

Supplementary Information

Title: *Error unawareness as a driver of cognitive decline in individuals at risk for Alzheimer's disease*

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Description: This document contains supplementary material supporting the main analyses presented in the manuscript "*Error unawareness as a driver of cognitive decline in individuals at risk for Alzheimer's disease*". Supplementary Tables provide detailed results from Poisson generalized linear mixed-effects models (GLMMs) modelling the evolution of correct and erroneous responses, as well as results from linear mixed-effects models (LMMs), estimated trends of self-monitoring efficiency index (SMI) in relation to Accuracy, pairwise comparisons, sensitivity analyses, and analyses of the contribution of the ES and CNS subcomponents using nested LMMs. All analyses were performed in R (version 4.3.2; R Core Team, 2023).

Supplementary Table 1. Evolution of erroneous responses by level of certainty and group. Results from the generalized linear mixed-effects model (GLMM) with a Poisson distribution. The model included fixed effects for Certainty levels (Error Sure / Error Not Sure), Time (i.e., visits treated as continuous), Group, and their interactions, with a random intercept for participant ID. Model fitted using the lme4 package (v1.1-35.1) in R.

- (i) **Type II Wald chi-square (χ^2) tests of the Poisson GLMM predicting evolution of erroneous responses by Certainty level and Group.** Obtained using the Anova() function from the car package (v3.1-2) to evaluate model effects. Abbreviation: Df, degrees of freedom.

Effect	χ^2	Df	Pr(> χ^2)
Certainty	1,043.7	1	<.001
Time	132.3	1	<.001
Group	88.9	2	<.001
Certainty × Time	22.7	1	<.001
Certainty × Group	9.6	2	0.0080
Time × Group	180.2	2	<.001
Certainty × Time × Group	20.7	2	<.001

- (ii) **Estimated slopes of evolution of erroneous responses (GLMM) by Certainty level and Group.** Slopes were calculated using the emtrends() function from the emmeans package (v1.8.9) on the original scale of values. Abbreviations: SE, standard error; Df, degrees of freedom.

Group	Certainty	Time trend	SE	df	Z ratio	P value
CTRL A-	Error Sure	0.025	0.050	Inf	0.512	0.61
CTRL A+	Error Sure	-0.069	0.023	Inf	-3.017	0.0026
PROG	Error Sure	0.238	0.016	Inf	14.540	<.001
CTRL A-	Error Not Sure	-0.045	0.099	Inf	-0.450	0.65
CTRL A+	Error Not Sure	-0.090	0.058	Inf	-1.552	0.12
PROG	Error Not Sure	0.518	0.041	Inf	12.571	<.001

- (iii) **Pairwise comparisons of estimated evolution slopes.** Comparisons were performed using the emmeans package (v1.8.9). Estimates represent differences between the estimated slopes. P value adjustment: Tukey method for comparing a family of 6 estimates. Abbreviations: SE, standard error; Df, degrees of freedom; ES, Erroneous–Sure responses; ENS, Error Not Sure responses.

Contrast	Estimate	SE	Df	z ratio	P value
(ES CTRL A-) – (ENS CTRL A-)	0.070	0.111	Inf	0.634	0.99
(ES CTRL A-) – (ES CTRL A+)	0.094	0.055	Inf	1.724	0.52
(ES CTRL A-) – (ENS CTRL A+)	0.115	0.076	Inf	1.511	0.66
(ES CTRL A-) – ES PROG	-0.211	0.052	Inf	-4.043	<.001
(ES CTRL A-) – ENS PROG	-0.493	0.065	Inf	-7.629	<.001
(ENS A-) – (ES CTRL A+)	0.024	0.102	Inf	0.237	1
(ENS CTRL A-) – (ENS CTRL A+)	0.045	0.115	Inf	0.394	1
(ENS CTRL A-) – ES PROG	-0.282	0.101	Inf	-2.800	0.057
(ENS CTRL A-) – ENS PROG	-0.563	0.107	Inf	-5.237	<.001
(ES CTRL A+) – (ENS CTRL A+)	0.021	0.062	Inf	0.339	1
(ES CTRL A+) – ES PROG	-0.306	0.028	Inf	-10.903	<.001
(ES CTRL A+) – ENS PROG	-0.587	0.047	Inf	-12.458	<.001
(ENS CTRL A+) – ES PROG	-0.327	0.060	Inf	-5.427	<.001
(ENS CTRL A+) – ENS PROG	-0.608	0.071	Inf	-8.547	<.001
ES PROG – ENS PROG	-0.281	0.043	Inf	-6.550	<.001

