# **Supplementary Materials**

## Dynamic modeling of practice effects across the healthy aging-Alzheimer's disease continuum

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Complete information on the modeling approach can be found online at:

https://github.com/Bender-Lab/Practice\_effects

#### Data analytic information

The following supplementary materials provide additional information on the data analytic procedures used. An anonymized version of the original data, R code and validation can be obtained from: <u>https://osf.io/52s64/?view\_only=5873db78acf24c13b938709c23bf8d32</u>.

### Continuous time structural equation modeling.

To analyze change, individual differences in change, and the impact of instructional interventions, we developed hierarchical Bayesian continuous time dynamic models and implemented them in the *ctsem* software (Driver and Voelkle, 2018). To account for varying observation timings and to allow for continuously interacting processes, *ctsem* estimates an underlying continuous time model, which is translated into discrete time expectations and covariance matrices by well-known approaches using matrix exponentiation (i.e., Voelkle and Oud, 2012; Voelkle, Oud, Davidov and Schmidt, 2012).

Three latent processes, including a general trend, a memory intervention effect, and a repetition effect constitute the core of the model. These processes are initialized to zero at the time of the first observation. Their evolution over time is described by the differential equation (1?), and together they predict the observed variables according to a measurement model that we describe below. The latent process differential equation is, in matrix form:

$$\frac{\mathrm{d}\boldsymbol{\eta}(t)}{\mathrm{d}t} = \mathbf{A}\boldsymbol{\eta}(t) + \mathbf{b} + \mathbf{M}\boldsymbol{\chi}(t)$$

Vector  $\mathbf{\eta}(t)$  represents the state of the 3 latent processes as a function of time (*t*), and therefore  $d\mathbf{\eta}(t)/dt$  simply means the gradient or directional change of the latent processes. The

diagonal matrix **A** contains freely estimated self-feedback terms of the processes, which are prefixed with sf in the variable names that appear in the output. These terms capture the rate of decline after a repetition or intervention effect, and the extent of non-linearity in the trend component. The continuous time intercept vector **b** provides a constant input to the latent processes  $\eta$ , and is fixed at zero except for the trend intercept, which is fixed to 1. The timedependent predictors,  $\chi(t)$ , represent exogenous inputs, and are assumed to be zero whenever unobserved. This leads to sharp impulses that affect the system via the effect matrix **M** whenever a non-zero value on an intervention variable occurs, and these impulses then decline according to the estimated self-feedback. For identification purposes, **M** is fixed to 1 for the impact of repetitions on the repetition latent variable as well as the influence of the first instructional intervention on the memory process. The second and third instructional interventions have an estimated parameter (memInt2 and memInt3) governing the size of the impulse generated, relative to the first.

To derive expectations for discretely sampled data, the differential equation is solved and translated to a discrete time representation, for any observation  $u \in U$ .

$$\mathbf{\eta}_{u} = e^{\mathbf{A}(t_{u} - t_{u-1})} \mathbf{\eta}_{u-1} + \mathbf{A}^{-1} (e^{\mathbf{A}(t_{u} - t_{u-1})} - \mathbf{I}) \mathbf{b} + \mathbf{M} \mathbf{x}_{u}$$

Models also included baseline measures of age and sex, and scores produced by the confirmatory factor models of working memory and metabolic risk as covariates on all parameters of the latent process and measurement models, which were also allowed to vary across subjects as random effects. This accounts for issues such as inhomogeneity of measurement error with age and performance, and helps understand, for example, under which circumstances the strategy intervention was most effective. Covariate effect parameters are prefixed by TIP, for time independent predictor. The resulting joint-posterior distribution for the model is:

$$p(\mathbf{\Phi}, \mathbf{\mu}, \mathbf{R}, \mathbf{\beta} | \mathbf{y}, \mathbf{x}, \mathbf{z}) \propto p(\mathbf{y} | \mathbf{\Phi}, \mathbf{x}) p(\mathbf{\Phi} | \mathbf{\mu}, \mathbf{R}, \mathbf{\beta}, \mathbf{z}) p(\mathbf{\mu}, \mathbf{R}, \mathbf{\beta})$$

