

Supplementary Materials

S1. Full Results of the Statistical Models and Model Comparisons

Tables summarizing the outcomes of linear models and generalized linear models were generated utilizing the *gtsummary* package [1]. Model comparisons were performed using the *flexplot* package [2].

S1.1 Statistical Models Predicting n-back Performance Across Gameplays and Between Groups

S1.1.1 Sensitivity Index d' in the 1-back Task Across Gameplays

Predictor	$d' \sim \text{gameplay} \times \text{group}$				...+ gameplay^2				...+ age				...+ MoCA_BL			
	N	Beta	95% CI	p-value	N	Beta	95% CI	p-value	N	Beta	95% CI	p-value	N	Beta	95% CI	p-value
gameplay	190	0.00	0.00, 0.00	0.8	190	0.00	0.00, 0.01	0.14	190	0.00	0.00, 0.00	0.8	190	0.00	0.00, 0.00	0.6
group				0.058				0.057				0.4				0.039
Sham tACS	95	—	—		95	—	—		95	—	—		95	—	—	
Active tACS	95	0.10	0.00, 0.21		95	0.10	0.00, 0.21		95	0.05	-0.09, 0.20		95	0.14	0.01, 0.27	
gameplay * group	190			0.4	190			0.4	190			0.5	190			0.4
gameplay * Active tACS	95	0.00	0.00, 0.00		95	0.00	0.00, 0.00		95	0.00	0.00, 0.00		95	0.00	0.00, 0.00	
I(gameplay ²)					190	0.00	0.00, 0.00	0.13								
age									190	-0.06	-0.18, 0.06	0.3				
MoCA_BL													190	0.12	-0.14, 0.38	0.4
R ²		0.033				0.045				0.039				0.038		
Adjusted R ²		0.018				0.025				0.018				0.017		
AIC		-91.1				-91.4				-90.2				-90.0		
σ		0.187				0.187				0.187				0.188		
Likelihood ratio test																
p-value						0.133				0.313				0.359		

Table S1.1.1: Model optimization for predicting 1-back d' across gameplays. We fitted different linear models to predict the sensitivity index d' in the 1-back task with Gameplay (1–96), Group (Active tACS vs. Sham tACS), age, and baseline Montreal Cognitive Assessment (MoCA_BL) score. The table contains full results of the predictors and model metrics (R^2 , adjusted R^2 , AIC, sigma σ). Models were compared using the likelihood ratio test (*model.comparison* in R), assessing the significant impact of a specific term added to the model (adapted model) versus the model without this term (current best model). The p-value of the likelihood ratio test refers to the comparison between the new, adapted model with the last best model (from left to right). $p \leq 0.05$ indicates statistical significance (highlighted in bold). For the prediction of 1-back d' , this optimization process resulted in the following best model: $d' \sim \text{Gameplay} \times \text{Group}$. tACS = transcranial alternating current stimulation; CI = confidence interval; AIC = Akaike Information Criteria.