Supplementary Table 2. Evolution of correct responses by level of certainty and group. Results from the generalized linear mixed-effects model (GLMM) with a Poisson distribution. The model included fixed effects for Certainty levels (Error Sure / Error Not Sure), Time (i.e., visits treated as continuous), Group, and their interactions, with a random intercept for participant ID. Model fitted using the lme4 package (v1.1-35.1) in R.

- (i) **Type II Wald chi-square (χ^2) tests of the Poisson GLMM predicting evolution of correct responses by Certainty level and Group.** Obtained using the Anova() function from the car package (v3.1-2) to evaluate model effects. Abbreviation: Df, degrees of freedom.

Effect	χ^2	Df	Pr(> χ^2)
Certainty	13,762.1	1	<.001
Time	6.5	1	0.011
Group	54.7	2	<.001
Certainty × Time	1.2	1	0.26
Certainty × Group	516.9	2	<.001
Time × Group	29.6	2	<.001
Certainty × Time × Group	269.7	2	<.001

- (ii) **Estimated slopes of evolution of correct responses (GLMM) by Certainty level and Group.** Slopes were calculated using the emtrends() function from the emmeans package (v1.8.9) on the original scale of values. Abbreviations: SE, standard error; Df, degrees of freedom.

Group	Certainty	Time trend	SE	Df	z ratio	P value
CTRL A-	Correct Sure	-0.00032	0.004856	Inf	-0.065	0.9481
CTRL A+	Correct Sure	0.014266	0.004536	Inf	3.144	0.0017
PROG	Correct Sure	-0.048849	0.005560	Inf	-8.786	<.001
CTRL A-	Correct Not Sure	0.041314	0.067409	Inf	0.613	0.5400
CTRL A+	Correct Not Sure	-0.201280	0.019835	Inf	-10.148	<.001
PROG	Correct Not Sure	0.219829	0.020713	Inf	10.613	<.001

- (iii) **Pairwise comparisons of estimated evolution slopes.** Comparisons were performed using the emmeans package (v1.8.9). Estimates represent differences between the estimated slopes. P value adjustment: Tukey method for comparing a family of 6 estimates. Abbreviations: SE, standard error; Df, degrees of freedom; CS, Correct–Sure responses; CNS, Correct Not Sure responses.

Contrast	Estimate	SE	Df	z ratio	P value
(CS CTRL A-) – (CNS CTRL A-)	-0.042	0.068	Inf	-0.616	0.9899
(CS CTRL A-) – (CS CTRL A+)	-0.015	0.007	Inf	-2.194	0.2404
(CS CTRL A-) – (CNS CTRL A+)	0.201	0.020	Inf	9.841	<.001
(CS CTRL A-) – CS PROG	0.049	0.007	Inf	6.575	<.001
(CS CTRL A-) – CNS PROG	-0.220	0.021	Inf	-10.348	<.001
(CNS CTRL A-) – (CS CTRL A+)	0.027	0.068	Inf	0.400	1
(CNS CTRL A-) – (CNS CTRL A+)	0.243	0.070	Inf	3.453	0.0073
(CNS CTRL A-) – CS PROG	0.090	0.068	Inf	1.333	0.77
(CNS CTRL A-) – CNS PROG	-0.179	0.071	Inf	-2.531	0.12
(CS CTRL A+) – (CNS CTRL A+)	0.216	0.020	Inf	10.595	<.001
(CS CTRL A+) – CS PROG	0.063	0.007	Inf	8.794	<.001
(CS CTRL A+) – CNS PROG	-0.206	0.021	Inf	-9.695	<.001
(CNS CTRL A+) – CS PROG	-0.152	0.021	Inf	-7.400	<.001
(CNS CTRL A+) – CNS PROG	-0.421	0.029	Inf	-14.684	<.001
CS PROG – CNS PROG	-0.269	0.021	Inf	-12.583	<.001