Where the subject specific parameters  $\Phi_i$  for the system and measurement model are determined in the following manner:

$$\mathbf{\Phi}_i = \mathrm{tform}(\mathbf{\mu} + \mathbf{R}\mathbf{h}_i + \mathbf{\beta}\mathbf{z}_i)$$

tform represents a transformation function chosen to ensure parameters are within the correct range (e.g., standard deviations must be positive).  $\mu$  parameterizes the means of the raw (i.e., before the tform operator is applied) population distributions of subject level parameters. **R** is the Cholesky factor of the raw population distribution covariance matrix, parameterizing the effect of subject specific deviations  $\mathbf{h}_i$  on  $\boldsymbol{\Phi}_i$ .  $\boldsymbol{\beta}$  is the raw effect of time independent predictors  $\mathbf{z}_i$  on  $\boldsymbol{\Phi}_i$ .

A useful visualization of the model can be found in Figure 3, which shows the trend and memory intervention latent processes for two subjects. That figure also illustrates how the processes combine to generate predictions for specific aspects of memory performance. In this case the two forms represent predicted associative hit rate performance on the third set of items (which had no repetition), separately for two subjects. This also illustrates differences in model output when conditioning predictions based only on covariates versus also conditioning on prior observations.

Model respecification for trial-level deviations from Trial 1.

We respecified the model to obtain the subject level parameters for the deviations of Trials 2, 3, and 4 from Trial 1.

require(data.table) subpars <- data.table(ctStanSubjectPars(f,cores=1)[1,,]) subpars\$mm\_t2diff <- subpars\$mm\_hvlt\_t2tc - subpars\$mm\_hvlt\_t1tc subpars\$mm\_t3diff <- subpars\$mm\_hvlt\_t3tc - subpars\$mm\_hvlt\_t1tc subpars\$mm\_t4diff <- subpars\$mm\_hvlt\_t4tc - subpars\$mm\_hvlt\_t1tc cor(subpars)

## References

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Sample	T0-T1	T1-T2	T2-T3
Total	1.11 (0.24)	1.09 (0.26)	1.07 (0.15)
CN	1.17 (0.30)	1.05 (0.15)	1.02 (0.04)
MCI	1.14 (0.31)	1.14 (0.30)	1.04 (0.09)
DAT	1.05 (0.22)	1.20 (0.37)	1.39 (0.22)

Table S1. Mean delays between measurement occasions.

Notes. Values are mean years between measurement occasions with standard deviation in parentheses. CN: cognitively normal; MCI: diagnosis of amnestic or non-amnestic MCI; DAT: diagnosis of multi-domain amnestic dementia. T0-T1: delay from baseline to 1-year follow-up.

