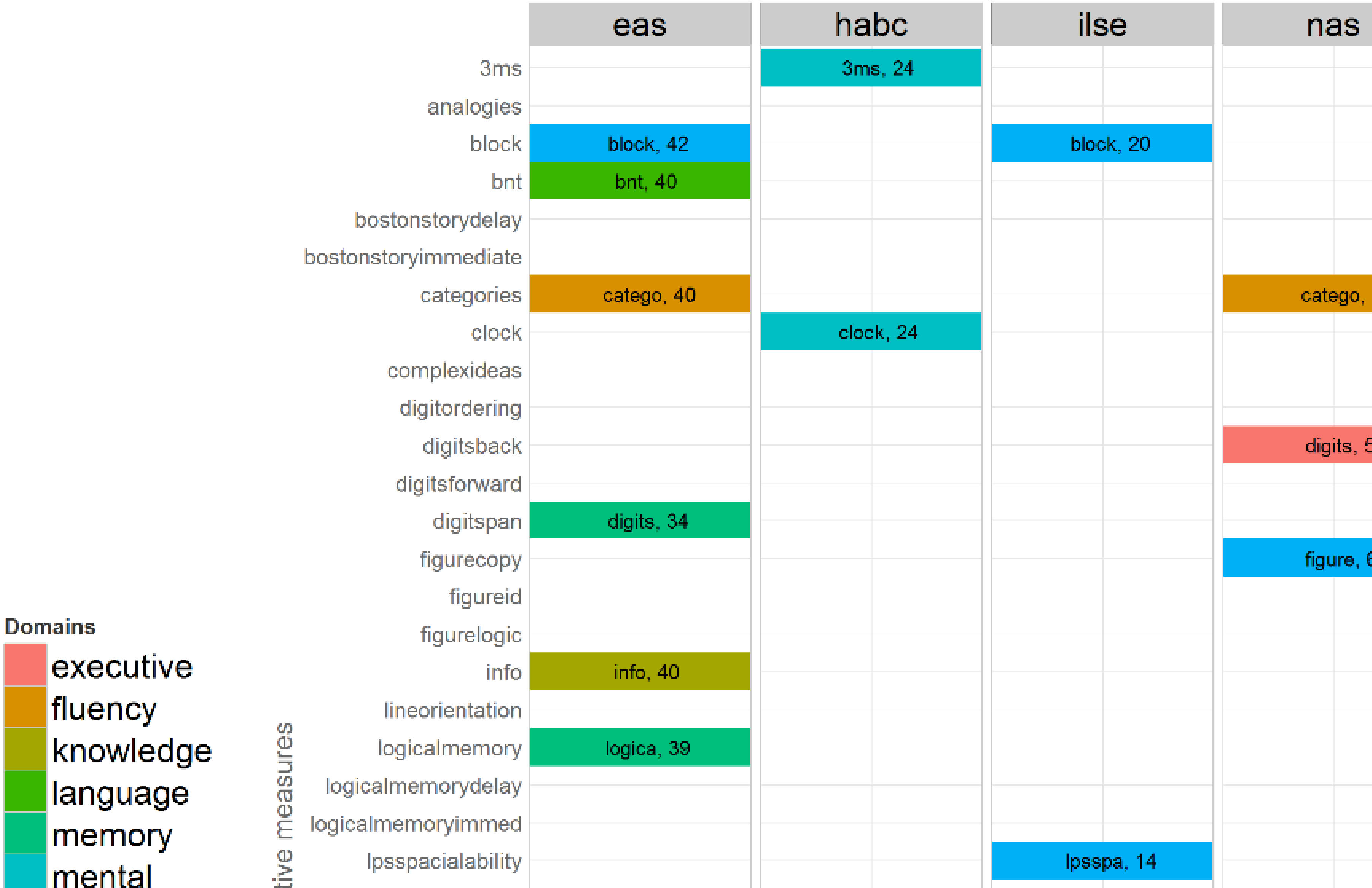




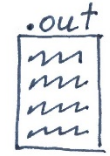


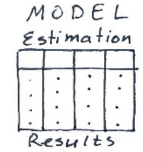


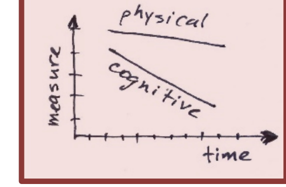
$$m y_i = m\beta_{0i} + m\beta_{1i}\, Time_i + m\varepsilon_i$$