Supplemental Table 3. Linear mixed-effects model predicting Accuracy, with fixed effects for SMI, Group, Visit, and their interactions, and a random intercept for participant ID. Model fitted using the lme4 package (v1.1-35.1) in R.

- (i) **Type II Wald chi-square (χ^2) tests.** Obtained using the Anova() function from the car package (v3.1-2) to evaluate model effects. Abbreviation: Df, degrees of freedom.

Effect	χ^2	Df	Pr(> χ^2)
SMI	146.7	1	<.001
Group	20.0	2	<.001
Visit	5.0	5	0.42
SMI $\times$ Group	48.4	2	<.001
SMI $\times$ Visit	49.6	5	<.001
Group $\times$ Visit	11.0	10	0.36
SMI $\times$ Group $\times$ Visit	15.1	10	0.13

- (ii) **Estimated trends of self-monitoring efficiency (SMI) predicting Accuracy by Group and Visit.** P values indicate the significance of the association (slope) between SMI and Accuracy for each group at each visit. Estimates were obtained using emmeans (v1.8.9). Abbreviations: SE, standard error; Df, degrees of freedom.

Group	Visit	SMI trend	SE	Df	t ratio	P value
CTRL A-	M0	-145.4	214.4	179.8	-0.678	0.50
CTRL A+	M0	-12.6	11.5	179.4	-1.089	0.28
PROG	M0	-169.1	23.8	196.1	-7.103	<.001
CTRL A-	M12	-103.9	171.9	179.8	-0.604	0.55
CTRL A+	M12	-15.0	56.9	178.0	-0.263	0.79
PROG	M12	-190.6	14.8	194.6	-12.842	<.001
CTRL A-	M24	-113.5	207.5	186.9	-0.547	0.58
CTRL A+	M24	-20.7	14.0	177.1	-1.477	0.14
PROG	M24	-68.8	14.0	193.1	-4.902	<.001
CTRL A-	M36	-49.1	175.1	181.2	-0.280	0.78
CTRL A+	M36	-9.5	15.0	178.8	-0.632	0.53
PROG	M36	-93.6	28.2	186.0	-3.322	0.0011
CTRL A-	M48	-173.5	199.0	183.9	-0.872	0.38
CTRL A+	M48	1.3	15.2	175.4	0.085	0.93
PROG	M48	-71.7	19.4	186.0	-3.697	<.001
CTRL A-	M60	-153.0	158.9	176.5	-0.963	0.34
CTRL A+	M60	-60.1	51.9	179.8	-1.157	0.25
PROG	M60	-174.5	16.7	178.6	-10.450	<.001

- (iii) **Pairwise comparisons of estimated SMI trends between groups at each visit.** P values indicate the significance of group differences in the slope of the association between SMI and Accuracy at each visit. Estimates were obtained using emmeans (v1.8.9). P value adjustment at each visit: Tukey method for comparing a family of three estimates. Abbreviations: SE, standard error; Df, degrees of freedom.