Cognitively	Age		Se	Sex		Education	
Normal	Mean (SD)	95% CI	Mean (SD)	95% CI	Mean (SD)	95% CI	
Population mea	ns						
sf_Practice	-0.687 (0.505)	-1.679, 0.307	-0.788 (0.502)	-1.833, 0.185	-0.725 (0.455)	-1.616, 0.139	
sf_Trial	-4.757 (1.525)	-7.812, -2.015	-4.557 (0.314)	-5.165, -3.956	-4.688 (1.631)	-7.981, -1.792	
Diffusion T1	4.555 (0.798)	3.129, 6.266	4.520 (0.308)	3.930, 5.152	4.580 (0.876)	3.097, 6.393	
Diffusion T2	3.721 (0.664)	2.626, 5.102	3.739 (0.248)	3.256, 4.235	3.756 (0.702)	2.497, 5.227	
Diffusion T3	2.878 (0.550)	1.931, 4.010	2.902 (0.232)	2.469, 3.388	2.862 (0.557)	1.896, 4.028	
Diffusion T4	6.177 (1.051)	4.226, 8.438	5.167 (0.353)	4.469, 5.859	5.747 (1.078)	3.842, 8.026	
Meas. Error	0.374 (0.216)	0.101, 0.954	0.357 (0.176)	0.130, 0.784	0.217 (0.103)	0.076, 0.462	
PE	0.572 (0.124)	0.338, 0.800	0.552 (0.132)	0.283, 0.812	0.571 (0.121)	0.348, 0.803	
Trial 1	6.401 (0.147)	6.123, 6.689	6.371 (0.166)	6.048, 6.712	6.482 (0.150)	6.201, 6.766	
Trial 2	9.156 (0.128)	8.911, 9.404	9.114 (0.142)	8.843, 9.386	9.203 (0.134)	8.947, 9.469	
Trial 3	10.164 (0.108)	9.963, 10.374	10.145 (0.123)	9.915, 10.391	10.233 (0.113)	10.011, 10.444	
Trial 4	9.124 (0.170)	8.794, 9.452	9.130 (0.182)	8.790, 9.494	9.181 (0.173)	8.846, 9.520	
Population corr	elations						
Trial 1-PE	-0.261 (0.215)	-0.609, 0.208	-0.280 (0.237)	-0.640, 0.248	-0.238 (0.217)	-0.587, 0.232	
Trial 2-PE	-0.186 (0.216)	-0.531, 0.318	-0.232 (0.233)	-0.594, 0.297	-0.229 (0.214)	-0.558, 0.226	
Trial 3-PE	-0.472 (0.187)	-0.747, -0.027	-0.463 (0.211)	-0.747, 0.040	-0.516 (0.184)	-0.768, -0.067	
Trial 4-PE	-0.463 (0.193)	-0.743, 0.012	-0.500 (0.218)	-0.790, 0.018	-0.477 (0.199)	-0.747, 0.024	
Trial 2-Trial 1	0.888 (0.058)	0.741, 0.963	0.897 (0.058)	0.755, 0.968	0.901 (0.059)	0.750, 0.973	
Trial 3-Trial 1	0.786 (0.102)	0.549, 0.924	0.813 (0.097)	0.564, 0.941	0.812 (0.094)	0.584, 0.934	
Trial 4-Trial 1	0.638 (0.132)	0.319, 0.838	0.653 (0.125)	0.362, 0.846	0.767 (0.102)	0.521, 0.912	
Trial 3-Trial 2	0.867 (0.070)	0.700, 0.961	0.877 (0.062)	0.712, 0.960	0.884 (0.058)	0.740, 0.963	
Trial 4-Trial 2	0.770 (0.092)	0.532, 0.907	0.770 (0.092)	0.553, 0.907	0.843 (0.073)	0.661, 0.944	
Trial 4-Trial 3	0.819 (0.090)	0.587, 0.940	0.836 (0.078)	0.643, 0.942	0.898 (0.059)	0.741, 0.973	

Table S2. Sensitivity model population means and correlations for the cognitively normal subgroup

Note. 95% CI: values are upper (2.5%) and lower (97.5%) bounds. sf\_Practice: Practice self-feedback; sf\_Trial: Trial self-feedback; Diffusion: standard deviation of diffusion processes for a given trial (e.g., T1 is Trial 1); Meas. Error: measurement error; Trial represents manifest mean recall for each Trial, aggregated across occasions. PE: Practice effect gains.