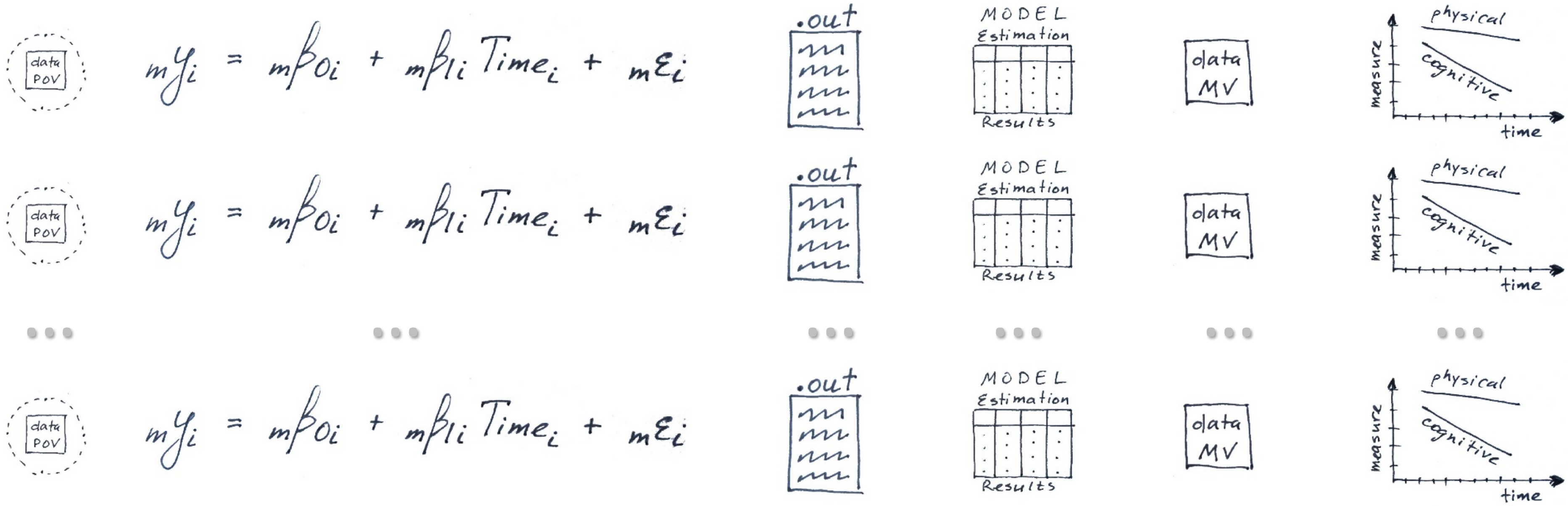


$$_m y_i = {}_m\beta_{0i} + {}_m\beta_{1i}\, Time_i + {}_m\varepsilon_i$$

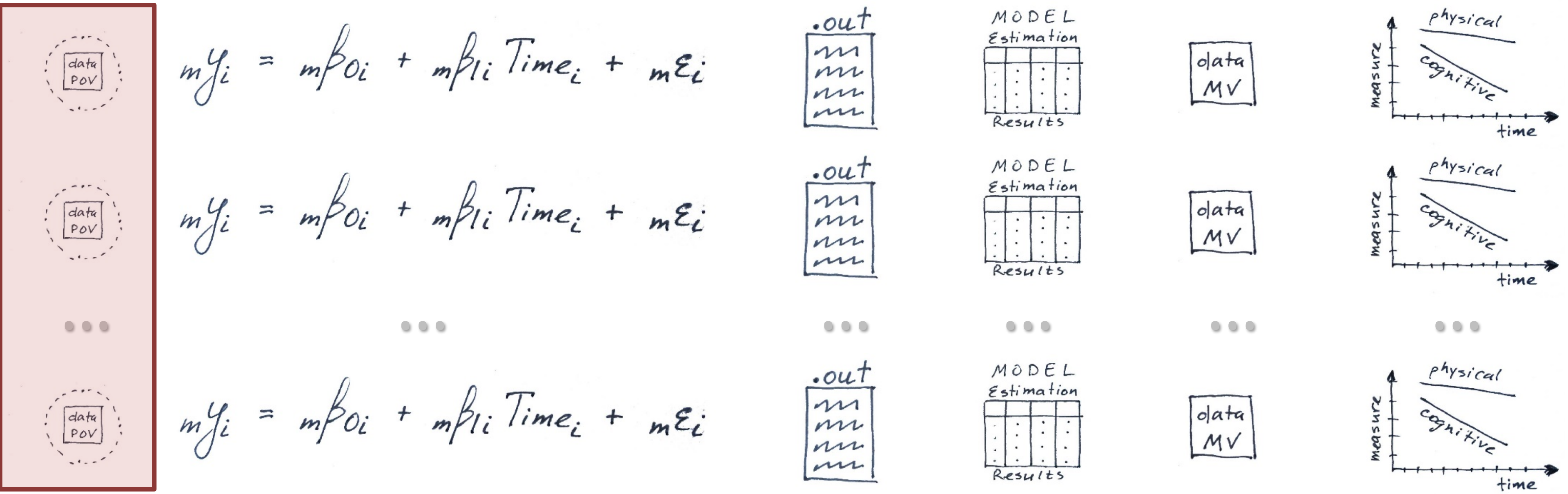








How can we optimize the workflow across studies?

