Multivariate Verfahren

MSc Klinische Psychologie und Psychotherapie

MSc Umweltpsychologie/Mensch-Technik-Interaktion

MSc Psychologie

Joram Soch | Wintersemester 2025/2026

Aufnahme läuft!

(0) Einführung (Seminar)

Formalia

Beispielstudie

Beispieldatensatz

Seminarrelevanz

Formalia

Beispielstudie

Beispieldatensatz

Seminarrelevanz

Vorlesung/Seminar *Multivariate Verfahren*, WiSe 25/26

- **Vorlesung:** freitags, 09-11 Uhr, G22A-013 (20.10.2025, 17-19 Uhr, G40B-231)
- **Seminar (MSc Psy):** donnerstags, 11-13 Uhr, G05-117
- **Seminar (MSc UPsy/MTI):** donnerstags, 13-15 Uhr, G03-214
- **Seminar (MSc KliPP):** donnerstags, 13-15 Uhr, G03-214 (08.01.2026, 13-17 Uhr)

Semesterplan *Multivariate Verfahren*

Wo.	KW	Jahr	Vorlesung Freitag	Seminar Donnerstag	Vorlesung "Multivariate Verfahren" (A1) Fr, 09-11	Seminar "Multivariate Verfahren" (A2/A1.2) Do, 11-13 (UPsy, Psy)	Do, 13-15 (MSc KliPP)
1	42	2025	17.10.2025	16.10.2025	(1) Einführung	Einführung & Paper-Vorstellung	
2	43	2025	20.10.2025	23.10.2025	(2) Matrizen	Paper-Lektüre (Soch et al., HBM, 2021)	
3	44	2025	31.10.2025	30.10.2025	– Reformationstag –	Demo-Präsentation (Multiple Regression)	
4	45	2025	07.11.2025	06.11.2025	(3) Eigenanalyse	Matrizen	
5	46	2025	14.11.2025	13.11.2025	(4) Multivariate Normalverteilungen	Eigenanalyse	
6	47	2025	21.11.2025	20.11.2025	(5) Multivariate Deskriptivstatistik	Multivariate Normalverteilungen	
7	48	2025	28.11.2025	27.11.2025	(6) Multivariate Varianzanalyse	Multivariate Deskriptivstatistik	
8	49	2025	05.12.2025	04.12.2025	(7) Kanonische Korrelation	Multivariate Varianzanalyse	
9	50	2025	12.12.2025	11.12.2025	(8) Prädiktive Modellierung	Kanonische Korrelation	
10	51	2025	19.12.2025	18.12.2025	(9) Dimensionsreduktion	Prädiktive Modellierung	
	52	2025	26.12.2025	25.12.2025	– Weihnachtspause –	– Weihnachtspause –	
	1	2026	02.01.2026	01.01.2026	– Weihnachtspause –	– Weihnachtspause –	
11	2	2026	09.01.2026	08.01.2026	(10) Bayes-Klassifikation	Dimensionsreduktion	Dimensionsreduktion Bayes-Klassifikation
12	3	2026	16.01.2026	15.01.2026	(11) Nichtlineare Optimierung	Bayes-Klassifikation	verschoben auf 08.01.
13	4	2026	23.01.2026	22.01.2026	(12) Logistische Regression	Nichtlineare Optimierung	
14	5	2026	30.01.2026	29.01.2026	(13) Neuronale Netze	Logistische Regression	

Feiertag/Ferien | Soch | Ostwald

Seminar *Multivariate Verfahren*

- vertiefende Begleitung der Vorlesungsinhalte
- LNW: Arbeitsblätter mit R-Programmieraufgaben
- (Gruppen-)Präsentation eines Arbeitsblatts im Seminar

Formalia

Beispielstudie

Beispieldatensatz

Seminarrelevanz

A comprehensive score reflecting memory-related fMRI activations and deactivations as potential biomarker for neurocognitive aging

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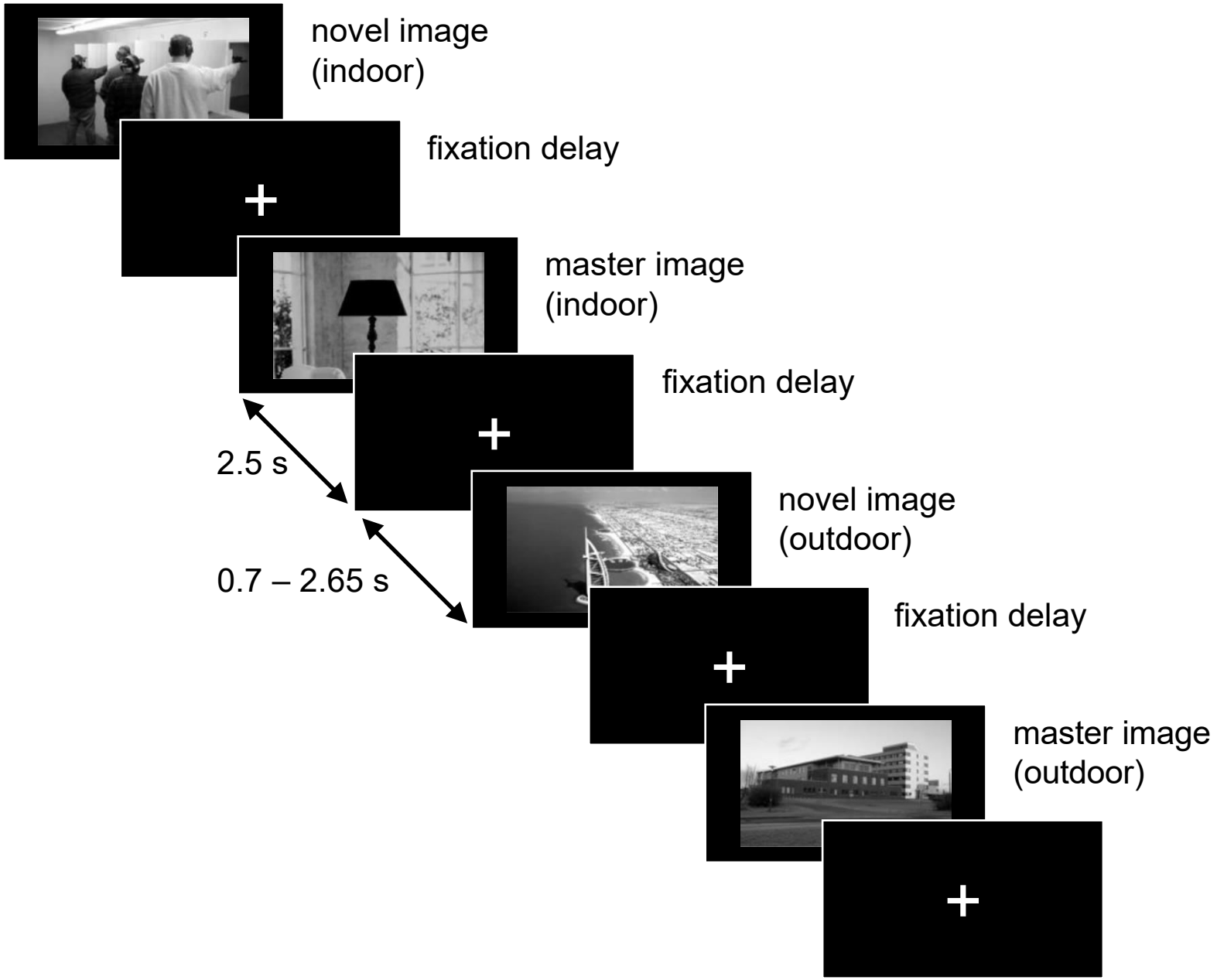
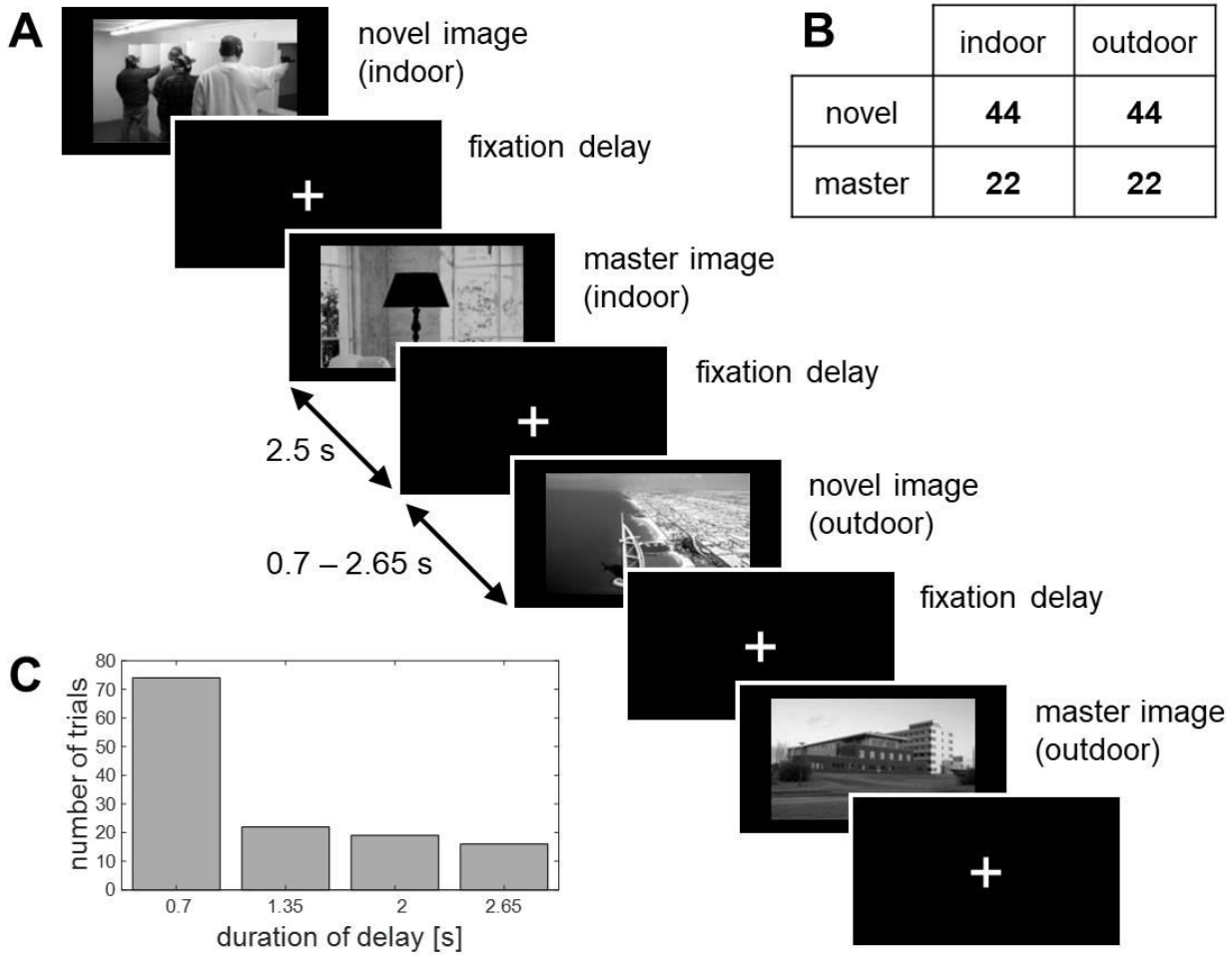
Abstract

Older adults and particularly those at risk for developing dementia typically show a decline in episodic memory performance, which has been associated with altered memory network activity detectable via functional magnetic resonance imaging (fMRI). To quantify the degree of these alterations, a score has been developed as a putative imaging biomarker for successful aging in memory for older adults (*Functional Activity Deviations during Encoding*, FADE; Düzel et al., Hippocampus, 2011; 21: 803–814). Here, we introduce and validate a more comprehensive version of the FADE score, termed FADE-SAME (*Similarity of Activations during Memory Encoding*), which differs from the original FADE score by considering not only activations but also deactivations in fMRI contrasts of stimulus novelty and successful encoding, and by taking into account the variance of young adults' activations. We computed both