	Age		Se	Sex		Education	
MCI	Mean (SD)	95% CI	Mean (SD)	95% CI	Mean (SD)	95% CI	
Population mean	ns						
sf_Practice	0.322 (0.276)	-0.229, 0.853	0.356 (0.252)	-0.149, 0.850	0.238 (0.293)	-0.338, 0.824	
sf_Trial	-4.041 (1.413)	-6.966, -1.626	-4.262 (1.928)	-8.533, -1.096	-4.332 (1.798)	-8.190, -1.283	
Diffusion T1	2.780 (0.783)	1.521, 4.504	2.935 (1.015)	1.392, 5.210	2.867 (1.015)	1.301, 5.308	
Diffusion T2	3.582 (0.857)	2.196, 5.421	3.846 (1.221)	1.995, 6.695	3.562 (1.160)	1.850, 6.152	
Diffusion T3	2.853 (0.738)	1.665, 4.511	3.361 (1.110)	1.612, 6.016	3.071 (0.985)	1.522, 5.467	
Diffusion T4	4.622 (0.990)	2.968, 6.807	4.942 (1.354)	2.752, 7.864	4.689 (1.242)	2.684, 7.558	
Meas. Error	0.591 (0.256)	0.227, 1.190	0.558 (0.359)	0.156, 1.572	0.608 (0.311)	0.208, 1.366	
PE	0.138 (0.119)	-0.105, 0.370	0.170 (0.123)	-0.064, 0.411	0.162 (0.135)	-0.089, 0.435	
Trial 1	4.604 (0.140)	4.323, 4.874	4.698 (0.169)	4.369, 5.039	4.682 (0.151)	4.381, 4.963	
Trial 2	6.941 (0.158)	6.612, 7.225	6.970 (0.177)	6.617, 7.320	7.016 (0.165)	6.682, 7.333	
Trial 3	8.043 (0.144)	7.753, 8.332	8.034 (0.171)	7.682, 8.369	8.124 (0.164)	7.805, 8.432	
Trial 4	5.277 (0.237)	4.820, 5.751	5.321 (0.282)	4.794, 5.854	5.454 (0.271)	4.894, 5.945	
Population corr	elations						
Trial 1-PE	-0.351 (0.212)	-0.701, 0.110	-0.209 (0.213)	-0.592, 0.214	-0.138 (0.219)	-0.531, 0.300	
Trial 2-PE	-0.227 (0.247)	-0.646, 0.279	0.006 (0.253)	-0.478, 0.477	-0.043 (0.224)	-0.464, 0.438	
Trial 3-PE	-0.058 (0.227)	-0.455, 0.383	0.146 (0.236)	-0.341, 0.575	0.075 (0.216)	-0.305, 0.529	
Trial 4-PE	0.094 (0.240)	-0.365, 0.539	0.343 (0.223)	-0.161, 0.715	0.252 (0.216)	-0.207, 0.644	
Trial 2-Trial 1	0.721 (0.141)	0.379, 0.905	0.802 (0.098)	0.551, 0.931	0.791 (0.101)	0.542, 0.924	
Trial 3-Trial 1	0.631 (0.142)	0.286, 0.838	0.709 (0.108)	0.466, 0.866	0.692 (0.111)	0.420, 0.855	
Trial 4-Trial 1	0.298 (0.164)	-0.029, 0.613	0.498 (0.125)	0.217, 0.717	0.528 (0.130)	0.243, 0.737	
Trial 3-Trial 2	0.875 (0.080)	0.664, 0.967	0.904 (0.061)	0.742, 0.977	0.913 (0.053)	0.768, 0.976	
Trial 4-Trial 2	0.623 (0.145)	0.284, 0.836	0.697 (0.112)	0.443, 0.869	0.710 (0.128)	0.415, 0.891	
Trial 4-Trial 3	0.777 (0.097)	0.545, 0.921	0.827 (0.071)	0.668, 0.926	0.821 (0.080)	0.605, 0.937	

Table S3. Sensitivity model population means and correlations for the diagnosed MCI subgroup

Note. 95% CI: values are upper (2.5%) and lower (97.5%) bounds. sf\_Practice: Practice self-feedback; sf\_Trial: Trial self-feedback; Diffusion: standard deviation of diffusion processes for a given trial (e.g., T1 is Trial 1); Meas. Error: measurement error; Trial represents manifest mean recall for each Trial, aggregated across occasions. PE: Practice effect gains.