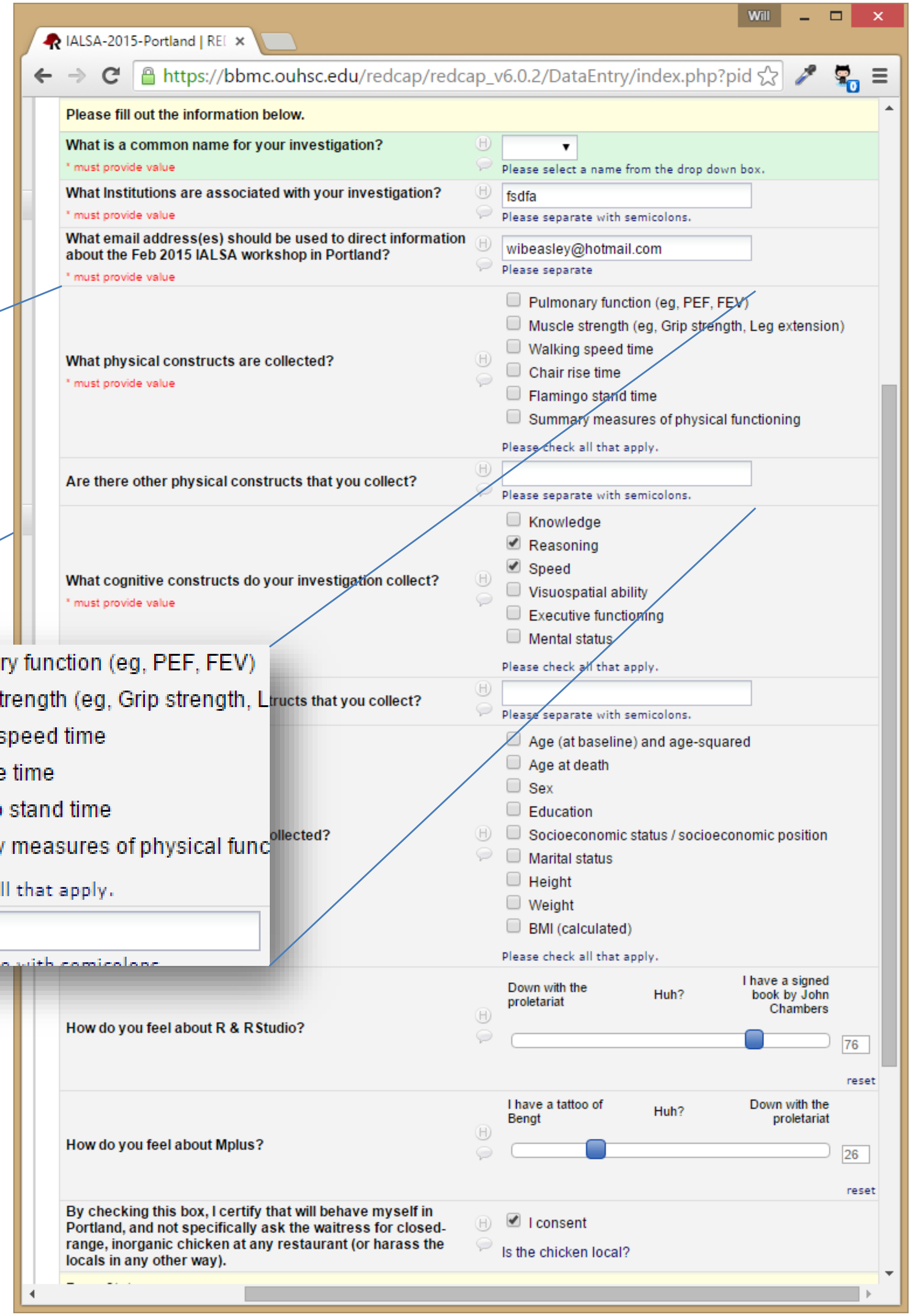


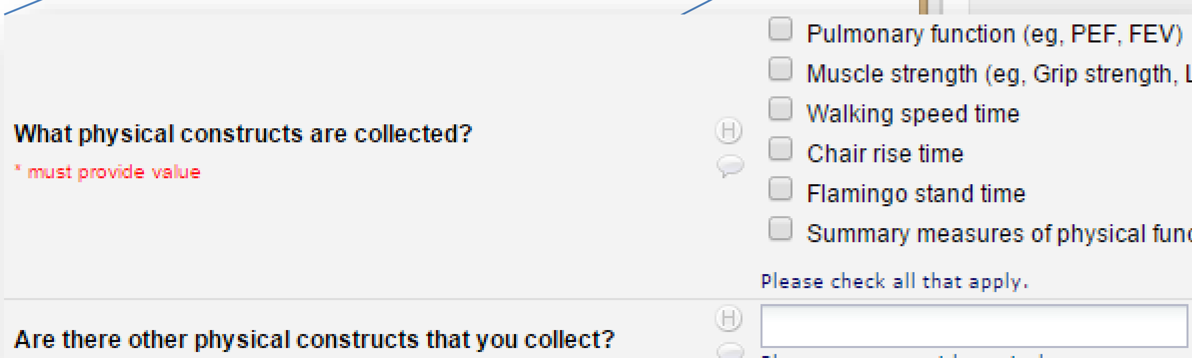
1) Pre-Conference Survey
2) Catalog
3) IalsaSynthesis
4) Reports