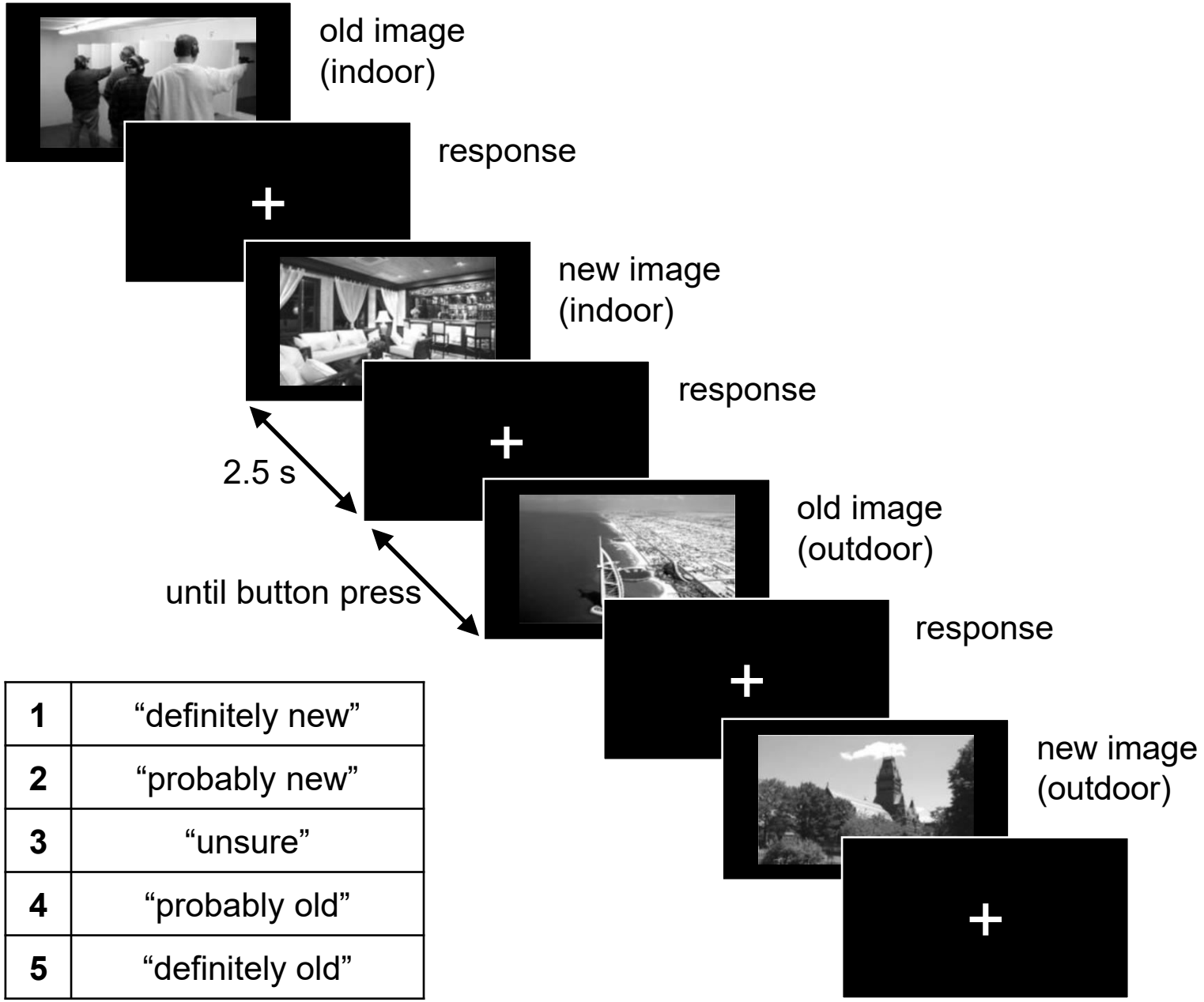

novel image
(indoor)
fixation delay
master image
(indoor)
fixation delay
2.5 s
novel image
(outdoor)
0.7 – 2.65 s
fixation delay
master image
(outdoor)

Subjects viewed indoor/outdoor scene photographs either new to them (novel) or pre-familiarized (master).



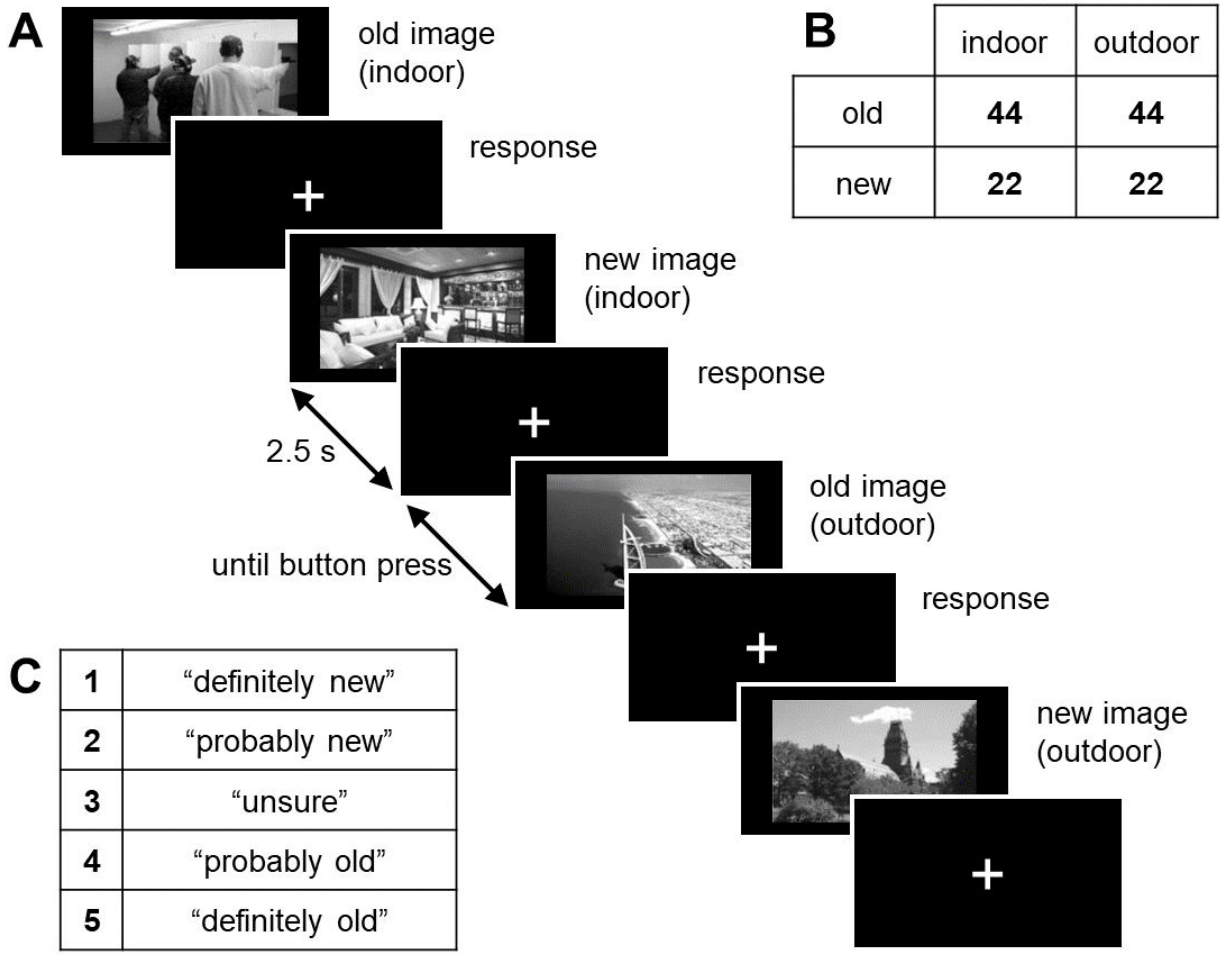
B	indoor	outdoor
novel	**44**	**44**
master	**22**	**22**

Soch*, Richter* et al., NeuroImage, 2021, Fig. 1.



1	“definitely new”
2	“probably new”
3	“unsure”
4	“probably old”
5	“definitely old”

In a surprise subsequent memory test, old and new items were asked to be rated in terms of recognition confidence.

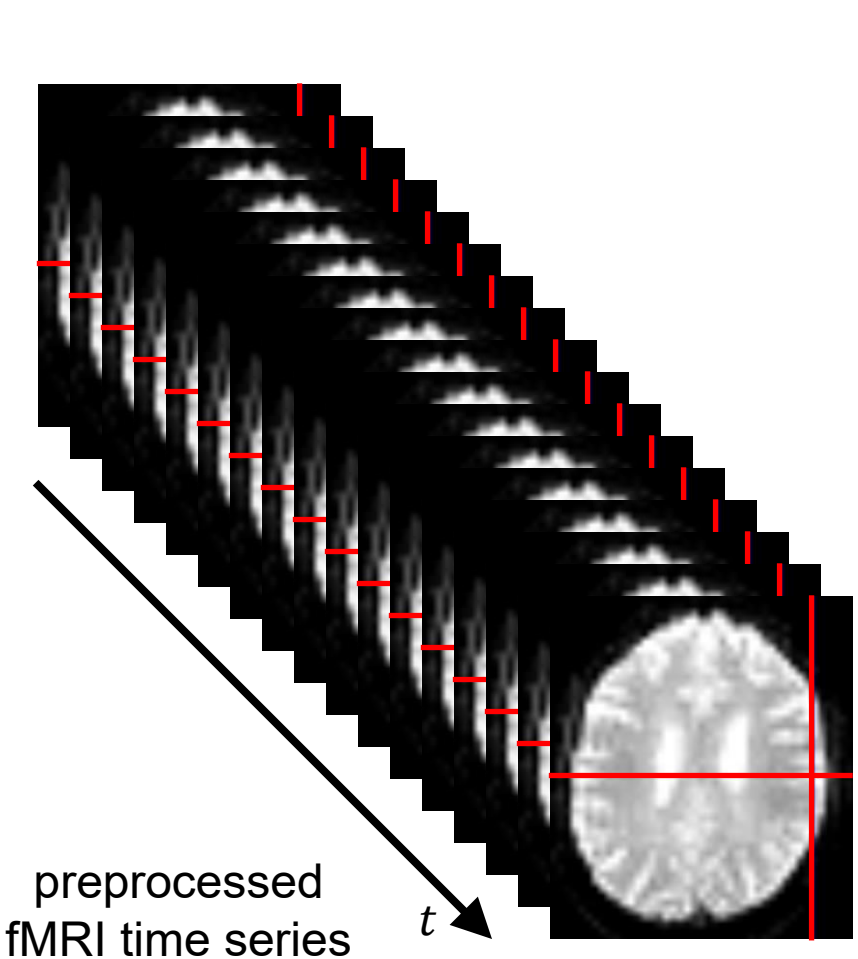


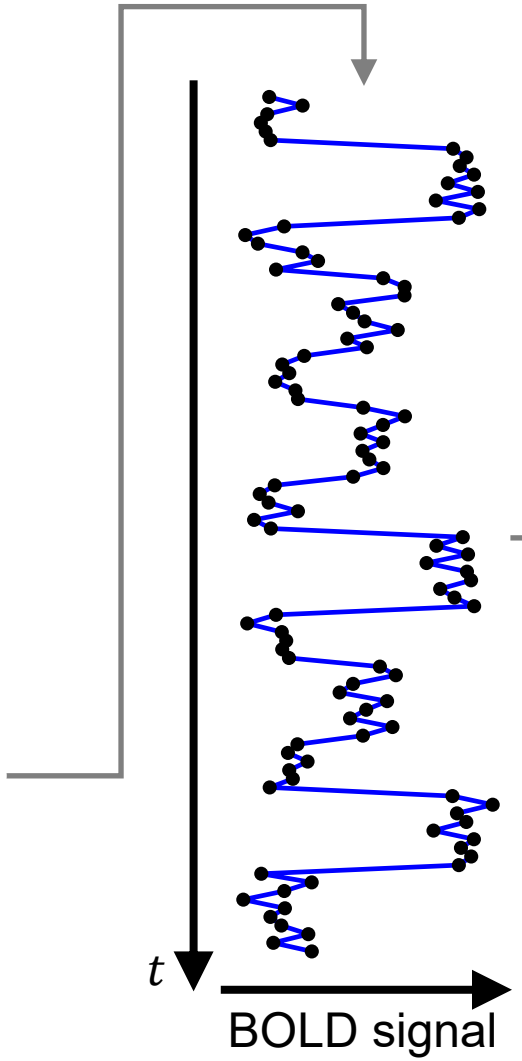
B	indoor	outdoor
old	**44**	**44**
new	**22**	**22**

C	
1	“definitely new”
2	“probably new”
3	“unsure”
4	“probably old”
5	“definitely old”

Soch*, Richter* et al., NeuroImage, 2021, pp. 2-3; Soch*, Richter* et al., HBM, 2021, p. 4.