S1.1.2 Sensitivity Index d' in the 2-back Task Across Gameplays

Predictor	d' ~ gameplay × group				...+ gameplay ²				...+ gameplay ² × group				...+ gameplay ² + age				...+ gameplay ² + MoCA_BL			
	N	Beta	95% CI	p-value	N	Beta	95% CI	p-value	N	Beta	95% CI	p-value	N	Beta	95% CI	p-value	N	Beta	95% CI	p-value
gameplay	318	0.00	0.00, 0.00	<0.001	318	0.00	0.00, 0.01	<0.001	318	0.00	0.00, 0.01	<0.001	318	0.00	0.00, 0.01	<0.001	318	0.00	0.00, 0.01	<0.001
group				0.032				0.020				0.6				0.018				0.2
Sham tACS	159	—	—		159	—	—		159	—	—		159	—	—		159	—	—	
Active tACS	159	0.04	0.00, 0.07		159	0.04	0.01, 0.07		159	0.01	-0.04, 0.06		159	0.12	0.02, 0.22		159	0.03	-0.01, 0.06	
gameplay * group	318			0.017	318			0.010	318			0.037	318			0.010	318			0.010
gameplay * Active tACS	159	0.00	0.00, 0.00		159	0.00	0.00, 0.00		159	0.00	0.00, 0.00		159	0.00	0.00, 0.00		159	0.00	0.00, 0.00	
I(gameplay ²)					318	0.00	0.00, 0.00	<0.001	318	0.00	0.00, 0.00	<0.001	318	0.00	0.00, 0.00	<0.001	318	0.00	0.00, 0.00	<0.001
group * I(gameplay ²)									318			0.14								
Active tACS * I(gameplay ²)									159	0.00	0.00, 0.00									
age													318	0.10	-0.01, 0.21	0.082				
MoCA_BL																	318	-0.12	-0.33, 0.10	0.3
R ²		0.716				0.758				0.760				0.761				0.759		
Adjusted R ²		0.714				0.755				0.756				0.757				0.755		
AIC		-726				-775				-775				-776				-774		
σ		0.077				0.071				0.071				0.071				0.071		
Likelihood ratio test																				
p-value						<0.001				0.137				0.082				0.3		

Table S1.1.2: Model optimization for predicting 2-back d' across gameplays. We fitted different linear models to predict the sensitivity index d' in the 2-back task with Gameplay (1-160), Group (Active tACS vs. Sham tACS), age, and baseline Montreal Cognitive Assessment (MoCA_BL) score. The table contains full results of the predictors and model metrics (R², adjusted R², AIC, sigma σ). Models were compared using the likelihood ratio test (*model.comparison* in R), assessing the significant impact of a specific term added to the model (adapted model) versus the model without this term (current best model). The p-value of the likelihood ratio test refers to the comparison between the new, adapted model with the last best model (from left to right). $p \leq 0.05$ indicates statistical significance (highlighted in bold). For the prediction of 2-back d' , this optimization process resulted in the following best model: $d' \sim \text{Gameplay} \times \text{Group} + \text{Gameplay}^2$. tACS = transcranial alternating current stimulation; CI = confidence interval; AIC = Akaike Information Criteria.

S1.1.3 Response Bias C in the 1-back Task Across Gameplays

Predictor	C ~ gameplay × group				...+ gameplay ²				...+ age				...+ MoCA_BL			
	N	Beta	95% CI	p-value	N	Beta	95% CI	p-value	N	Beta	95% CI	p-value	N	Beta	95% CI	p-value
gameplay	190	0.00	0.00, 0.00	0.078	190	0.00	0.00, 0.00	0.9	190	0.00	0.00, 0.00	0.088	190	0.00	0.00, 0.00	0.2
group				>0.9				>0.9				0.7				0.7
Sham tACS	95	—	—		95	—	—		95	—	—		95	—	—	
Active tACS	95	0.00	-0.04, 0.04		95	0.00	-0.04, 0.04		95	-0.01	-0.07, 0.05		95	0.01	-0.04, 0.07	
gameplay * group	190			0.5	190			0.5	190			0.6	190			0.5
gameplay * Active tACS	95	0.00	0.00, 0.00		95	0.00	0.00, 0.00		95	0.00	0.00, 0.00		95	0.00	0.00, 0.00	
I(gameplay ²)					190	0.00	0.00, 0.00	0.4								
age									190	-0.01	-0.06, 0.03	0.6				
MoCA_BL													190	0.04	-0.06, 0.15	0.4
R ²		0.058				0.061				0.059				0.062		
Adjusted R ²		0.043				0.041				0.039				0.041		
AIC		-440				-439				-438				-439		
σ		0.075				0.075				0.075				0.075		
Likelihood ratio test																
p-value						0.42				0.607				0.401		

Table S1.1.3: Model optimization for predicting 1-back C across gameplays. We fitted different linear models to predict the response bias C in the 1-back task with Gameplay (1–96), Group (Active tACS vs. Sham tACS), age, and baseline Montreal Cognitive Assessment (MoCA_BL) score. The table contains full results of the predictors and model metrics (R², adjusted R², AIC, sigma σ). Models were compared using the likelihood ratio test (*model.comparison* in R), assessing the significant impact of a specific term added to the model (adapted model) versus the model without this term (current best model). The p-value of the likelihood ratio test refers to the comparison between the new, adapted model with the last best model (from left to right). $p \leq 0.05$ indicates statistical significance (highlighted in bold). For the prediction of 1-back C, this optimization process resulted in the following best model: $C \sim \text{Gameplay} \times \text{Group}$. tACS = transcranial alternating current stimulation; CI = confidence interval; AIC = Akaike Information Criteria.