	Age		Se	Sex		Education	
DAT	Mean (SD)	95% CI	Mean (SD)	95% CI	Mean (SD)	95% CI	
Population mea	ns						
sf_Practice	0.538 (0.026)	0.486, 0.588	0.556 (0.024)	0.508, 0.603	0.431 (0.143)	0.146, 0.699	
sf_Trial	-3.494 (1.836)	-7.534, -0.805	-3.166 (1.646)	-6.730, -0.631	-3.041 (2.005)	-7.531, -0.304	
Diffusion T1	4.041 (1.223)	2.132, 6.959	3.943 (1.222)	1.986, 6.716	3.293 (1.247)	1.431, 6.269	
Diffusion T2	3.687 (1.153)	1.933, 6.434	3.482 (1.116)	1.681, 5.914	3.540 (1.400)	1.480, 6.786	
Diffusion T3	3.544 (1.193)	1.798, 6.343	3.063 (1.039)	1.461, 5.510	3.054 (1.197)	1.326, 6.043	
Diffusion T4	0.565 (0.399)	0.125, 1.653	0.472 (0.375)	0.080, 1.483	1.020 (0.444)	0.428, 2.008	
Meas. Error	0.099 (0.104)	0.014, 0.352	0.095 (0.084)	0.014, 0.337	0.159 (0.339)	0.006, 0.788	
PE	-0.870 (0.279)	-1.408, -0.314	-0.888 (0.277)	-1.435, -0.325	-0.368 (0.203)	-0.761, 0.010	
Trial 1	3.115 (0.302)	2.519, 3.715	3.139 (0.277)	2.595, 3.685	3.085 (0.281)	2.563, 3.654	
Trial 2	4.248 (0.236)	3.779, 4.700	4.247 (0.240)	3.787, 4.701	4.258 (0.232)	3.807, 4.708	
Trial 3	4.747 (0.274)	4.197, 5.276	4.784 (0.246)	4.320, 5.293	4.734 (0.263)	4.232, 5.264	
Trial 4	0.970 (0.290)	0.398, 1.512	0.957 (0.286)	0.414, 1.530	1.080 (0.338)	0.407, 1.744	
Populat	ion correlations						
Trial 1-PE	0.081 (0.151)	-0.216, 0.372	0.031 (0.167)	-0.301, 0.366	0.111 (0.308)	-0.494, 0.604	
Trial 2-PE	-0.438 (0.145)	-0.684, -0.118	-0.367 (0.148)	-0.627, -0.053	-0.348 (0.301)	-0.785, 0.355	
Trial 3-PE	-0.037 (0.144)	-0.318, 0.256	-0.018 (0.137)	-0.278, 0.250	-0.094 (0.333)	-0.667, 0.456	
Trial 4-PE	-0.964 (0.016)	-0.983, -0.930	-0.967 (0.012)	-0.984, -0.938	-0.584 (0.406)	-0.947, 0.573	
Trial 2-Trial 1	0.390 (0.228)	-0.133, 0.744	0.358 (0.253)	-0.180, 0.757	0.460 (0.220)	-0.021, 0.825	
Trial 3-Trial 1	0.550 (0.187)	0.103, 0.835	0.484 (0.216)	0.003, 0.826	0.581 (0.214)	0.107, 0.892	
Trial 4-Trial 1	0.043 (0.156)	-0.266, 0.339	0.062 (0.161)	-0.267, 0.370	0.178 (0.202)	-0.224, 0.551	
Trial 3-Trial 2	0.764 (0.139)	0.414, 0.929	0.803 (0.114)	0.517, 0.944	0.775 (0.129)	0.440, 0.940	
Trial 4-Trial 2	0.534 (0.147)	0.204, 0.770	0.455 (0.137)	0.170, 0.691	0.480 (0.235)	-0.109, 0.817	
Trial 4-Trial 3	0.155 (0.148)	-0.135, 0.431	0.124 (0.135)	-0.139, 0.377	0.155 (0.241)	-0.438, 0.524	

Table S4. Sensitivity model population means and correlations for the diagnosed dementia subgroup

Note. 95% CI: values are upper (2.5%) and lower (97.5%) bounds. sf\_Practice: Practice self-feedback; sf\_Trial: Trial self-feedback; Diffusion: standard deviation of diffusion processes for a given trial (e.g., T1 is Trial 1); Meas. Error: measurement error; Trial represents manifest mean recall for each Trial, aggregated across occasions. PE: Practice effect gains.

	Cl	N	Ν	MCI	Ľ	DAT
Interaction	Mean (sd)	95% CI	Mean (sd)	95% CI	Mean (sd)	95% CI
Age $\times$ sf_Practice	-0.002 (0.095)	-0.196, 0.175	0.044 (0.093)	-0.130, 0.217	-0.067 (0.033)	-0.130, -0.002 *
Age $\times$ sf_Trial	0.160 (0.317)	-0.477, 0.758	-0.199 (0.307)	-0.877, 0.393	0.065 (0.293)	-0.532, 0.646
Age $\times$ Diffusion T1	-0.065 (0.258)	-0.549, 0.465	0.002 (0.300)	-0.548, 0.597	0.085 (0.437)	-0.817, 0.981
Age $\times$ Diffusion T2	0.060 (0.229)	-0.358, 0.538	-0.207 (0.341)	-0.879, 0.488	0.463 (0.347)	-0.130, 1.241
Age $\times$ Diffusion T3	0.431 (0.210)	0.048, 0.909*	-0.568 (0.331)	-1.235, 0.085	-0.016 (0.360)	-0.750, 0.712
Age × Diffusion T4	0.699 (0.365)	0.034, 1.473 *	-0.687 (0.409)	-1.499, 0.069	-0.060 (0.133)	-0.388, 0.138
Age × Meas. Error	0.023 (0.065)	-0.088, 0.173	0.047 (0.098)	-0.166, 0.243	0.001 (0.033)	-0.056, 0.061
Age $\times$ PE	0.080 (0.094)	-0.107, 0.260	-0.181 (0.131)	-0.435, 0.082	0.074 (0.201)	-0.330, 0.468
Age × Trial 1	-0.489 (0.140)	-0.763, -0.221 *	-0.706 (0.139)	-0.980, -0.432 *	0.163 (0.258)	-0.324, 0.627
Age × Trial 2	-0.305 (0.124)	-0.556, -0.067*	-0.660 (0.155)	-0.969, -0.375 *	0.493 (0.203)	0.097, 0.893 *
Age × Trial 3	-0.330 (0.104)	-0.532, -0.136*	-0.669 (0.145)	-0.972, -0.400 *	0.473 (0.224)	0.047, 0.900*
Age × Trial 4	-0.482 (0.167)	-0.784, -0.175 *	-1.200 (0.256)	-1.724, -0.703 *	-0.090 (0.215)	-0.497, 0.313