Voxel-wise time series analysis

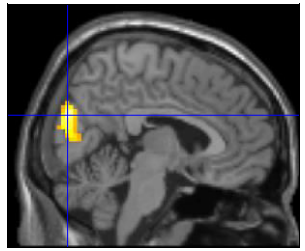




model specification

model estimation

statistical inference

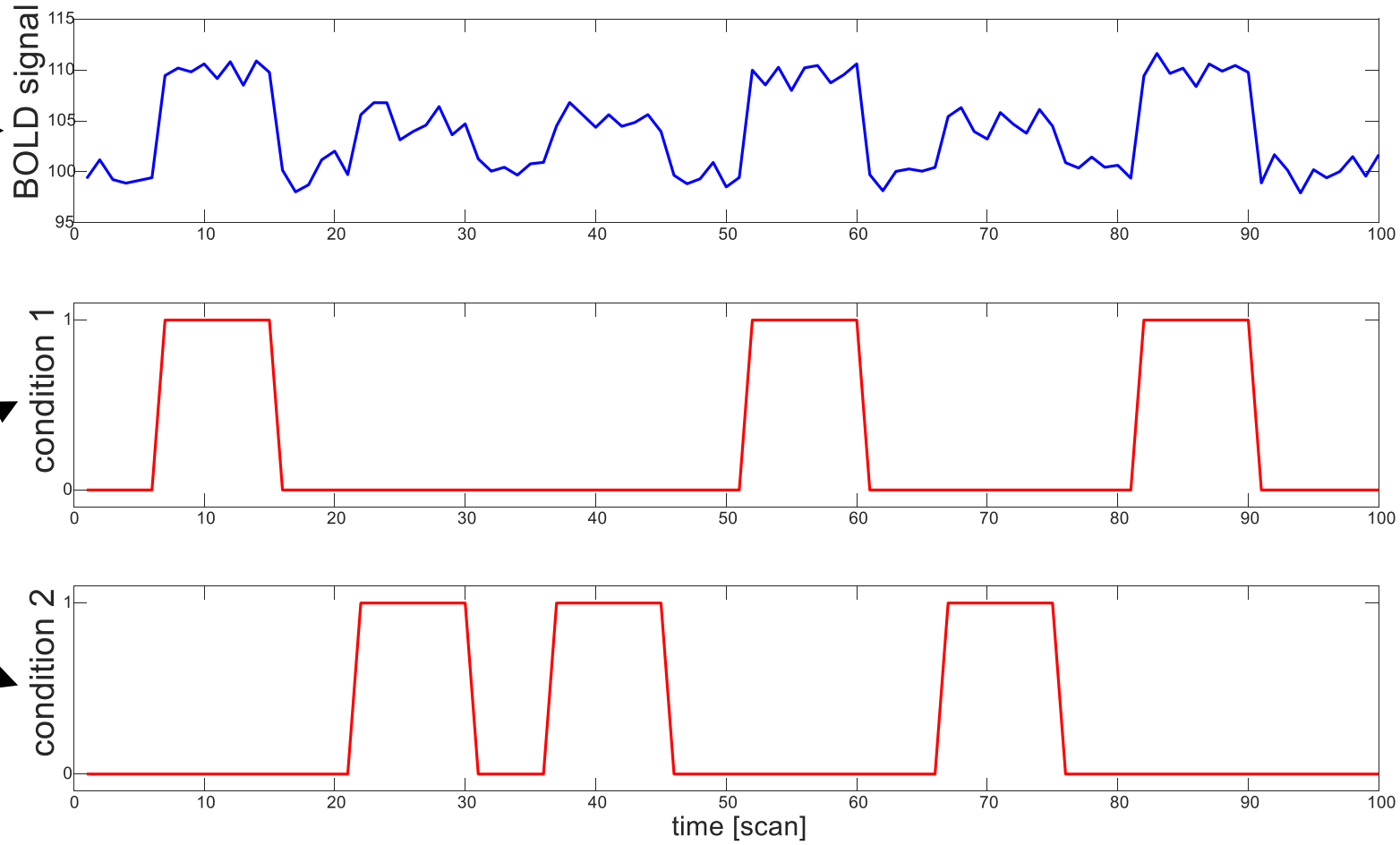


thresholded SPM

Voxel-wise time series analysis

“fMRI signal”

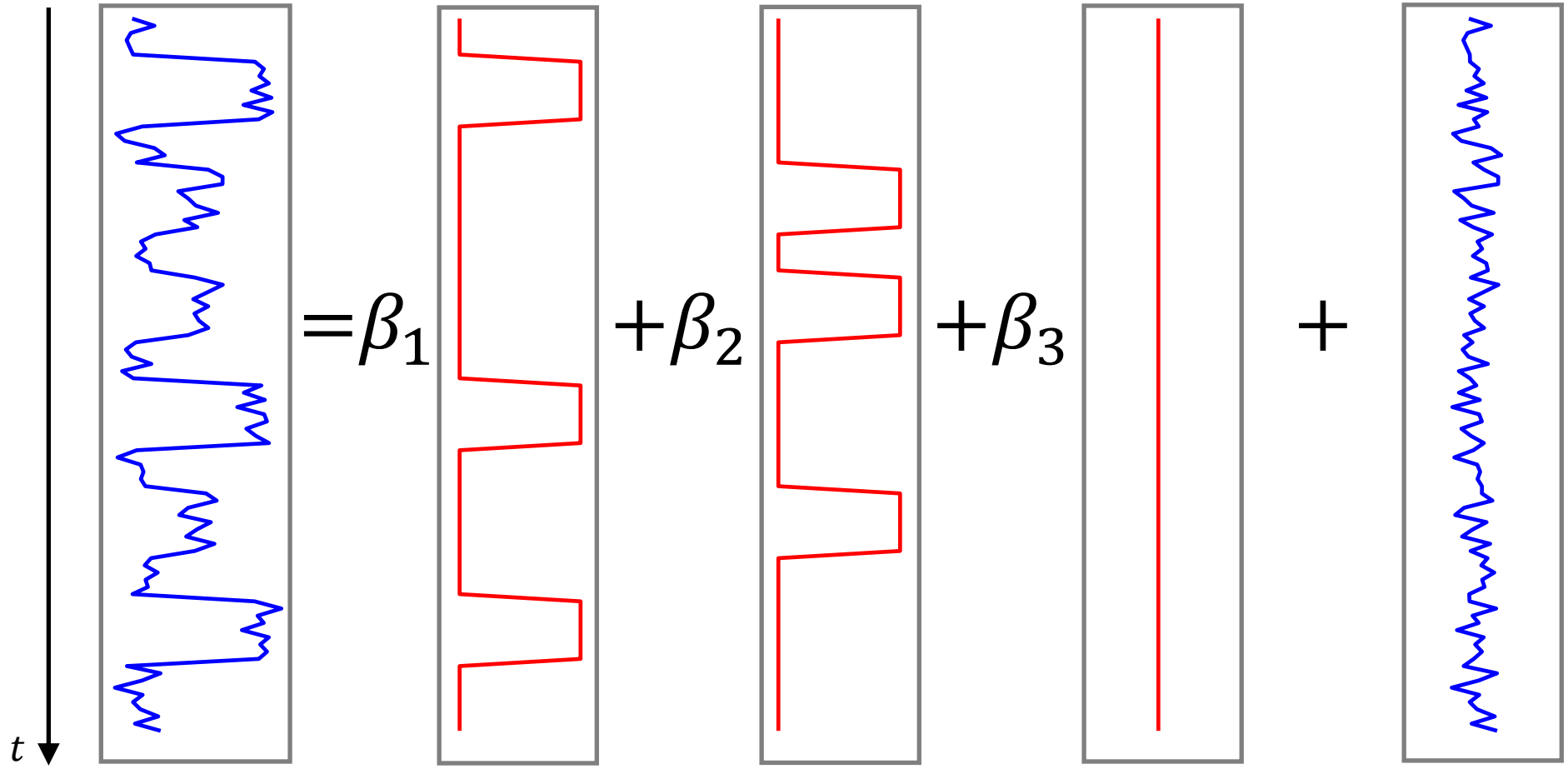
“stimulus functions”



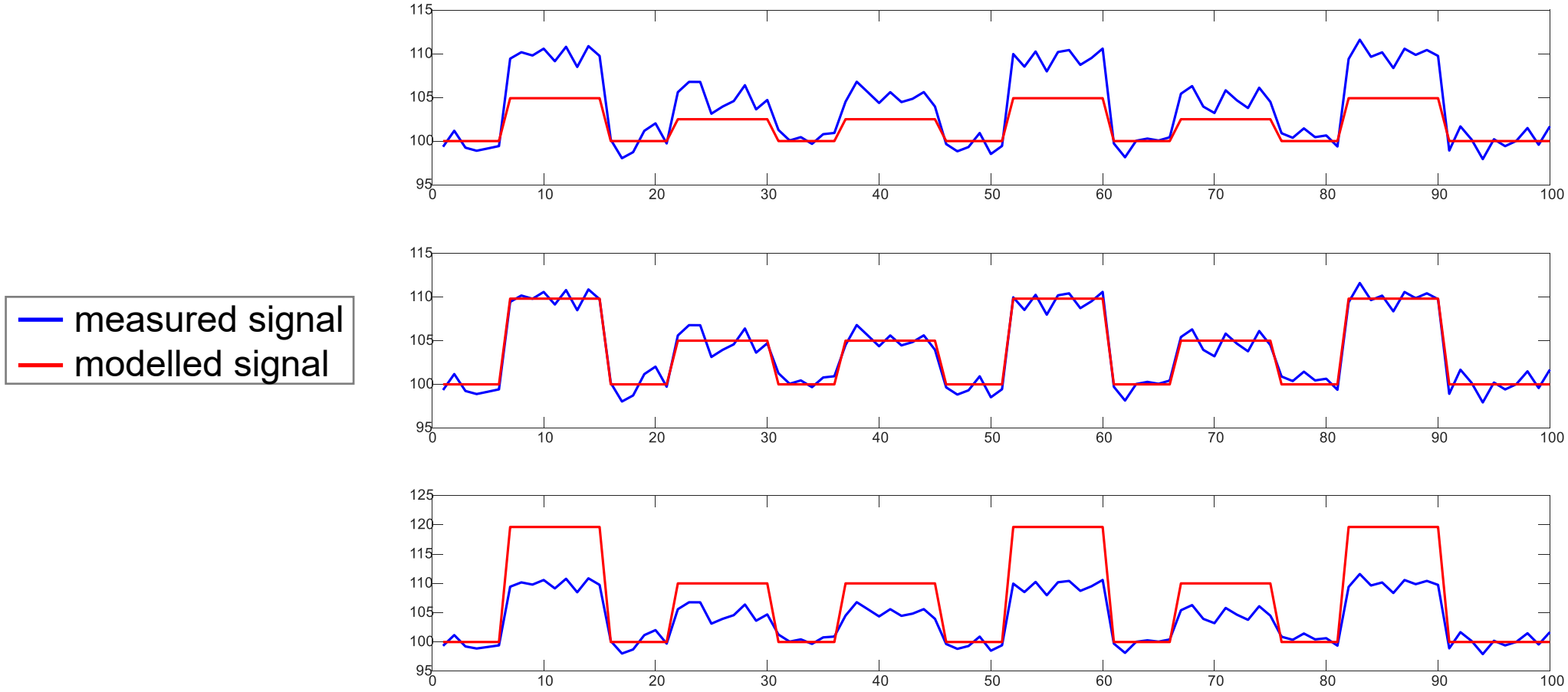
We also know the fMRI signal, because we have measured it.