Contrast	Visit	Estimate	SE	Df	t ratio	P value
CTRL A- – CTRL A+	M0	-132.8	214.7	179.8	-0.619	0.81
CTRL A- – PROG	M0	23.7	215.7	180.1	0.110	0.99
CTRL A- – PROG	M0	156.5	26.4	193.7	5.918	<.001
CTRL A- – CTRL A+	M12	-89.0	181.1	179.6	-0.491	0.88
CTRL A- – PROG	M12	86.7	172.6	179.9	0.502	0.87
CTRL A+ – PROG	M12	175.7	58.8	179.2	2.988	0.0089
CTRL A+ – CTRL A+	M24	-92.8	208.0	186.8	-0.446	0.90
CTRL A- – PROG	M24	-44.7	208.0	186.9	-0.215	0.97
CTRL A+ – PROG	M24	48.1	19.96	185.9	2.422	0.043
CTRL A- – CTRL A+	M36	-39.6	175.7	181.2	-0.225	0.97
CTRL A- – PROG	M36	44.5	177.4	181.3	0.251	0.97
CTRL A+ – PROG	M36	84.1	31.9	184.5	2.637	0.025
CTRL A- – CTRL A+	M48	-174.8	199.6	183.9	-0.876	0.66
CTRL A- – PROG	M48	-101.8	200.0	183.9	-0.509	0.87
CTRL A+ – PROG	M48	73.0	24.7	182.2	2.962	0.0097
CTRL A- – CTRL A+	M60	-92.9	167.2	176.8	-0.556	0.84
CTRL A- – PROG	M60	21.4	159.8	176.5	0.134	0.99
CTRL A+ – PROG	M60	114.3	54.6	179.7	2.096	0.094

Supplemental Table 4. Sensitivity analysis after removing three CTRL A+ participants exhibiting outlying values in SMI (see Figure 2). Linear mixed-effects model predicting Accuracy, with fixed effects for SMI, Group, Visit, and their interactions, and a random intercept for participant ID. Model fitted using the lme4 package (v1.1-35.1) in R.

- (i) **Type II Wald chi-square (χ^2) tests.** Obtained using the Anova() function from the car package (v3.1-2) to evaluate model effects. Abbreviation: Df, degrees of freedom.

Effect	χ^2	Df	Pr(> χ^2)
SMI	317.6	1	<.001
Group	8.8	2	0.012
Visit	4.7	5	0.46
SMI $\times$ Group	9.5	2	0.0085
SMI $\times$ Visit	89.5	5	<.001
Group $\times$ Visit	24.2	10	0.0070
SMI $\times$ Group $\times$ Visit	21.6	10	0.017

- (ii) **Estimated trends of self-monitoring efficiency (SMI) predicting Accuracy by Group and Visit.** P values indicate the significance of the association (slope) between SMI and Accuracy for each group at each visit. Estimates were obtained using emmeans (v1.8.9). Abbreviations: SE, standard error; Df, degrees of freedom.

Group	Visit	SMI trend	SE	Df	t ratio	P value
CTRL A-	M0	-145.2	182.5	162.8	-0.796	0.43
CTRL A+	M0	-149.3	43.2	172.6	-3.457	<.001
PROG	M0	-168.7	20.3	178.0	-8.319	<.001
CTRL A-	M12	-103.8	146.3	162.8	-0.709	0.48
CTRL A+	M12	-55.9	49.6	168.8	-1.127	0.26
PROG	M12	-190.5	12.6	176.6	-15.066	<.001
CTRL A-	M24	-113.1	176.7	169.3	-0.640	0.52
CTRL A+	M24	-162.6	41.4	173.7	-3.931	<.001
PROG	M24	-68.8	12.0	175.2	-5.751	<.001
CTRL A-	M36	-49.1	149.0	164.0	-0.330	0.74
CTRL A+	M36	-117.4	37.4	171.0	-3.140	0.0020
PROG	M36	-93.3	24.0	168.5	-3.892	<.001
CTRL A-	M48	-173.3	169.4	166.6	-1.023	0.31
CTRL A+	M48	3.3	13.1	158.7	0.254	0.80
PROG	M48	-71.6	16.5	168.5	-4.334	<.001
CTRL A-	M60	-153.0	135.3	159.8	-1.131	0.26
CTRL A+	M60	-97.7	49.0	174.7	-1.992	0.048
PROG	M60	-174.4	14.2	161.7	-12.275	<.001