S1.1.4 Response Bias C in the 2-back Task Across Gameplays

Predictor	C ~ gameplay × group				...+ gameplay ²				...+ gameplay ² × group				...+ gameplay ² + age				...+ gameplay ² + MoCA_BL			
	N	Beta	95% CI	p-value	N	Beta	95% CI	p-value	N	Beta	95% CI	p-value	N	Beta	95% CI	p-value	N	Beta	95% CI	p-value
gameplay	318	0.00	0.00, 0.00	<0.001	318	0.00	0.00, 0.00	<0.001	318	0.00	0.00, 0.00	<0.001	318	0.00	0.00, 0.00	<0.001	318	0.00	0.00, 0.00	<0.001
group				0.041				0.014				0.5				0.2				0.12
Sham tACS	159	—	—		159	—	—		159	—	—		159	—	—		159	—	—	
Active tACS	159	0.03	0.00, 0.05		159	0.03	0.01, 0.05		159	0.01	-0.02, 0.04		159	0.05	-0.02, 0.12		159	0.02	-0.01, 0.05	
gameplay * group	318			<0.001	318			<0.001	318			0.6	318			<0.001	318			<0.001
gameplay * Active tACS	159	0.00	0.00, 0.00		159	0.00	0.00, 0.00		159	0.00	0.00, 0.00		159	0.00	0.00, 0.00		159	0.00	0.00, 0.00	
I(gameplay ²)					318	0.00	0.00, 0.00	<0.001	318	0.00	0.00, 0.00	<0.001	318	0.00	0.00, 0.00	<0.001	318	0.00	0.00, 0.00	<0.001
group * I(gameplay ²)									318			0.2								
Active tACS * I(gameplay ²)									159	0.00	0.00, 0.00									
age													318	0.03	-0.05, 0.11	0.5				
MoCA_BL																	318	-0.07	-0.22, 0.09	0.4
R ²		0.593				0.722				0.723				0.722				0.723		
Adjusted R ²		0.590				0.718				0.719				0.718				0.718		
AIC		-869				-988				-988				-986				-986		
σ		0.061				0.051				0.051				0.051				0.051		
Likelihood ratio test																				
p-value						<0.001				0.182				0.507				0.395		

Table S1.1.4: Model optimization for predicting 2-back C across gameplays. We fitted different linear models to predict the response bias C in the 2-back task with Gameplay (1–160), Group (Active tACS vs. Sham tACS), age, and baseline Montreal Cognitive Assessment (MoCA_BL) score. The table contains full results of the predictors and model metrics (R², adjusted R², AIC, sigma σ). Models were compared using the likelihood ratio test (*model.comparison* in R), assessing the significant impact of a specific term added to the model (adapted model) versus the model without this term (current best model). The p-value of the likelihood ratio test refers to the comparison between the new, adapted model with the last best model (from left to right). $p \leq 0.05$ indicates statistical significance (highlighted in bold). For the prediction of 2-back C, this optimization process resulted in the following best model: $C \sim \text{Gameplay} \times \text{Group} + \text{Gameplay}^2$. tACS = transcranial alternating current stimulation; CI = confidence interval; AIC = Akaike Information Criteria.