We know at which point in time the subject was in which experimental condition.

General linear model for fMRI data



General linear model for fMRI data

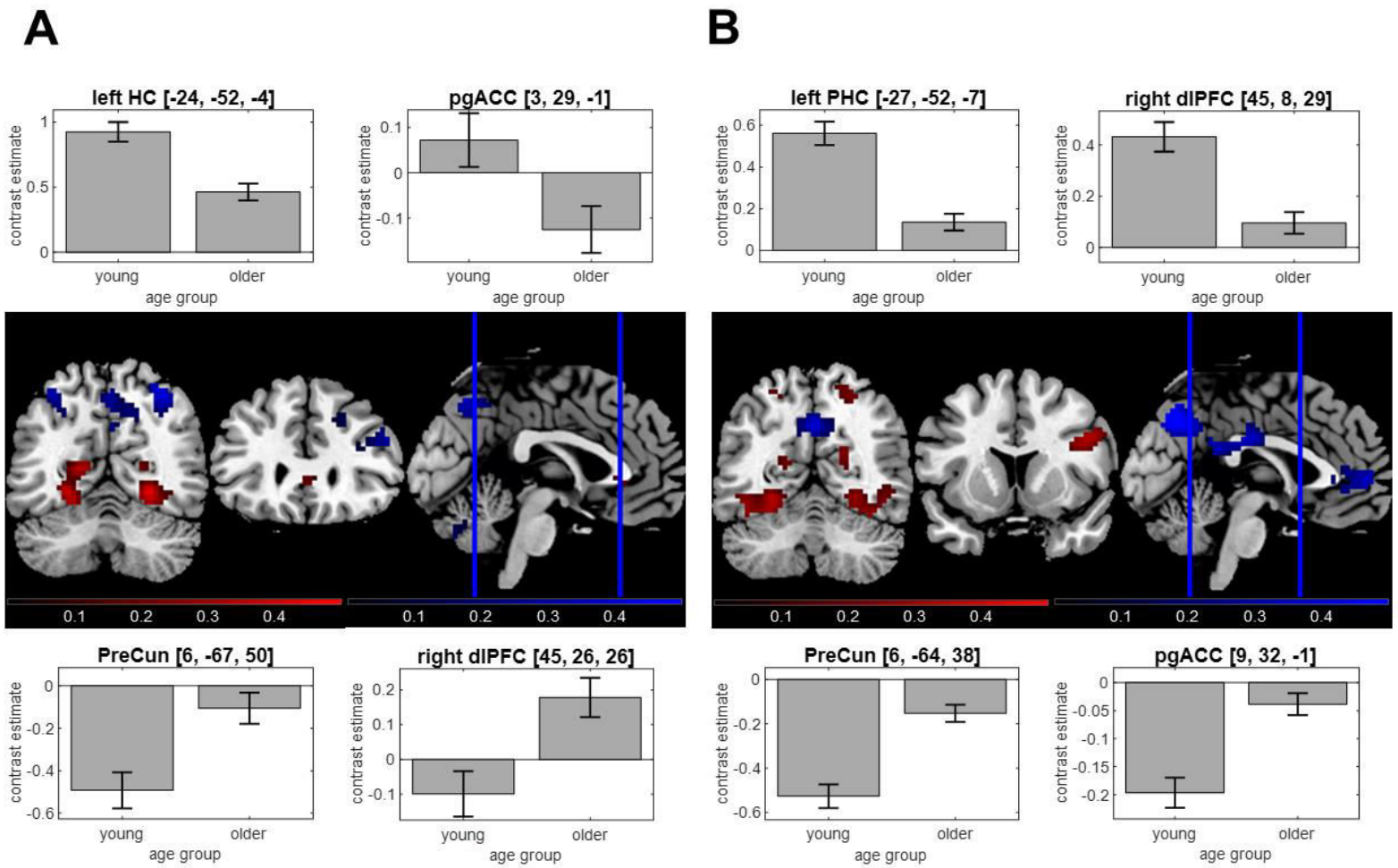


β's too small

β's optimal

β's too large

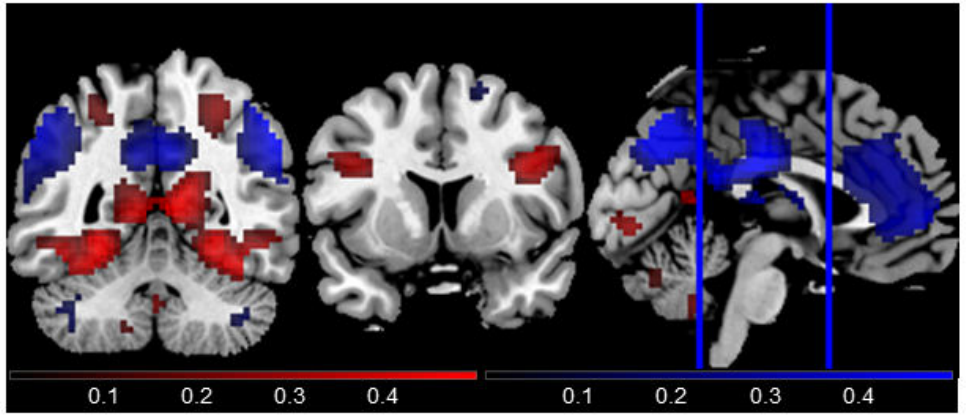
Using fMRI, we observe age-related differences for novelty processing and subsequent memory.



Soch*, Richter* et al., HBM, 2021, Fig. 2.

This motivates two fMRI biomarker scores quantifying the deviation/similarity of older from/with young subjects.

A



i, j index subject and voxel, respectively

$\hat{\beta}_j$ mean β of young subjects in j-th voxel

$\hat{\sigma}_j$ SD of β of young subjects in j-th voxel

J_+ set of voxels in which $\beta_j > 0$ significantly

J_- set of voxels in which $\beta_j < 0$ significantly

B

$$\mathrm{FADE}_i = \frac{1}{v}\sum_{j \notin J_+} t_{ij} - \frac{1}{v_+}\sum_{j \in J_+} t_{ij}$$

$$\mathrm{SAME}_i = \frac{1}{v_+}\sum_{j \in J_+} \frac{\hat{\gamma}_{ij} - \hat{\beta}_j}{\hat{\sigma}_j} + \frac{1}{v_-}\sum_{j \in J_-} \frac{\hat{\beta}_j - \hat{\gamma}_{ij}}{\hat{\sigma}_j}$$

t_{ij} t-value of i-th subject in j-th voxel

$\hat{\gamma}_{ij}$ β-value of i-th subject in j-th voxel

v, v_+ number of voxels outside/inside J_+

v_+, v_- number of voxels inside J_+ / J_-

Düzel et al., Hippocampus, 2011; Soch*, Richter* et al., HBM, 2021, Fig. 1.

	FADE-Score	**SAME-Score**
Novelty-Kontrast	novelty-FADE	novelty-SAME
Memory-Kontrast	memory-FADE	memory-SAME

Novelty-Kontrast = Hirnaktivitätsunterschiede zwischen neuen und bekannten Items
Memory-Kontrast = Hirnaktivitätsunterschiede zwischen erinnerten und vergessenen Items
FADE-Score = Abweichung des Aktivitätsmusters von dem junger Personen
SAME-Score = Ähnlichkeit von Aktivierungen und Deaktivierung mit jungen Personen

Formalia

Beispielstudie

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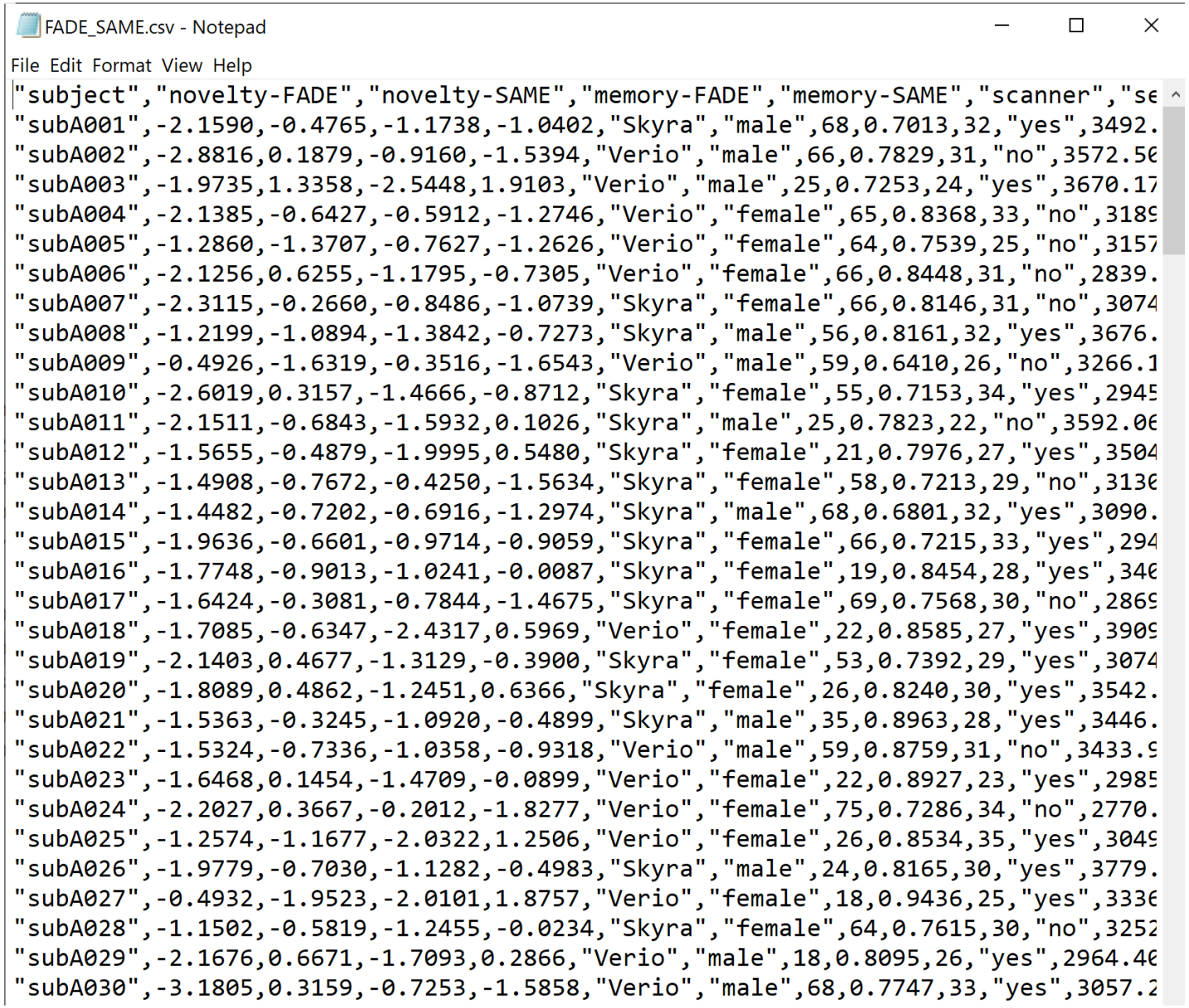
LIN Magdeburg: „Autonomy in Old Age” (AiA) cohort