Table S5. Covariate effects of Age on model parameters by subgroup.

Note. CN: cognitively normal; MCI: diagnosis of amnestic or non-amnestic MCI; DAT: diagnosis of dementia of the Alzheimer's type. 95% CI: values are upper (2.5%) and lower (97.5%) bounds. sf\_Practice: Practice self-feedback; sf\_Trial: Trial self-feedback; Diffusion: standard deviation of diffusion processes for a given trial (e.g., T1 is Trial 1); Meas. Error: measurement error; Trial represents manifest mean recall for each Trial, aggregated across occasions. PE: Practice effect gains.

	CN		МС	ZI	DA	Т
Interaction	Mean (sd)	95% CI	Mean (sd)	95% CI	Mean (sd)	95% CI
$Sex \times sf$ _Practice	0.002 (0.096)	-0.186, 0.177	0.031 (0.091)	-0.152, 0.214	-0.026 (0.024)	-0.072, 0.020
$Sex \times sf_Trial$	0.009 (0.320)	-0.626, 0.626	-0.032 (0.322)	-0.636, 0.607	-0.146 (0.275)	-0.698, 0.389
Sex $\times$ Diffusion T1	-0.086 (0.266)	-0.610, 0.432	0.305 (0.283)	-0.210, 0.917	0.151 (0.372)	-0.599, 0.900
Sex $\times$ Diffusion T2	-0.156 (0.237)	-0.647, 0.294	-0.160 (0.325)	-0.872, 0.449	-0.298 (0.330)	-0.958, 0.279
Sex $\times$ Diffusion T3	-0.305 (0.194)	-0.693, 0.073	-0.279 (0.304)	-0.907, 0.307	-0.506 (0.348)	-1.284, 0.135
Sex $\times$ Diffusion T4	1.113 (0.322)	0.471, 1.737*	-0.019 (0.417)	-0.838, 0.785	-0.057 (0.133)	-0.403, 0.118
Sex × Meas. Error	0.003 (0.064)	-0.127, 0.119	0.009 (0.113)	-0.220, 0.276	0.000 (0.024)	-0.049, 0.046
$\text{Sex} \times \text{PE}$	0.058 (0.109)	-0.158, 0.258	-0.049 (0.117)	-0.279, 0.180	0.033 (0.235)	-0.432, 0.470
Sex $\times$ Trial 1	0.242 (0.155)	-0.077, 0.536	0.056 (0.157)	-0.249, 0.359	-0.298 (0.258)	-0.789, 0.212
Sex $\times$ Trial 2	0.191 (0.139)	-0.082, 0.453	0.230 (0.175)	-0.100, 0.569	-0.231 (0.229)	-0.682, 0.218
Sex $\times$ Trial 3	0.146 (0.121)	-0.095, 0.382	0.347 (0.169)	0.014, 0.691 *	-0.659 (0.240)	-1.166, -0.226*
Sex $\times$ Trial 4	0.133 (0.176)	-0.223, 0.481	0.455 (0.274)	-0.048, 0.970	-0.059 (0.248)	-0.545, 0.439

Table S6. Covariate effects of participant sex on model parameters by subgroup.

Note. CN: cognitively normal; MCI: diagnosis of amnestic or non-amnestic MCI; DAT: diagnosis of dementia of the Alzheimer's type. 95% CI: values are upper (2.5%) and lower (97.5%) bounds. sf\_Practice: Practice self-feedback; sf\_Trial: Trial self-feedback; Diffusion: standard deviation of diffusion processes for a given trial (e.g., T1 is Trial 1); Meas. Error: measurement error; Trial represents manifest mean recall for each Trial, aggregated across occasions. PE: Practice effect gains.