S1.1.5 Reaction Time in the 1-back Task Across Gameplays

Predictor	RT ~ gameplay × group				...+ gameplay ²				...+ gameplay ² × group				...+ gameplay ² + age				...+ gameplay ² + age + MoCA_BL			
	N	Beta	95% CI	p-value	N	Beta	95% CI	p-value	N	Beta	95% CI	p-value	N	Beta	95% CI	p-value	N	Beta	95% CI	p-value
gameplay	7,123	0.00	0.00, 0.00	<0.001	7,123	-0.01	-0.01, -0.01	<0.001	7,123	-0.01	-0.01, -0.01	<0.001	7,123	-0.01	-0.01, -0.01	<0.001	7,123	-0.01	-0.01, -0.01	<0.001
group				<0.001				<0.001				<0.001				<0.001				<0.001
Sham tACS	3,579	—	—		3,579	—	—		3,579	—	—		3,579	—	—		3,579	—	—	
Active tACS	3,544	-0.07	-0.09, -0.04		3,544	-0.07	-0.09, -0.04		3,544	-0.08	-0.12, -0.05		3,544	-0.05	-0.07, -0.03		3,544	-0.06	-0.08, -0.04	
gameplay * group	7,123			0.018	7,123			0.024	7,123			0.035	7,123			0.053	7,123			0.062
gameplay * Active tACS	3,544	0.00	0.00, 0.00		3,544	0.00	0.00, 0.00		3,544	0.00	0.00, 0.00		3,544	0.00	0.00, 0.00		3,544	0.00	0.00, 0.00	
I(gameplay ²)					7,123	0.00	0.00, 0.00	<0.001	7,123	0.00	0.00, 0.00	<0.001	7,123	0.00	0.00, 0.00	<0.001	7,123	0.00	0.00, 0.00	<0.001
group * I(gameplay ²)									7,123			0.11								
Active tACS * I(gameplay ²)									3,544	0.00	0.00, 0.00									
age													7,123	0.02	0.02, 0.02	<0.001	7,123	0.01	0.01, 0.01	<0.001
MoCA_BL																	7,123	-0.03	-0.03, -0.02	<0.001
Nagelkerke's R ²		0.22				0.24				0.24				0.43				0.5		
AIC		94,487				94,329				94,328				92,269				91,363		
Deviance		387				379				379				284				250		
Likelihood ratio test																				
p-value						<0.001				0.112				<0.001				<0.001		

Table S1.1.5: Model optimization for predicting 1-back reaction time across gameplays. We fitted different generalized linear models to predict the reaction time (RT) in the 1-back task with Gameplay (1–96), Group (Active tACS vs. Sham tACS), age, and baseline Montreal Cognitive Assessment (MoCA_BL) score. The table contains full results of the predictors and model metrics (Nagelkerke's R², AIC, deviance). Models were compared using the likelihood ratio test (*model.comparison* in R), assessing the significant impact of a specific term added to the model (adapted model) versus the model without this term (current best model). The p-value of the likelihood ratio test refers to the comparison between the new, adapted model with the last best model (from left to right). $p \leq 0.05$ indicates statistical significance (highlighted in bold). For the prediction of 1-back RT, this optimization process resulted in the following best model: $RT \sim \text{Gameplay} \times \text{Group} + \text{Gameplay}^2 + \text{age} + \text{MoCA}_{\text{baseline}}$. tACS = transcranial alternating current stimulation; CI = confidence interval; AIC = Akaike Information Criteria.