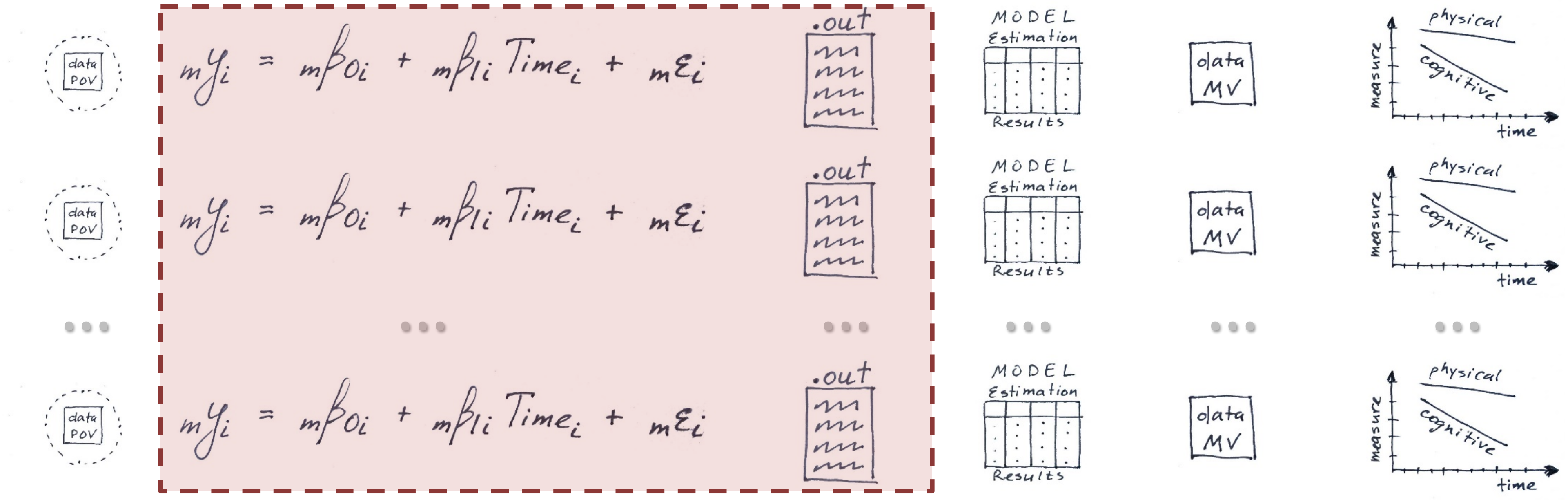
Goal of these four steps: automate many menial tasks

- Have more fun.
- Produce fewer errors.
- Complete faster.
- *Address more ambitious research questions.*