- **young:** N = 106; 47/59 m/f, 18-35 yrs, 24.12 ± 4.00 yrs.
- **older:** N = 111; 46/65 m/f, 60-80 yrs, 67.28 ± 4.65 yrs.
- **middle-aged:** N = 42; 13/29 m/f, 51-59 yrs, 55.48 ± 2.57 yrs.
- **yFADE (2012):** N = 117; 60/57 m/f, 19-33 yrs, 24.37 ± 2.60 yrs.
- comparison of interest: **young** vs. **older**
- robustness check: **yFADE** replicates **young**

Soch*, Richter* et al., HBM, 2021, Tab. 1 & S1


FADE_SAME.csv - Notepad
File Edit Format View Help
"subject","novelty-FADE","novelty-SAME","memory-FADE","memory-SAME","scanner","se
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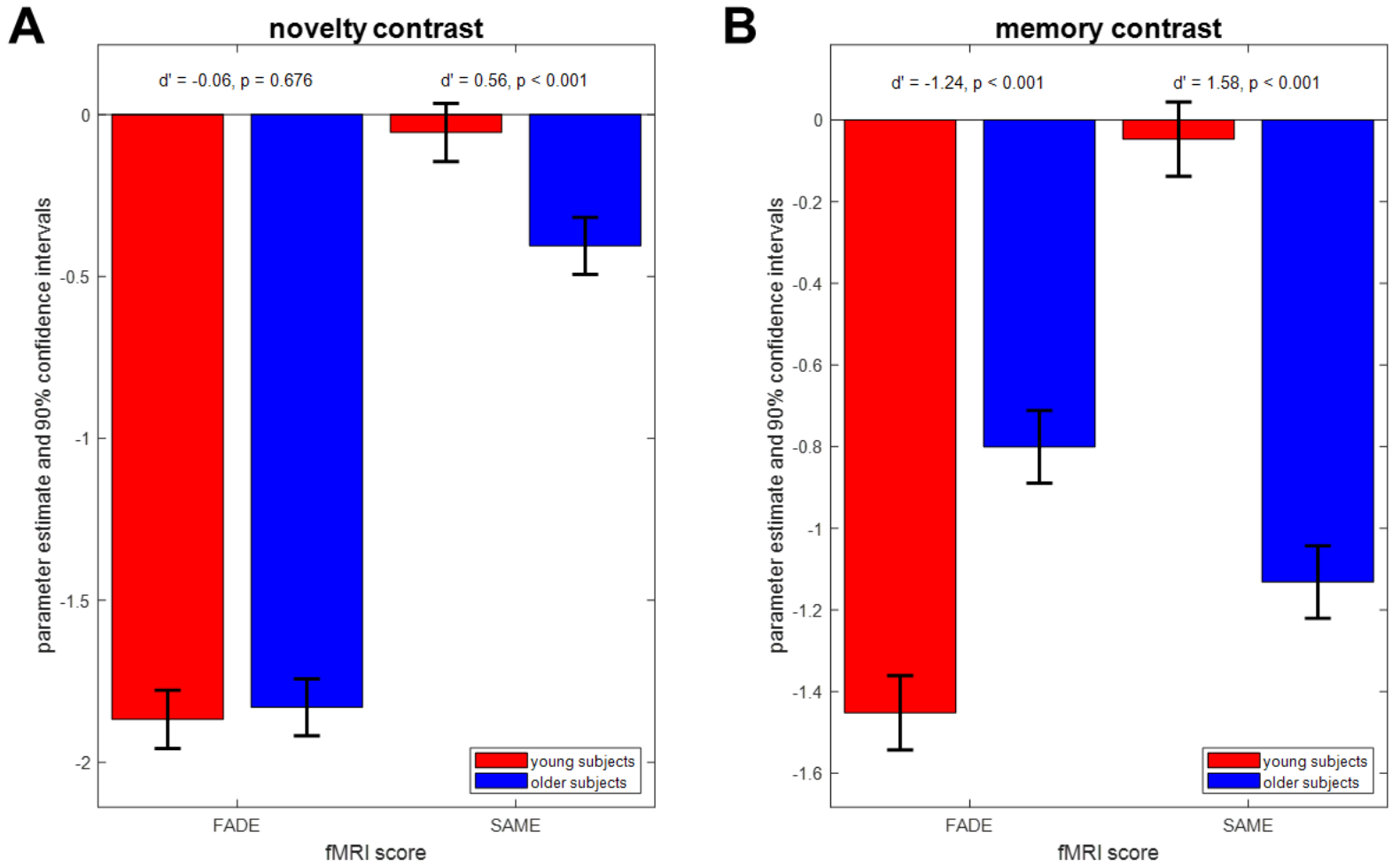
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	subject	novelty-FADE	novelty-SAME	memory-FADE	memory-SAME	scanner	sex	age	memory	MWT-B	Abitur	V-HC-left	V-HC-right	V-left-Hippo	V-left-Subicu	V-left-CA1	V-left-CA3	V-left-CA4	V-right-Hipp
2	subA001	-2,1590	-0,4765	-1,1738	-1,0402	Skyra	male	68	0,7013	32	yes	3492,9	3710,6	526,9	473,5	634,1	214,6	246,5	624,7
3	subA002	-2,8816	0,1879	-0,9160	-1,5394	Verio	male	66	0,7829	31	no	3572,5	3677,0	575,6	530,3	675,3	199,4	261,5	620,8
4	subA003	-1,9735	1,3358	-2,5448	1,9103	Verio	male	25	0,7253	24	yes	3670,2	3798,1	564,2	538,2	764,8	173,2	251,6	629,6
5	subA004	-2,1385	-0,6427	-0,5912	-1,2746	Verio	female	65	0,8368	33	no	3189,5	3118,7	465,8	501,6	660,5	175,4	225,1	463,4
6	subA005	-1,2860	-1,3707	-0,7627	-1,2626	Verio	female	64	0,7539	25	no	3157,0	3035,6	516,6	420,9	585,7	203,3	233,5	483,0
7	subA006	-2,1256	0,6255	-1,1795	-0,7305	Verio	female	66	0,8448	31	no	2839,9	3014,2	449,6	429,5	581,4	172,0	196,1	499,7
8	subA007	-2,3115	-0,2660	-0,8486	-1,0739	Skyra	female	66	0,8146	31	no	3074,1	3193,8	487,6	456,5	575,3	177,5	222,1	504,3
9	subA008	-1,2199	-1,0894	-1,3842	-0,7273	Skyra	male	56	0,8161	32	yes	3676,6	3480,1	460,0	468,0	734,5	260,7	294,9	519,2
10	subA009	-0,4926	-1,6319	-0,3516	-1,6543	Verio	male	59	0,6410	26	no	3266,2	3295,3	429,4	439,1	608,2	168,2	250,5	413,1
11	subA010	-2,6019	0,3157	-1,4666	-0,8712	Skyra	female	55	0,7153	34	yes	2945,7	3141,1	485,4	400,5	525,5	173,9	208,6	534,1
12	subA011	-2,1511	-0,6843	-1,5932	0,1026	Skyra	male	25	0,7823	22	no	3592,1	3475,2	468,5	500,7	755,9	188,4	293,4	476,2
13	subA012	-1,5655	-0,4879	-1,9995	0,5480	Skyra	female	21	0,7976	27	yes	3504,7	3832,6	669,2	461,9	664,2	195,8	259,7	702,4
14	subA013	-1,4908	-0,7672	-0,4250	-1,5634	Skyra	female	58	0,7213	29	no	3130,6	3362,7	497,7	422,0	591,1	184,7	231,6	574,7
15	subA014	-1,4482	-0,7202	-0,6916	-1,2974	Skyra	male	68	0,6801	32	yes	3090,7	3504,5	458,2	448,5	614,0	157,9	242,1	512,1
16	subA015	-1,9636	-0,6601	-0,9714	-0,9059	Skyra	female	66	0,7215	33	yes	2945,6	3016,4	458,7	429,3	512,0	178,3	215,3	456,9
17	subA016	-1,7748	-0,9013	-1,0241	-0,0087	Skyra	female	19	0,8454	28	yes	3405,1	3335,7	585,7	410,1	661,1	222,0	261,6	596,1
18	subA017	-1,6424	-0,3081	-0,7844	-1,4675	Skyra	female	69	0,7568	30	no	2869,3	2748,5	350,4	446,3	548,1	130,8	230,9	339,2
19	subA018	-1,7085	-0,6347	-2,4317	0,5969	Verio	female	22	0,8585	27	yes	3909,1	3986,4	574,3	500,4	812,3	240,3	291,6	623,4
20	subA019	-2,1403	0,4677	-1,3129	-0,3900	Skyra	female	53	0,7392	29	yes	3074,5	3357,1	491,8	423,5	570,6	214,1	221,9	527,8
21	subA020	-1,8089	0,4862	-1,2451	0,6366	Skyra	female	26	0,8240	30	yes	3542,7	3549,7	485,7	554,0	673,9	197,0	282,4	602,6
22	subA021	-1,5363	-0,3245	-1,0920	-0,4899	Skyra	male	35	0,8963	28	yes	3446,0	3726,1	545,9	510,8	581,4	184,3	257,6	552,5
23	subA022	-1,5324	-0,7336	-1,0358	-0,9318	Verio	male	59	0,8759	31	no	3433,9	3570,6	498,0	448,9	700,1	211,3	269,8	560,3
24	subA023	-1,6468	0,1454	-1,4709	-0,0899	Verio	female	22	0,8927	23	yes	2985,2	3292,9	577,9	390,3	522,9	180,7	220,9	557,8
25	subA024	-2,2027	0,3667	-0,2012	-1,8277	Verio	female	75	0,7286	34	no	2770,9	2748,0	404,7	352,5	510,5	155,2	203,3	375,1
26	subA025	-1,2574	-1,1677	-2,0322	1,2506	Verio	female	26	0,8534	35	yes	3049,1	3071,2	543,9	422,4	611,6	174,6	207,4	552,4
27	subA026	-1,9779	-0,7030	-1,1282	-0,4983	Skyra	male	24	0,8165	30	yes	3779,6	3738,9	540,6	516,7	807,8	202,9	275,7	527,9
28	subA027	-0,4932	-1,9523	-2,0101	1,8757	Verio	female	18	0,9436	25	yes	3336,9	3451,3	523,0	474,4	636,3	201,2	246,4	539,1
29	subA028	-1,1502	-0,5819	-1,2455	-0,0234	Skyra	female	64	0,7615	30	no	3253,0	3566,6	535,8	451,1	616,9	197,6	240,6	639,5
30	subA029	-2,1676	0,6671	-1,7093	0,2866	Verio	male	18	0,8095	26	yes	2964,4	3227,2	437,1	421,7	529,3	161,6	231,4	505,3
31	subA030	-3,1805	0,3159	-0,7253	-1,5858	Verio	male	68	0,7747	33	yes	3057,3	3265,7	454,4	394,9	610,2	206,9	243,1	506,0

Variable	Wertebereich	Bedeutung
subject	$\mathrm{subANNN}$ $\mathrm{subBNNN}$	individuelle VP-ID (“subANNN”: Studie A (young, older, middle-aged); “subBNNN”: Studie B (yFADE))
novelty-FADE	$\mathbb{R}$	FADE-Score für den Novelty-Kontrast
novelty-SAME	$\mathbb{R}$	SAME-Score für den Novelty-Kontrast
memory-FADE	$\mathbb{R}$	FADE-Score für den Memory-Kontrast
memory-SAME	$\mathbb{R}$	SAME-Score für den Memory-Kontrast
scanner	$\{\mathrm{Skyra}, \mathrm{Verio}\}$	MRT-Scanner, an dem die betreffende VP gemessen wurde
sex	$\{\mathrm{female}, \mathrm{male}\}$	Geschlecht
age	$18 \leq x \leq 80$	Alter in Jahren
memory	$0 \leq x \leq 1$	Gedächtnisleistung gemäß Retrieval-Session der Studie (berechnet als area under the curve (AUC))
MWT-B	$0 \leq x \leq 37$	Ergebnis im Mehrfachwahl-Wortschatz-Intelligenztest (MWT), Version B
Abitur	$\{\mathrm{yes}, \mathrm{no}\}$	Allgemeine Hochschulreife
V-HC-left	$\mathbb{R}$	Volumen des linken Hippocampus in mm^3
V-HC-right	$\mathbb{R}$	Volumen des rechten Hippocampus in mm^3
V-left-[…]	$\mathbb{R}$	Volumen von Subregionen des linken Hippocampus in mm^3 (Hippocampal tail, Subiculum, CA1/3/4)
V-right-[…]	$\mathbb{R}$	Volumen von Subregionen des rechten Hippocampus in mm^3 (Hippocampal tail, Subiculum, CA1/3/4)

All scores except novelty-FADE significantly differ between young and older adults.