S1.1.6 Reaction Time in the 2-back Task Across Gameplays

Predictor	RT ~ gameplay × group				...+ gameplay ²				...+ gameplay ² × group				...+ gameplay ² × group + age				...+ gameplay ² × group + age + MoCA_BL			
	N	Beta	95% CI	p-value	N	Beta	95% CI	p-value	N	Beta	95% CI	p-value	N	Beta	95% CI	p-value	N	Beta	95% CI	p-value
gameplay	12,081	0.00	0.00, 0.00	<0.001	12,081	-0.01	-0.01, -0.01	<0.001	12,081	-0.01	-0.01, -0.01	<0.001	12,081	-0.01	-0.01, -0.01	<0.001	12,081	-0.01	-0.01, -0.01	<0.001
group				0.14				0.2				0.001				0.014				0.007
Sham tACS	6,125	—	—		6,125	—	—		6,125	—	—		6,125	—	—		6,125	—	—	
Active tACS	5,956	-0.02	-0.04, 0.01		5,956	-0.02	-0.04, 0.01		5,956	-0.06	-0.10, -0.03		5,956	-0.05	-0.08, -0.01		5,956	-0.05	-0.08, -0.01	
gameplay × group	12,081			0.002	12,081			0.003	12,081			<0.001	12,081			<0.001	12,081			<0.001
gameplay × Active tACS	5,956	0.00	0.00, 0.00		5,956	0.00	0.00, 0.00		5,956	0.00	0.00, 0.00		5,956	0.00	0.00, 0.00		5,956	0.00	0.00, 0.00	
I(gameplay ²)					12,081	0.00	0.00, 0.00	<0.001	12,081	0.00	0.00, 0.00	<0.001	12,081	0.00	0.00, 0.00	<0.001	12,081	0.00	0.00, 0.00	<0.001
group × I(gameplay ²)									12,081			0.001				<0.001	12,081			<0.001
Active tACS × I(gameplay ²)									5,956	0.00	0.00, 0.00		5,956	0.00	0.00, 0.00		5,956	0.00	0.00, 0.00	
age													12,081	0.01	0.01, 0.01	<0.001	12,081	0.01	0.01, 0.01	<0.001
MoCA_BL																	12,081	-0.01	-0.01, -0.01	<0.001
Nagelkerke's R ²		0.27				0.29				0.29				0.35				0.35		
AIC		188,920				188,543				188,533				187,579				187,512		
Deviance		1,359				1,318				1,316				1,218				1,211		
Likelihood ratio test																				
p-value						<0.001				0.001				<0.001				<0.001		

Table S1.1.6: Model optimization for predicting 2-back reaction time across gameplays. We fitted different generalized linear models to predict the reaction time (RT) in the 1-back task with Gameplay (1–160), Group (Active tACS vs. Sham tACS), age, and baseline Montreal Cognitive Assessment (MoCA_BL) score. The table contains full results of the predictors and model metrics (Nagelkerke's R², AIC, deviance). Models were compared using the likelihood ratio test (*model.comparison* in R), assessing the significant impact of a specific term added to the model (adapted model) versus the model without this term (current best model). The p-value of the likelihood ratio test refers to the comparison between the new, adapted model with the last best model (from left to right). $p \leq 0.05$ indicates statistical significance (highlighted in bold). For the prediction of 2-back RT, this optimization process resulted in the following best model: $RT \sim \text{Gameplay} \times \text{Group} + \text{Gameplay}^2 \times \text{Group} + \text{age} + \text{MoCA}_{\text{baseline}}$. tACS = transcranial alternating current stimulation; CI = confidence interval; AIC = Akaike Information Criteria.

S1.2 Statistical Models Predicting Between-Group n-back Performances at Stimulation Sessions