Pre-Conference Survey Example





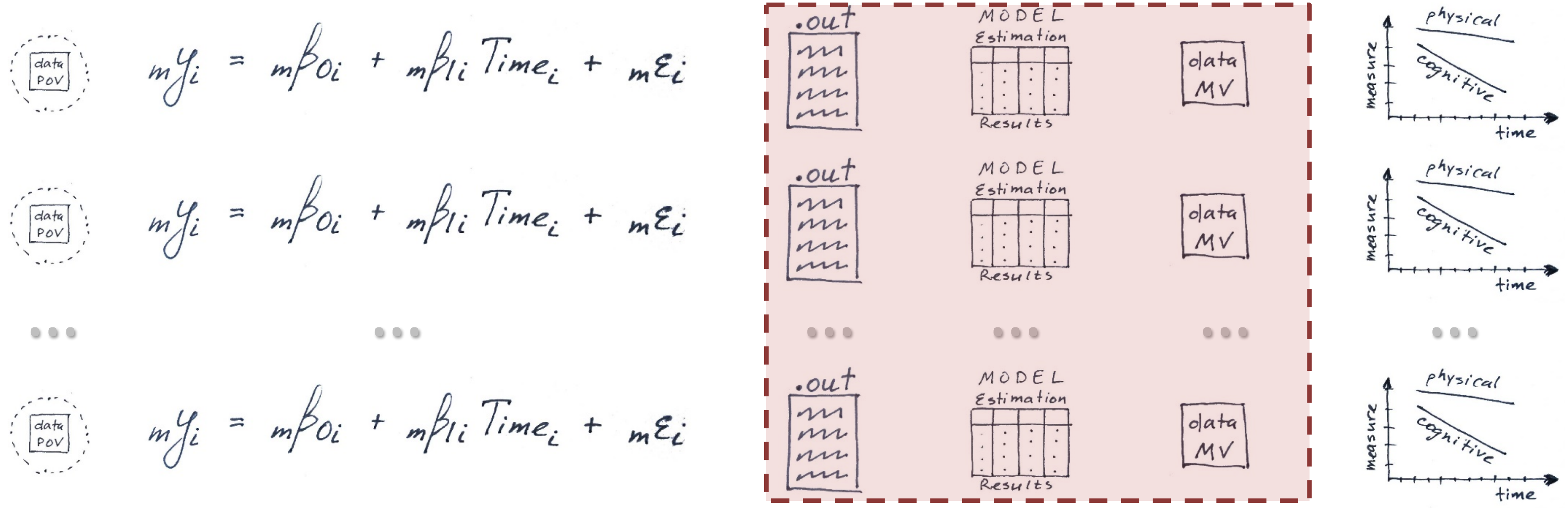


1)Pre-Conference Survey

2)Catalog

3)IalsaSynthesis

4)Reports



1)Pre-Conference Survey
2)Catalog
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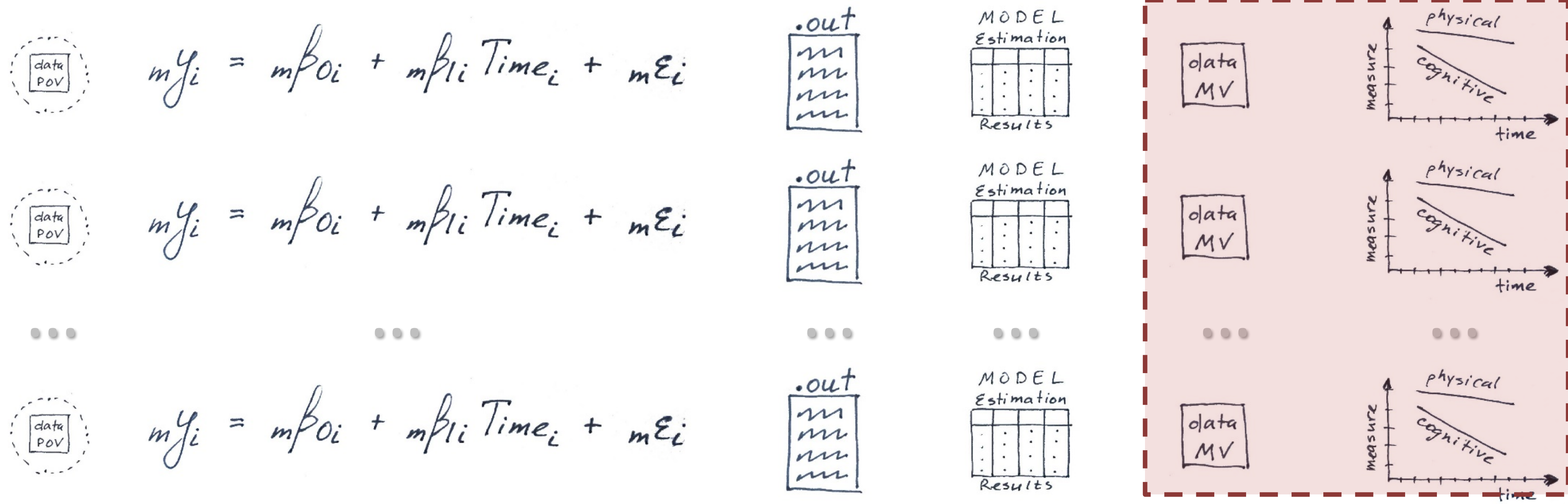
4)Reports

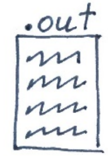


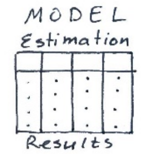
1) Pre-Conference Survey
2) Catalog
3) IalsaSynthesis
4) Reports

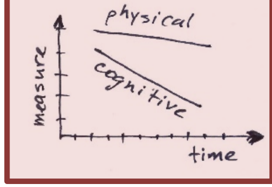
	within study	across studies
progress	A1	A2
analysis	B1	B2

Example of A1, A2

$$m y_i = m\beta_{0i} + m\beta_{1i}\, Time_i + m\varepsilon_i$$







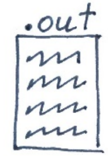
STUDY: eas PHYSICAL MEASURE: grip DISPLAY: display