Soch*, Richter* et al., HBM, 2021, Fig. 3.

There are no effect of scanner or gender or interactions with them on any of the fMRI scores.

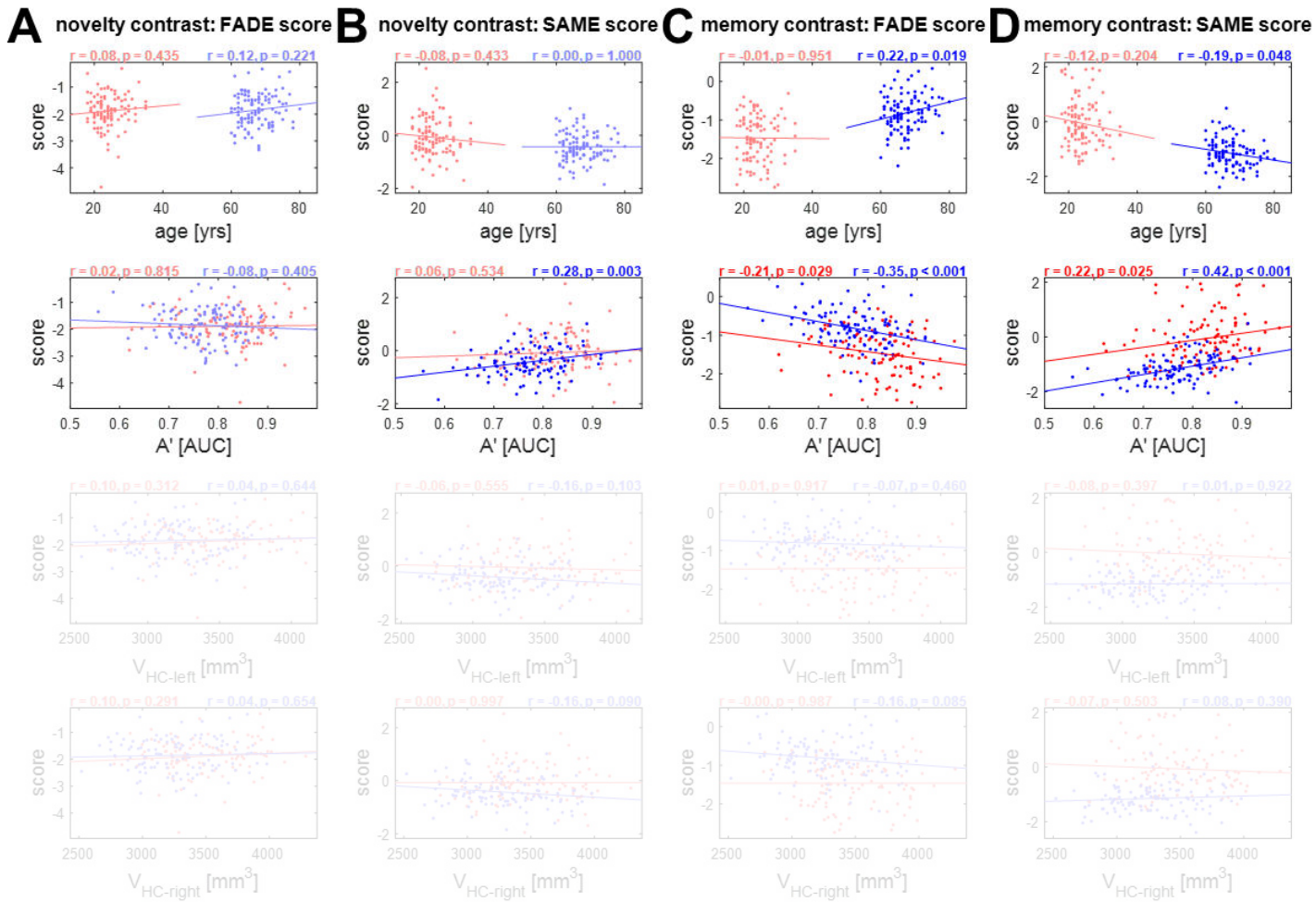
TABLE 2 Between-subject ANOVAs for FADE-classic and FADE-SAME scores

	Novelty contrast		Memory contrast	
	FADE score	**SAME score**	**FADE score**	**SAME score**
main effect of scanner	$F = 0.11, p = .742$	$F = 0.14, p = .707$	$F = 0.13, p = .723$	$F = 1.65, p = .201$
main effect of gender	$F = 0.22, p = .636$	$F = 1.41, p = .236$	$F = 0.36, p = .550$	$F = 2.67, p = .104$
main effect of age group	$F = 0.16, p = .686$	$F = 16.56, p < .001$	$F = 81.76, p < .001$	$F = 135.04, p < .001$
interaction of scanner and gender	$F = 0.05, p = .815$	$F = 0.00, p = .999$	$F = 0.06, p = 0.810$	$F = 0.20, p = .653$
interaction of scanner and age group	$F = 1.84, p = .177$	$F = 0.02, p = .900$	$F = 0.97, p = .325$	$F = 0.71, p = .399$
interaction of gender and age group	$F = 2.10, p = .149$	$F = 0.01, p = .908$	$F = 0.44, p = .507$	$F = 0.84, p = .360$
interaction of age group, scanner, and gender	$F = 0.40, p = .528$	$F = 0.05, p = .826$	$F = 0.00, p = .995$	$F = 0.03, p = .853$

Note: Results from three-way ANOVAs with scanner, gender, and age group as factors for both scores computed from both, novelty and memory contrast. All F values have one numerator degree of freedom and 209 denominator degrees of freedom.

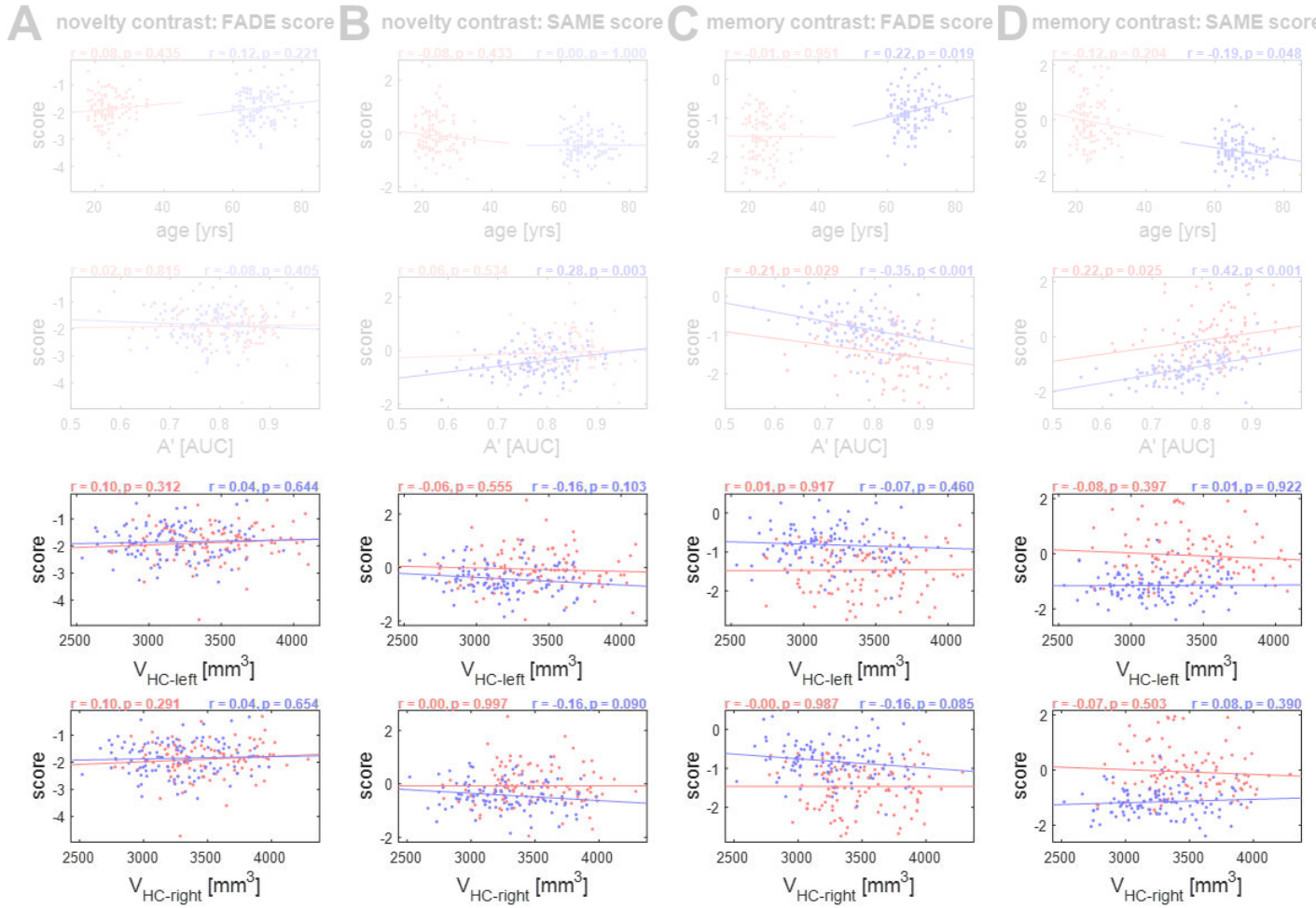
Soch*, Richter* et al., HBM, 2021, Tab. 2.

When controlling for age group, FADE and SAME score are significantly correlated to memory performance…



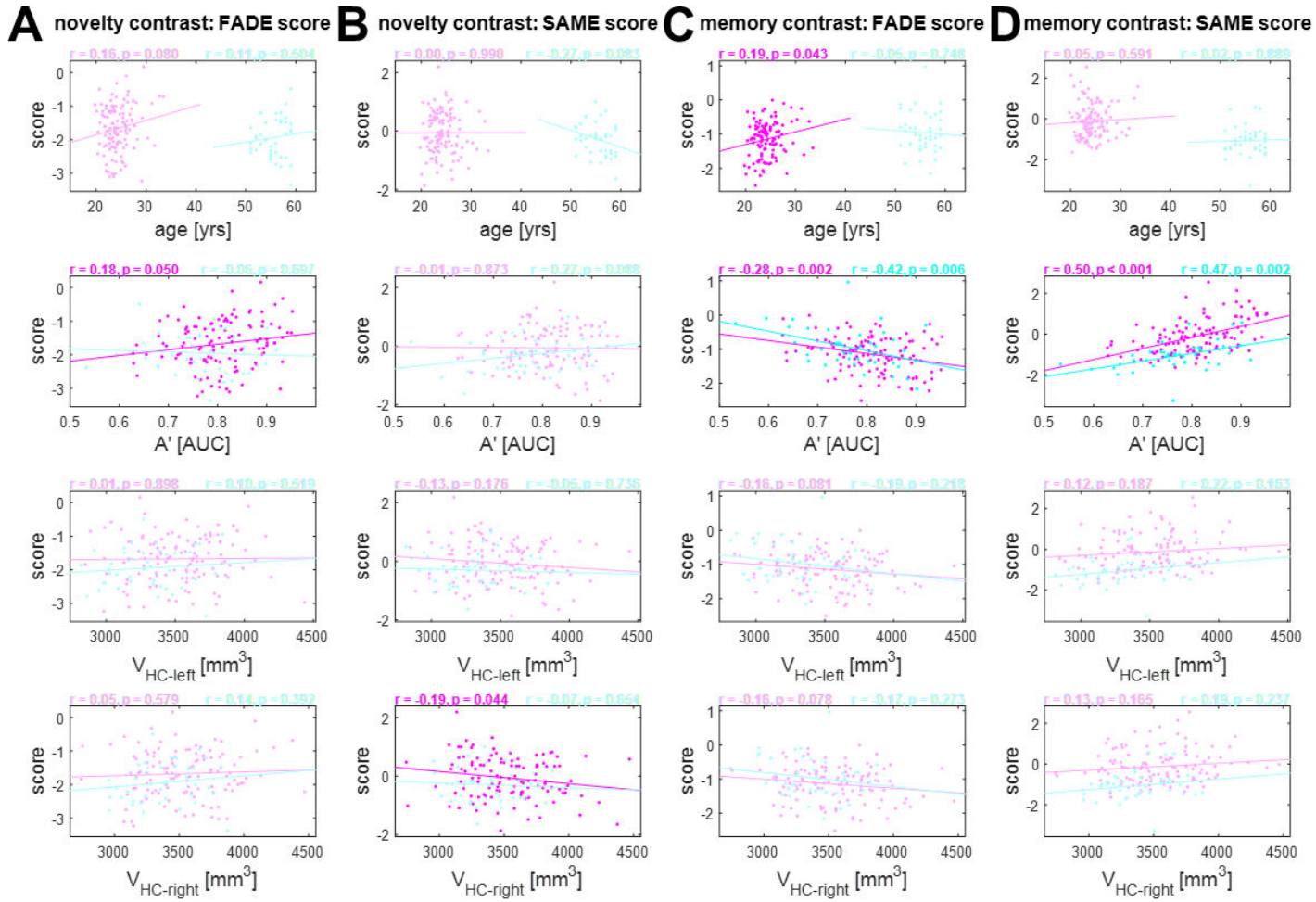
Soch*, Richter* et al., HBM, 2021, Fig. 4.