Predictor	d' ~ Stim. session $\times$ group				...+ age				...+ age + MoCA_BL			
	N	Beta	95% CI	p-value	N	Beta	95% CI	p-value	N	Beta	95% CI	p-value
stim_session				<0.001				<0.001				<0.001
1	18	—	—		18	—	—		18	—	—	
2	20	0.02	-0.04, 0.08		20	0.03	-0.03, 0.09		20	0.03	-0.03, 0.09	
3	20	0.01	-0.05, 0.07		20	0.02	-0.04, 0.08		20	0.02	-0.04, 0.08	
4	20	0.12	0.06, 0.18		20	0.12	0.06, 0.18		20	0.12	0.06, 0.18	
5	20	0.13	0.07, 0.19		20	0.14	0.08, 0.20		20	0.14	0.08, 0.20	
6	20	0.21	0.15, 0.27		20	0.21	0.15, 0.27		20	0.21	0.15, 0.27	
7	20	0.23	0.17, 0.29		20	0.23	0.17, 0.29		20	0.23	0.17, 0.29	
8	20	0.28	0.22, 0.34		20	0.28	0.22, 0.35		20	0.29	0.23, 0.35	
9	20	0.27	0.21, 0.33		20	0.27	0.21, 0.33		20	0.27	0.21, 0.33	
10	20	0.36	0.30, 0.42		20	0.36	0.30, 0.42		20	0.36	0.30, 0.43	
11	20	0.32	0.26, 0.38		20	0.32	0.26, 0.38		20	0.32	0.26, 0.39	
12	20	0.33	0.27, 0.39		20	0.34	0.28, 0.40		20	0.34	0.28, 0.40	
13	20	0.41	0.35, 0.47		20	0.41	0.35, 0.47		20	0.41	0.35, 0.47	
14	20	0.36	0.30, 0.42		20	0.36	0.30, 0.42		20	0.36	0.30, 0.42	
15	20	0.33	0.27, 0.39		20	0.33	0.27, 0.39		20	0.33	0.27, 0.39	
16	20	0.39	0.33, 0.45		20	0.39	0.33, 0.45		20	0.39	0.33, 0.45	
group				>0.9				0.062				0.11
Active tACS	159	—	—		159	—	—		159	—	—	
Sham tACS	159	0.00	-0.06, 0.06		159	-0.10	-0.21, 0.01		159	-0.13	-0.29, 0.03	
stim_session * group	318			.015	318			.009	318			0.008
2 * Sham tACS	10	-0.09	-0.17, 0.00		10	-0.10	-0.18, -0.01		10	-0.10	-0.19, -0.01	
3 * Sham tACS	10	-0.03	-0.12, 0.06		10	-0.04	-0.13, 0.04		10	-0.04	-0.13, 0.04	
4 * Sham tACS	10	-0.01	-0.09, 0.08		10	-0.02	-0.11, 0.07		10	-0.02	-0.11, 0.07	
5 * Sham tACS	10	-0.03	-0.11, 0.06		10	-0.04	-0.13, 0.04		10	-0.04	-0.13, 0.04	
6 * Sham tACS	10	-0.09	-0.18, 0.00		10	-0.10	-0.19, -0.02		10	-0.10	-0.19, -0.02	
7 * Sham tACS	10	-0.06	-0.14, 0.03		10	-0.07	-0.16, 0.01		10	-0.07	-0.16, 0.01	
8 * Sham tACS	10	-0.08	-0.17, 0.00		10	-0.10	-0.19, -0.01		10	-0.10	-0.19, -0.01	
9 * Sham tACS	10	-0.10	-0.18, -0.01		10	-0.11	-0.20, -0.03		10	-0.11	-0.20, -0.03	
10 * Sham tACS	10	-0.14	-0.23, -0.06		10	-0.16	-0.25, -0.07		10	-0.16	-0.25, -0.08	
11 * Sham tACS	10	-0.07	-0.16, 0.01		10	-0.09	-0.17, 0.00		10	-0.09	-0.18, 0.00	
12 * Sham tACS	10	-0.10	-0.19, -0.01		10	-0.11	-0.20, -0.03		10	-0.11	-0.20, -0.03	
13 * Sham tACS	10	-0.13	-0.22, -0.05		10	-0.15	-0.23, -0.06		10	-0.15	-0.23, -0.06	
14 * Sham tACS	10	-0.06	-0.15, 0.02		10	-0.08	-0.16, 0.01		10	-0.08	-0.17, 0.01	
15 * Sham tACS	10	-0.03	-0.11, 0.06		10	-0.04	-0.13, 0.05		10	-0.04	-0.13, 0.05	
16 * Sham tACS	10	-0.11	-0.19, -0.02		10	-0.11	-0.19, -0.02		10	-0.11	-0.19, -0.02	
age					318	0.13	0.02, 0.24	0.024	318	0.15	0.00, 0.31	0.051
MoCA_BL									318	0.07	-0.23, 0.37	0.6
R ²		0.802				0.805				0.805		
Adjusted R ²		0.780				0.783				0.783		
AIC		-783				-787				-785		
σ		0.067				0.067				0.067		
Likelihood ratio test												
p-value						0.024				0.649		