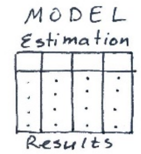
Physical Measure: grip	female intercept	female slope	female residual	male intercept	male slope	male residual
trailsb	-.39 (-.52, -.24)	-.58 (-.68, -.46)	+.14 (-.02, +.29)	+.21 (-.03, +.42)	-.39 (-.57, -.17)	-.07 (-.30, +.16)
categories	+.21 (+.05, +.36)	+.36 (+.21, +.49)	-.05 (-.21, +.11)	-.25 (-.45, -.02)	-.57 (-.71, -.39)	+.07 (-.16, +.30)
verbal fluency	+.24 (+.09, +.39)	+.23 (+.07, +.37)	+.06 (-.10, +.22)	-.29 (-.49, -.06)	-.51 (-.66, -.31)	-.02 (-.25, +.21)
info	+.05 (-.11, +.21)	-.65 (-.74, -.55)	+.11 (-.06, +.26)	+.15 (-.09, +.37)	+.36 (+.14, +.54)	+.00 (-.24, +.23)
wais vocab	+.21 (+.05, +.36)	+.74 (+.65, +.80)	-.09 (-.25, +.07)	-.06 (-.29, +.17)	+.83 (+.74, +.89)	-.06 (-.29, +.18)
bnt	+.39 (+.24, +.52)	+.36 (+.22, +.49)	+.01 (-.15, +.17)	-.12 (-.34, +.12)	-.12 (-.35, +.11)	-.02 (-.25, +.21)
digit span	-.05 (-.21, +.11)	-.19 (-.34, -.03)	+.02 (-.14, +.18)	+.18 (-.06, +.39)	+.01 (-.22, +.25)	-.03 (-.26, +.20)
logical memory	+.14 (-.02, +.30)	+.15 (-.01, +.30)	+.06 (-.10, +.22)			
mmse	+.34 (+.19, +.47)	+.34 (+.19, +.48)	-.03 (-.19, +.13)	-.05 (-.28, +.18)	+.59 (+.42, +.73)	+.04 (-.20, +.27)
block	+.23 (+.07, +.38)	+.09 (-.07, +.24)	-.01 (-.17, +.15)	+.16 (-.08, +.38)	+.89 (+.83, +.93)	+.00 (-.23, +.24)
symbol	+.32 (+.17, +.45)	-.11 (-.27, +.05)	-.08 (-.23, +.09)	-.14 (-.36, +.09)	+.60 (+.43, +.73)	+.07 (-.16, +.30)

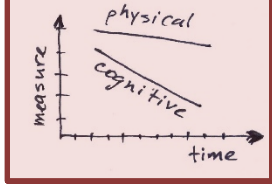
Cognitive Domains
- EXECUTIVE
- FLUENCY
- KNOWLEDGE
- LANGUAGE
- MEMORY
- MENTAL
- REASONING
- SPEED

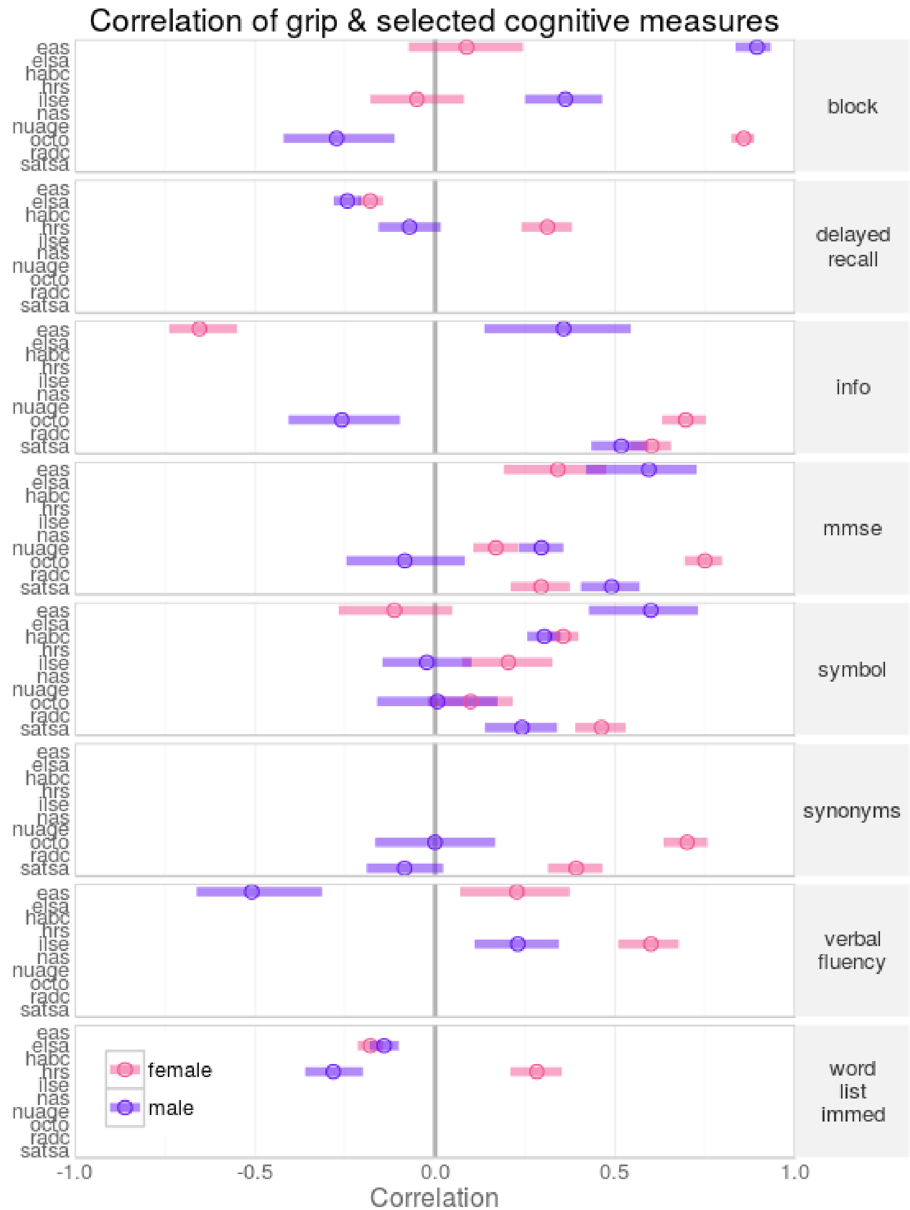
p-value
- <=.05
- <=.10
- > .10

$$_m y_i = {}_m\beta_{0i} + {}_m\beta_{1i}\, Time_i + {}_m\varepsilon_i$$









RADC: Extending wave counts

- Rush MAP study
  - Began in 1997, rolling enrollment
  - Northeastern Illinois, residents of continuous care communities
  - Up to 17 waves of data, few people actually have this number
  - Decision about how many waves to include