	CN	I	MC	Ι	DA	Г
Interaction	Mean (sd)	95% CI	Mean (sd)	95% CI	Mean (sd)	95% CI
Education × sf_Practice	0.056 (0.092)	-0.121, 0.227	0.026 (0.041)	-0.053, 0.109	0.033 (0.049)	-0.066, 0.126
Education $\times$ sf_Trial	0.027 (0.250)	-0.470, 0.529	0.150 (0.301)	-0.407, 0.725	0.086 (0.254)	-0.475, 0.550
Education × Diffusion T1	0.098 (0.159)	-0.204, 0.439	0.120 (0.201)	-0.310, 0.502	0.076 (0.350)	-0.468, 0.900
Education × Diffusion T2	0.107 (0.133)	-0.131, 0.385	0.268 (0.227)	-0.172, 0.739	0.204 (0.292)	-0.230, 0.886
Education × Diffusion T3	0.075 (0.113)	-0.157, 0.291	0.030 (0.176)	-0.345, 0.366	0.063 (0.260)	-0.332, 0.645
Education × Diffusion T4	0.753 (0.247)	0.336, 1.252*	0.305 (0.270)	-0.223, 0.852	0.450 (0.316)	0.035, 1.144+
Education × Meas. Error	-0.050 (0.010)	-0.070, -0.032*	-0.037 (0.050)	-0.123, 0.094	0.024 (0.083)	-0.033, 0.178
Education × PE	-0.018 (0.040)	-0.096, 0.062	-0.101 (0.058)	-0.217, 0.015+	-0.081 (0.080)	-0.240, 0.079
Education × Trial 1	0.035 (0.055)	-0.069, 0.146	0.107 (0.062)	-0.011, 0.227+	0.016 (0.112)	-0.205, 0.238
Education × Trial 2	0.063 (0.048)	-0.034, 0.159	0.095 (0.069)	-0.029, 0.233+	0.101 (0.094)	-0.088, 0.282
Education × Trial 3	0.072 (0.041)	-0.007, 0.153+	0.127 (0.065)	-0.002, 0.255+	0.074 (0.107)	-0.128, 0.277
Education × Trial 4	-0.004 (0.059)	-0.117, 0.110	0.077 (0.111)	-0.130, 0.291	0.150 (0.144)	-0.129, 0.427

Table S7. Covariate effects of participant educational attainment on model parameters by subgroup.

Note. CN: cognitively normal; MCI: diagnosis of amnestic or non-amnestic MCI; DAT: diagnosis of dementia of the Alzheimer's type. 95% CI: values are upper (2.5%) and lower (97.5%) bounds. sf\_Practice: Practice self-feedback; sf\_Trial: Trial self-feedback; Diffusion: standard deviation of diffusion processes for a given trial (e.g., T1 is Trial 1); Meas. Error: measurement error; Trial represents manifest mean recall for each Trial, aggregated across occasions. PE: Practice effect gains.

Population means	Mean (SD)	95% CI
sf_Practice	0.098 (0.277)	-0.430, 0.096
sf_Trial	-3.065 (0.791)	-4.684, -3.043
Diffusion T1	3.588 (0.553)	2.620, 3.551
Diffusion T2	3.243 (0.541)	2.344, 3.218
Diffusion T3	4.873 (0.384)	4.169, 4.857
Diffusion T4	5.119 (0.709)	3.8845, 5.103
Meas. Error	0.506 (0.372)	0.107, 0.407
PE	0.302 (0.100)	0.106, 0.302
Baseline	6.479 (0.148)	6.170, 6.481
$T2\Delta$	2.671 (0.092)	2.491, 2.669
$T3\Delta$	3.699 (0.105)	3.497, 3.696
$T4\Delta$	2.493 (0.170)	2.158, 2.491

Table S8. Population means for the reparametrized model of trial-level deviations

Note. These results are from the reparametrized model that included the Trial level deviations from Trial 1 (e.g.,  $T2\Delta$  is the difference between Trial 2 and Trial 1). 95% CI: values are upper (2.5%) and lower (97.5%) bounds. sf\_Practice: Practice self-feedback; sf\_Trial: Trial self-feedback; Diffusion: standard deviation of diffusion processes for a given trial (e.g., T1 is Trial 1); Meas. Error: measurement error; Trial represents manifest mean recall for each Trial, aggregated across occasions. PE: Practice effect gains; Baseline: aggregate performance at first assessment.