… but they are not correlated with hippocampal volume.



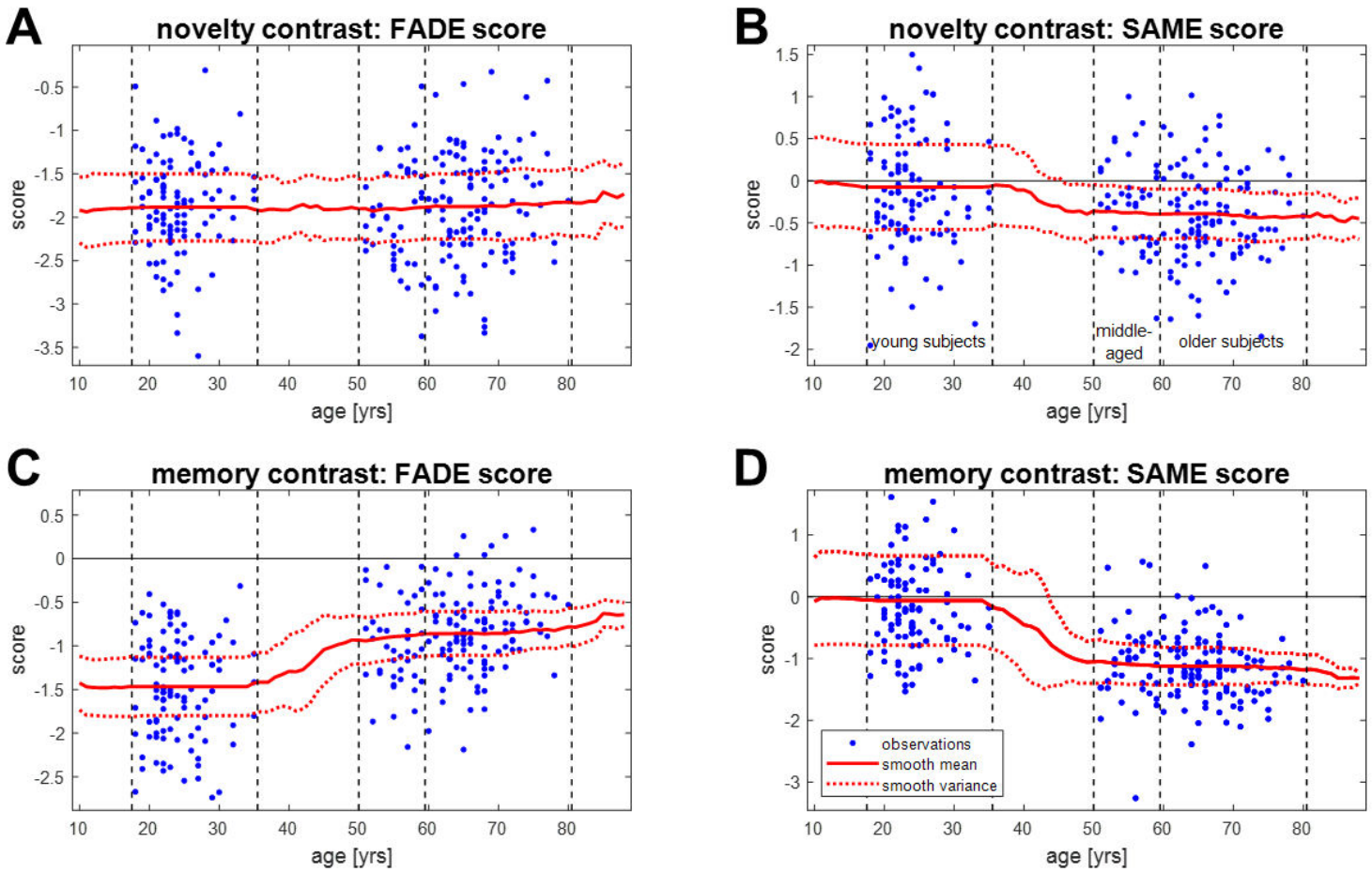
Soch*, Richter* et al., HBM, 2021, Fig. 4.

These patterns replicate in middle-aged and yFADE subjects.



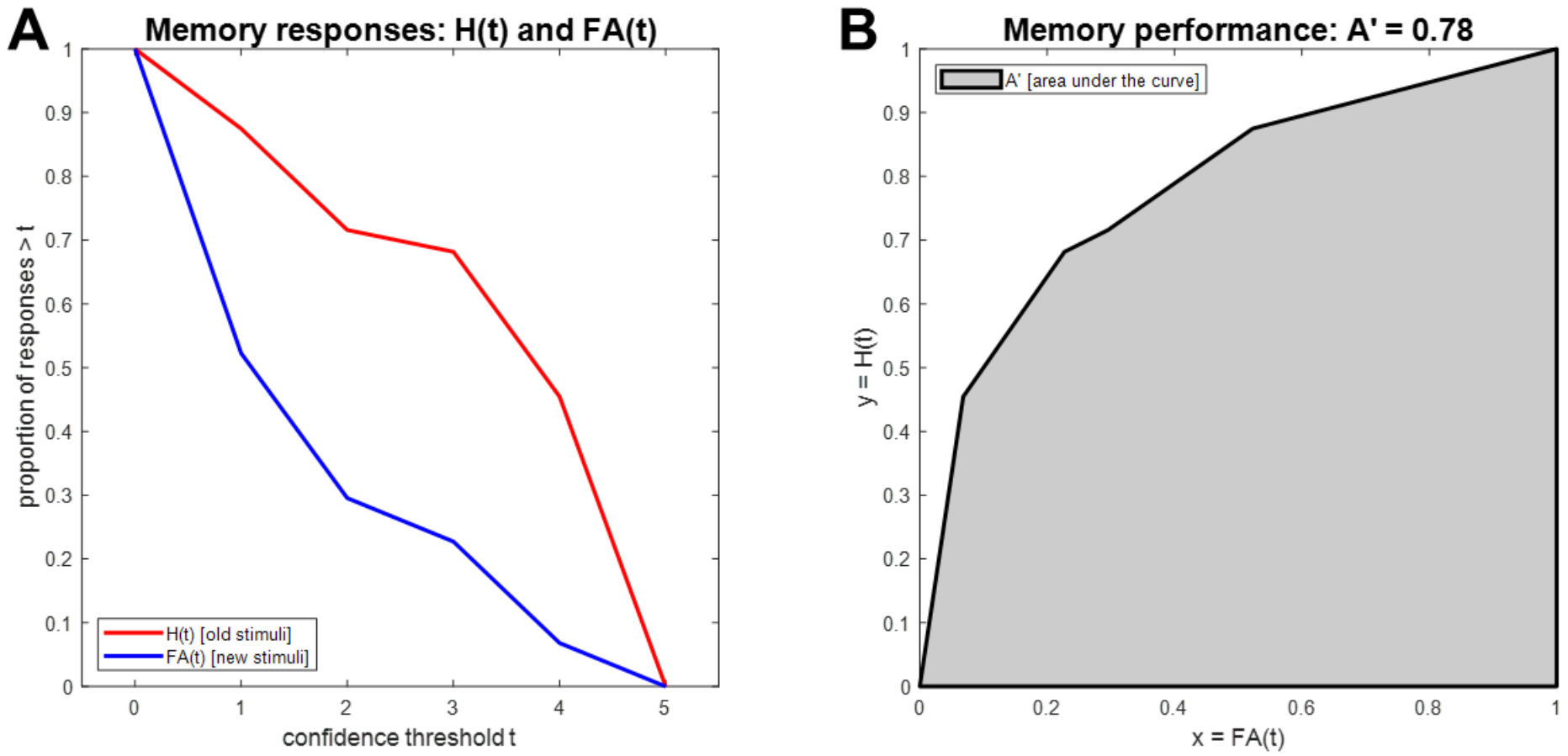
Soch*, Richter* et al., HBM, 2021, Fig. S5.

Relationships of scores with age are largely between-group rather than within-group effects.



Soch*, Richter* et al., HBM, 2021, Fig. S4.

In the FADE paradigm, memory performance can be measured as area under the curve (AUC).



Soch*, Richter* et al., HBM, 2021, Fig. 8.

Formalia

Beispielstudie

Beispieldatensatz

Seminarrelevanz

Kognitiv-neurowissenschaftliche Relevanz (MSc Psy KON)

- Gedächtnis-Netzwerk im menschlichen Gehirn
- (para-)hippocampal: aktiviert für neuartig/erinnert
- default mode network: deaktiviert für neuartig/erinnert
- Prädiktion von Gedächtnisleistung aus Hirnaktivitätsmustern

Kim, NeuImg, 2011; Maillet & Rajah, NeurosciBiobehavRev, 2014; Soch*, Richter* et al., HBM, 2021, Fig. 7; Soch*, Richter* et al., eNeuro, 2022, Fig. 5.