Participants

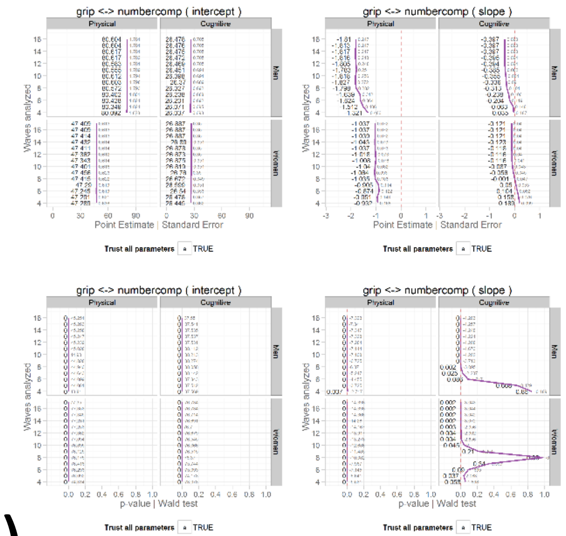
Follow up year		
	Women	Men
0	961	336
1	850	280
2	724	234
3	598	196
4	486	166
5	386	126
6	338	109
7	283	88
8	233	77
9	180	54
10	121	39
11	63	19
12	32	5
13	23	2
14	17	2
15	13	2
16	1	0

Question

- Do the number of waves included in the growth model impact the conclusions?

- Examine cognitive and physical outcomes with increasing numbers of waves included

Plots



- [KB profiles]
- Left column: Intercepts (baseline)
- Right column: Slope (rate of change)
- Vertical facet: Gender
- Horizontal facet: Outcome measures
- X-axis: Numerical value
- Y-axis: Waves included in analysis
- Labels: `Estimate|S.E.|Est./S.E. |P-Value`

Intercepts

- Intercepts show little change over the number of waves used in the analysis.
- Across all outcome pairs this remains true
- Intercepts are the baseline levels of the outcome measure
- Fluctuations over the number of waves might indicate model misspecification

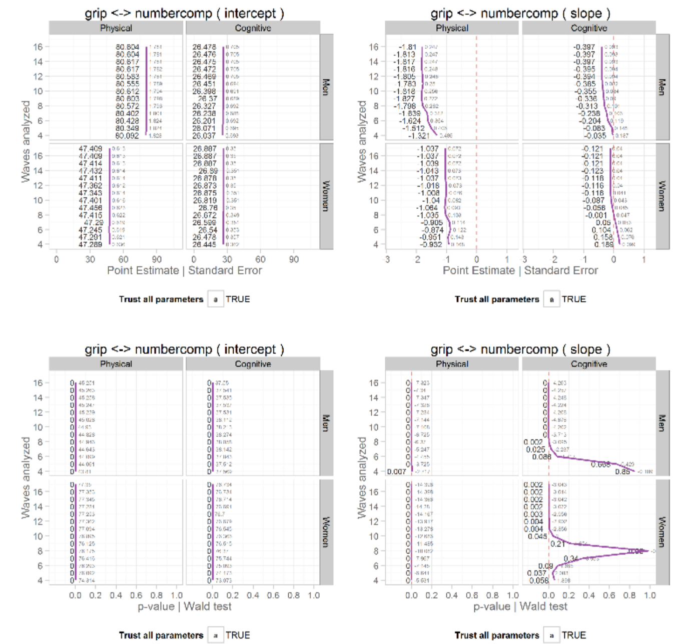
Grip-Category Fluency

- Slope column, physical facet
- Regardless of the number of waves analyzed we see a steady decline in grip strength for both sexes.
- Women: The straight vertical purple line suggests a consistent rate of decline regardless of waves count included.
- Men: The curvature of the line between wave count 4 and 8 hints at an accelerated rate of decline between those time points.