- (iii) **Pairwise comparisons of estimated SMI trends between groups at each visit.** P values indicate the significance of group differences in the slope of the association between SMI and Accuracy at each visit. Estimates were obtained using emmeans (v1.8.9). P value adjustment at each visit: Tukey method for comparing a family of three estimates. Abbreviations: SE, standard error; Df, degrees of freedom.

Contrast	Visit	Estimate	SE	Df	t ratio	P value
CTRL A- – CTRL A+	M0	4.0	187.5	163.4	0.021	1
CTRL A- – PROG	M0	23.5	183.6	163.1	0.128	1
CTRL A+ – PROG	M0	19.4	47.7	173.7	0.408	0.91
CTRL A- – CTRL A+	M12	-47.9	154.5	163.4	-0.310	0.95
CTRL A- – PROG	M12	86.7	146.9	162.9	0.590	0.83
CTRL A+ – PROG	M12	134.6	51.2	169.3	2.629	0.025
CTRL A- – CTRL A+	M24	49.5	181.5	169.6	0.273	0.96
CTRL A- – PROG	M24	-44.3	177.1	169.3	-0.250	0.97
CTRL A+ – PROG	M24	-93.8	43.1	173.8	-2.178	0.078
CTRL A- – CTRL A+	M36	68.3	153.7	164.5	0.445	0.90
CTRL A- – PROG	M36	44.2	151.1	164.2	0.293	0.95
CTRL A+ – PROG	M36	-24.1	44.4	170.3	-0.543	0.85
CTRL A- – CTRL A+	M48	-176.6	169.9	166.5	-1.039	0.55
CTRL A- – PROG	M48	-101.7	170.2	166.6	-0.597	0.82
CTRL A+ – PROG	M48	74.9	21.1	164.9	3.555	0.0014
CTRL A- – CTRL A+	M60	-55.3	143.9	161.7	-0.384	0.92
CTRL A- – PROG	M60	21.4	136.0	159.8	0.158	0.99
CTRL A+ – PROG	M60	76.7	51.1	173.9	1.503	0.29

Supplemental Table 5. Comparison of nested linear mixed-effects models predicting Accuracy. All models included a random intercept for participant ID. Fixed effects tested include Visit, ES, CNS, and their interactions with Visit (ES × Visit and CNS × Visit). Log-likelihood ratio (LR χ^2) tests indicate model improvements, and relative contributions of ES and CNS were estimated using log-likelihood and marginal R² calculated with the MuMIn package (v1.46.0). All models were fitted using the lme4 package (v1.1-35.1) in R. Abbreviations: ES, Erroneous–Sure responses; CNS, Correct–Not sure responses; Df, degrees of freedom.

Model	Fixed Effects	logLik	LR χ^2 (vs.)	Df	P value	Contribution logLik (%)	Contribution R ² marginal (%)
LMM1	Visit	55.14	-	-	-	-	-
LMM2	ES + Visit	159.07	207.88 (vs. LMM1)	1	<.001	-	-
LMM3	CNS + Visit	55.15	0.038 (vs. LMM1)	1	0.85	-	-
LMM4	ES + Visit + ES × Visit	161.91	5.67 (vs. LMM2)	5	0.34	-	-
LMM5	CNS + Visit + CNS × Visit	55.33	0.35 (vs. LMM3)	5	1	-	-
LMM6	ES + CNS + Visit	174.48	30.81 (vs. LMM2) 238.65 (vs. LMM3)	1 1	<.001 <.001	ES: 94.5% CNS: 5.5%	ES: 98.1% CNS: 1.9%