Kognitiv-neurowissenschaftliche Relevanz (MSc Psy KON)

- Gedächtnis-Netzwerk im
- (para-)hippocampal: aktiv
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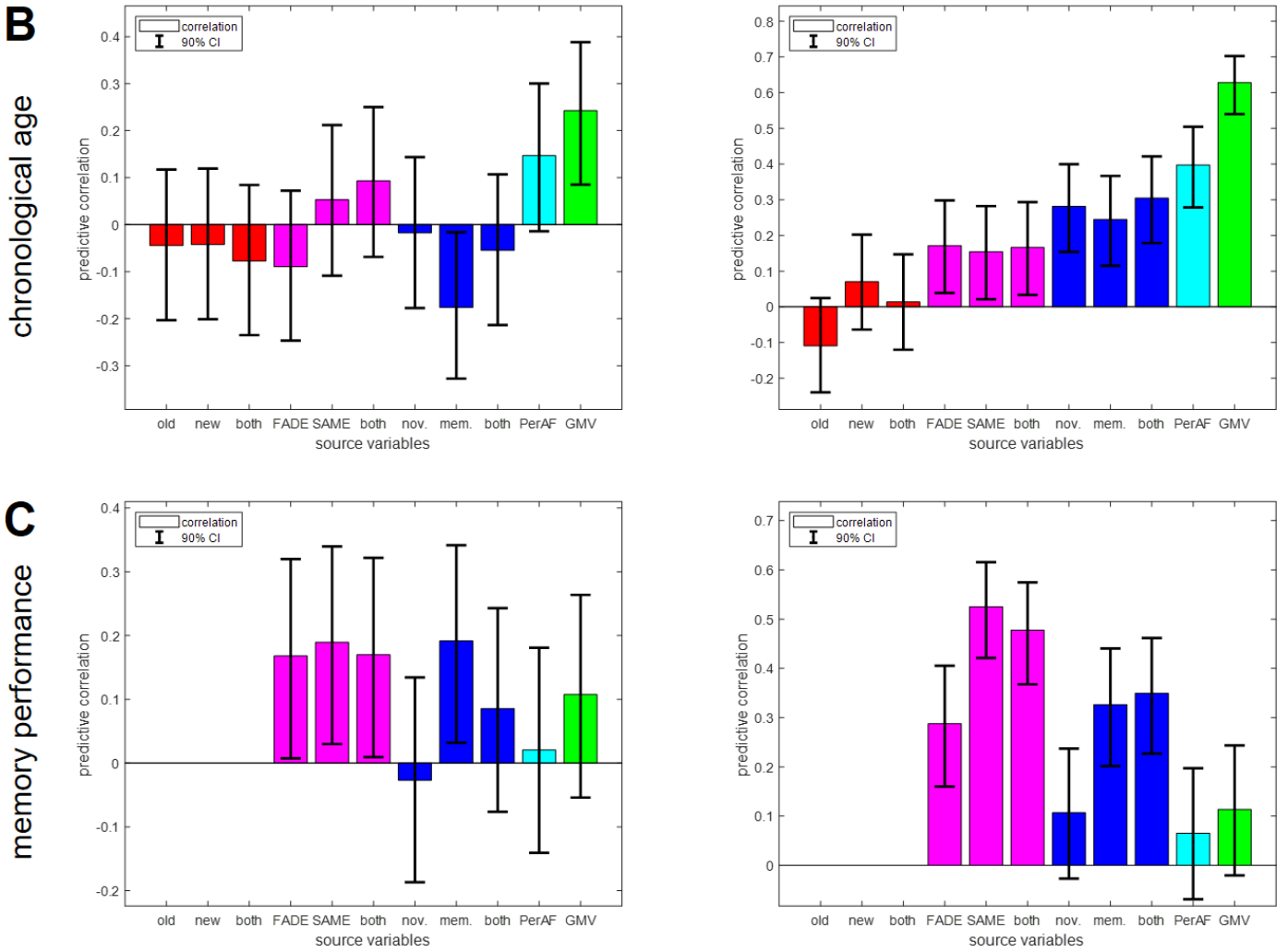
- Prädiktion von Gedächtni



Kim, NeuImg, 2011; Maillet & Rajah, NeurosciBiobehavRev, 2014; Soch*, Richter* et al., HBM, 2021, Fig. 7; Soch*, Richter* et al., eNeuro, 2022, Fig. 5.

Klinische Relevanz (MSc KliPP, MSc Psy KLN)

- kognitives Altern
- „successful agers“
- gesundes Altern vs. (Alzheimer-)Demenz
- SCD und MCI als Vorstufen der Alzheimer-Erkrankung

Nyberg et al., TICS, 2012; Cabeza et al., NatRevNeurosci, 2018; Soch et al., Brain, 2024, Fig. 2.

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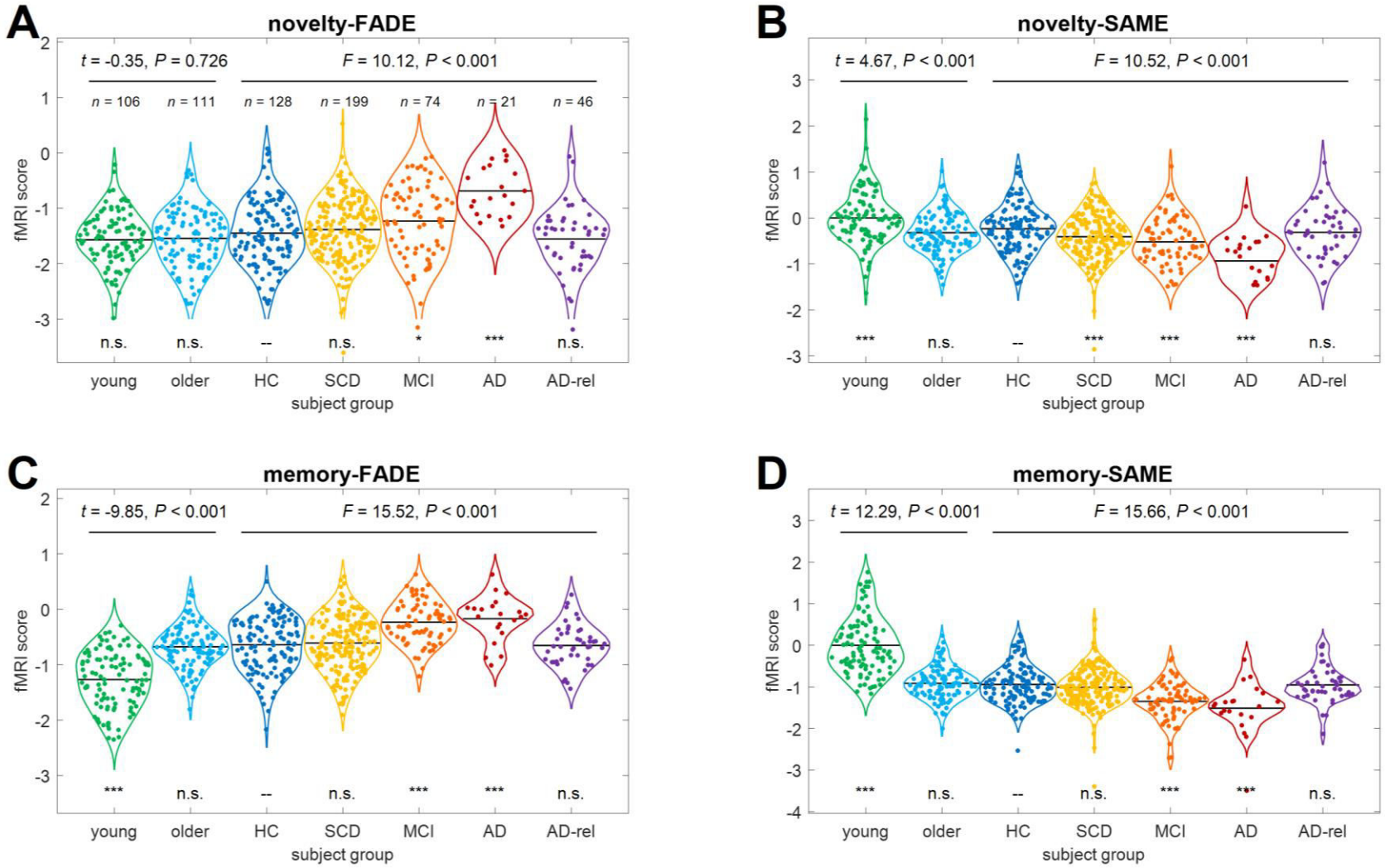

Nyberg et al., TICS, 2012; Cabeza et al., NatRevNeurosci, 2018; Soch et al., Brain, 2024, Fig. 2.

Umweltpsychologische Relevanz (MSc UPsy/MTI)

- Interaktion zwischen Mensch und Umwelt
- modifizierbare vs. nicht-modifizierbare Risikofaktoren
- nicht-modifizierbar: genetische Veranlagung
- modifizierbar: Bildung, Alkohol, Tabak, soziale Kontakte etc.
- Abitur und MWT-B als Proxy für Bildungsstatus
- Bildungs-/Berufsjahre, IQ, BMI, Lifestyle-Faktoren

Livingston et al., Lancet, 2017, Fig. 4; Livingston et al., Lancet, 2020, Fig. 7; Soch et al., Brain, 2024, Fig. 3.

Umweltpsychologische Relevanz

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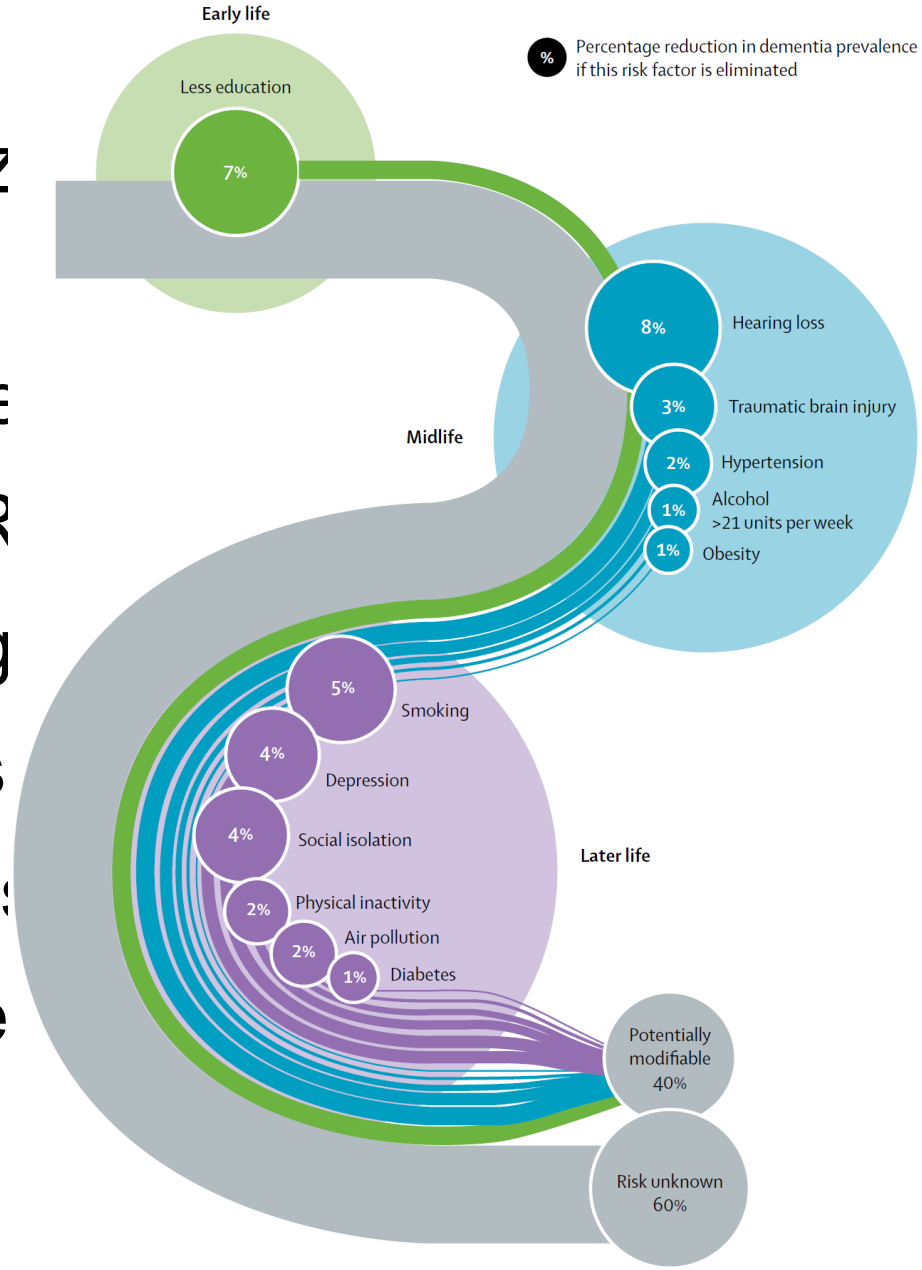

Livingston et al., Lancet, 2017, Fig. 4; Livingston et al., Lancet, 2020, Fig. 7; Soch et al., Brain, 2024, Fig. 3.

Zusammenfassung

- 16.10.2025: inhaltliche Einführung
- 23.10.2025: Paper lesen (bei Fragen melden!)
- 30.10.2025: Demo-Präsentation & Vergabe der LNWs

Q & A