Grip-Category Fluency

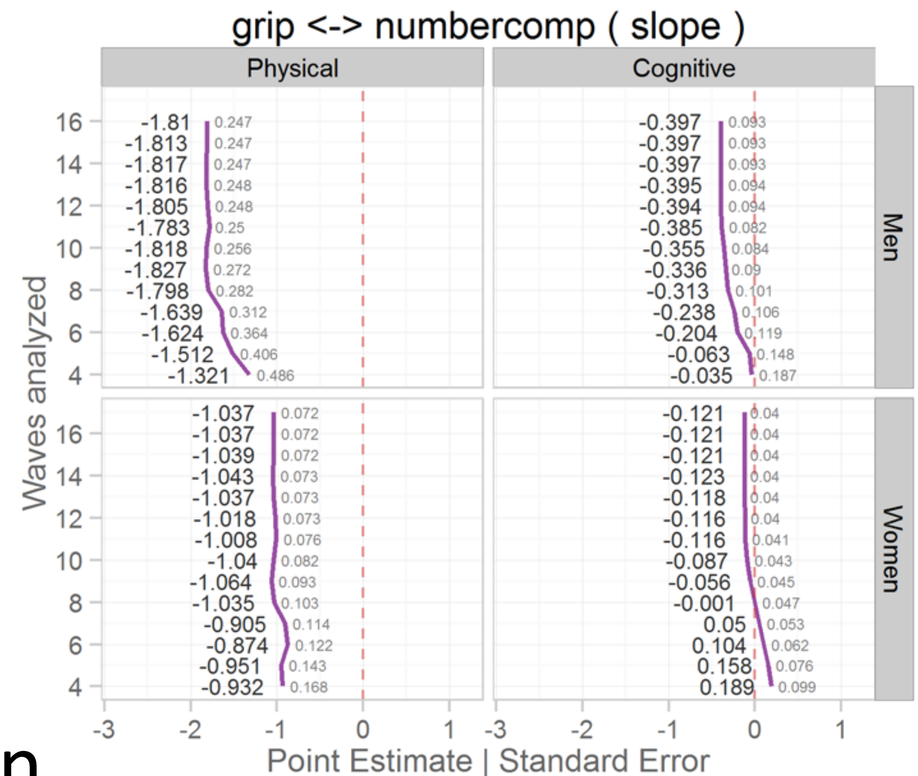
- Slope column, significance row, cognitive facet
- Slopes become significant once at least 9-10 waves are included
- If we analyze fewer than 9 waves of data we fail to detect a significant decline in category fluency test performance.
- Men require fewer waves (9) of data in the analysis to detect a significant decline than women (10).

Grip-
Number Comparison



- [KB fans]()
- Slope column, significance, cognitive facet
- Men: We can detect a significant decline in number comparison task performance once at least 7 waves are included.
- Women: Both positive (wave 5) and negative slopes (wave 9+) reached significance.

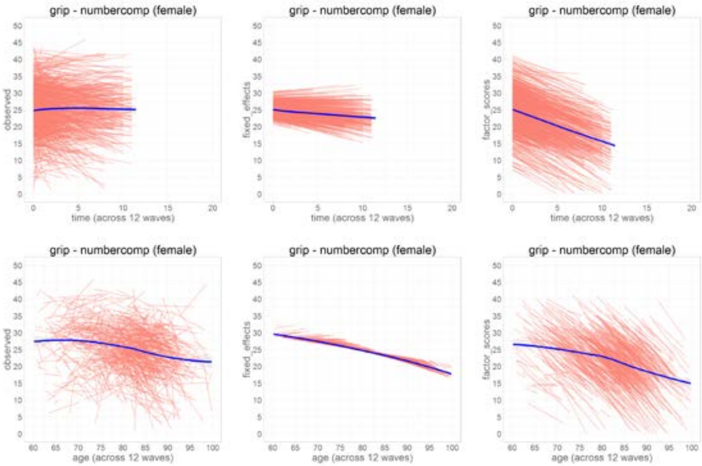
Grip-
Number Comparison



- Zoom on top right cell
- Facets: cognitive, women.
- Changing signs of the slope suggests non-linearity in the observed data.
- We explore the observed and modeled data in the next series of dynamic plots.

Kb Fans: grip-NUMBERCOMP

- Red lines: trajectories of individuals across time.
- Y-axis: performance on the number comparison task
- X-axis: time metric
- Top row: time in study*
- Bottom row: biological age
- Blue lines: smooth average



Kb Fans: grip-NUMBERCOMP

- Left column: observed trajectories
- Middle column: predicted trajectories reconstructed from the fixed effects (.out files) estimated by Mplus.
- Right column: trajectories reconstructed from factor scores (gh5. file) created during model estimation in Mplus.

Kb Fans: grip-NUMBERCOMP

- Left, age
- The curvilinear shape of the trajectory is evident
- Supports our hypothesis from Kb profile graph
- Small increase in performance between ages and 60 and 65 likely represent practice effects
- Decline begins ~67 yrs
- Accelerates ~82 yrs

Kb Fans: grip-NUMBERCOMP

- Middle, age
- The blue line (smoothed average) becomes steeper as more waves are included in the analysis.
- It appears that women show a practice effect but decline sooner (~67)
- Men do not show a practice effect but decline later (~80)
- There are fewer men than women

Kb Fans: grip-NUMBERCOMP

- Right
- Trajectories reconstructed from the estimated factor scores (Mplus .gh5 file)

Questions/Discussion

Q1: What exactly do factor scores reconstruct?

Q2: At what wave count do trajectories become unreliable?