Interaction	Mean (sd)	95% CI
$MCI \times sf$ _Practice	0.058 (0.097)	-0.145, 0.238
$MCI \times sf_Trial$	-0.008 (0.283)	-0.563, 0.565
$MCI \times Diffusion T3$	-0.525 (0.218)	-0.931, -0.096*
MCI × Meas. Error	-0.020 (0.114)	-0.313, 0.179
$MCI \times PE$	-0.009 (0.119)	-0.244, 0.229
MCI × Baseline	-1.954 (0.226)	-2.381, -1.492*
$MCI \times T2\Delta$	-0.329 (0.152)	-0.614, -0.023 *
$MCI \times T3\Delta$	-0.298 (0.167)	-0.621, 0.030
$MCI \times T4\Delta$	-1.664 (0.258)	-2.169, -1.161 *
$DAT \times sf_Practice$	-0.005 (0.103)	-0.208, 0.197
$DAT \times sf_Trial$	0.112 (0.289)	-0.441, 0.672
$DAT \times Diffusion T3$	-0.857 (0.316)	-1.494, -0.249*
DAT $\times$ Meas. Error	0.001 (0.105)	-0.232, 0.241
$DAT \times PE$	-0.113 (0.236)	-0.569, 0.375
$DAT \times Baseline$	-3.630 (0.304)	-4.215, -3.031*
$DAT \times T2\Delta$	-1.347 (0.241)	-1.837, -0.878*
$DAT \times T3\Delta$	-1.865 (0.255)	-2.355, -1.381*
$DAT \times T4\Delta$	-4.154 (0.351)	-4.806, -3.474 *

Table S9. Dynamic covariate effects from model reparametrized to estimate trial-level deviations.

Note. These results are from the reparametrized model that included the Trial level deviations from Trial 1 (e.g., T2 $\Delta$  is the difference between Trial 2 and Trial 1). MCI: diagnosis of amnestic or non-amnestic mild cognitive impairment; DAT: diagnosis of dementia of the Alzheimer's type. 95% CI: values are upper (2.5%) and lower (97.5%) bounds. sf\_Practice: Practice self-feedback; sf\_Trial: Trial self-feedback; Diffusion: standard deviation of diffusion processes for a given trial (e.g., T1 is Trial 1); Meas. Error: measurement error; PE: Practice effect gains; Baseline: mean estimate for first trial recall performance. Only effects that were significant or included PE or nonlinear estimates are shown.

Interaction	Mean (sd)	95% CI
T2∆–Baseline	-0.4696 (0.1733)	-0.7295, -0.0475
T3∆–Baseline	-0.4348 (0.1532)	-0.6763, -0.0805
T4∆–Baseline	-0.0754 (0.1523)	-0.3673, 0.2428
Baseline-PE	-0.0204 (0.235)	-0.4516, 0.4297
Τ2Δ-ΡΕ	0.4249 (0.2619)	-0.1986, 0.821
Т3Δ-РЕ	0.2258 (0.2648)	-0.3063, 0.6807
Τ4Δ-ΡΕ	0.2618 (0.218)	-0.1859, 0.645
Τ2Δ-Τ3Δ	0.7828 (0.1508)	0.3515, 0.9533
$T2\Delta - T4\Delta$	0.6551 (0.1663)	0.256, 0.883
Τ3Δ–Τ4Δ	0.7014 (0.1419)	0.3548, 0.8959

Table S10. Population correlations between trial-level deviations and dynamic parameter estimates.

Note. The  $\Delta$  symbol denotes estimated Trial-level deviation scores, or the differences in performance between Trial 1 and Trial 2 (T2 $\Delta$ ), Trial 3 (T3 $\Delta$ ), and Trial 4 (T4 $\Delta$ ) in the reparametrized model. Values are means with standard deviations (sd); 95% CI: values are upper (2.5%) and lower (97.5%) bounds. PE: practice effects. Baseline estimates reflect overall performance at the first occasion. Here, higher baseline performance is associated with lower within-occasion improvement across recall trials, but not PE. However, greater trial-level improvement is significantly correlated across trials.