Table S1.2.1: Model optimization for predicting 2-back d' at stimulation sessions. We fitted different linear models to predict the sensitivity index d' in the 2-back task with Stimulation Session

(1–16), Group (Active tACS vs. Sham tACS), age, and baseline Montreal Cognitive Assessment (MoCA) score. The table contains full results of the predictors and model metrics (R^2 , adjusted R^2 , AIC, sigma σ). Models were compared using the likelihood ratio test (*model.comparison* in R), assessing the significant impact of a specific term added to the model (adapted model) versus the model without this term (current best model). The p-value of the likelihood ratio test refers to the comparison between the new, adapted model with the last best model (from left to right). $p \leq 0.05$ indicates statistical significance (highlighted in bold). For the prediction of 2-back d' , this optimization process resulted in the following best model: $d' \sim \text{Stimulation Session} \times \text{Group} + \text{age}$. tACS = transcranial alternating current stimulation; CI = confidence interval; AIC = Akaike Information Criteria.

Stimulation session	Effect	EMMeans Difference	lower.CI	upper.CI	p-value	Cohen's d effect size
1	Active tACS - Sham tACS	0.10	-0.01	0.21	0.062	1.50
2	Active tACS - Sham tACS	0.20	0.09	0.31	0.001	2.97
3	Active tACS - Sham tACS	0.14	0.03	0.26	0.013	2.16
4	Active tACS - Sham tACS	0.12	0.01	0.23	0.039	1.81
5	Active tACS - Sham tACS	0.14	0.03	0.26	0.015	2.14
6	Active tACS - Sham tACS	0.20	0.09	0.32	< 0.001	3.04
7	Active tACS - Sham tACS	0.17	0.06	0.29	0.003	2.58
8	Active tACS - Sham tACS	0.20	0.08	0.32	0.001	3.02
9	Active tACS - Sham tACS	0.21	0.10	0.33	< 0.001	3.20
10	Active tACS - Sham tACS	0.26	0.14	0.38	< 0.001	3.92
11	Active tACS - Sham tACS	0.19	0.07	0.30	0.001	2.83
12	Active tACS - Sham tACS	0.21	0.10	0.33	< 0.001	3.19
13	Active tACS - Sham tACS	0.25	0.13	0.36	< 0.001	3.70
14	Active tACS - Sham tACS	0.18	0.06	0.29	0.002	2.67
15	Active tACS - Sham tACS	0.14	0.03	0.26	0.016	2.11
16	Active tACS - Sham tACS	0.21	0.10	0.31	< 0.001	3.10

Table S1.2.2: Post hoc pairwise comparisons based on the optimized model predicting 2-back d' at stimulation sessions. Based on the optimized model to predict the sensitivity index d' in the 2-back task (see table S1.2.1), we calculated estimated marginal means (EMMs) and performed post hoc pairwise comparisons between the active tACS and the sham tACS group at each stimulation session. The p-values have been Bonferroni-corrected. $p \leq 0.05$ indicates statistical

significance (highlighted in bold). Effect sizes were computed utilizing Cohen's *d*. tACS = transcranial alternating current stimulation; CI = confidence interval.

Predictor	C ~ Stim. session × group				...+ age				...+ MoCA_BL			
	N	Beta	95% CI	p-value	N	Beta	95% CI	p-value	N	Beta	95% CI	p-value
stim_session				<0.001				<0.001				<0.001
1	18	—	—		18	—	—		18	—	—	
2	20	0.02	-0.02, 0.07		20	0.02	-0.02, 0.07		20	0.02	-0.02, 0.07	
3	20	-0.09	-0.14, -0.05		20	-0.09	-0.14, -0.05		20	-0.09	-0.14, -0.05	
4	20	-0.18	-0.22, -0.13		20	-0.18	-0.22, -0.13		20	-0.18	-0.22, -0.13	
5	20	-0.17	-0.22, -0.13		20	-0.17	-0.21, -0.12		20	-0.17	-0.22, -0.13	
6	20	-0.18	-0.23, -0.14		20	-0.18	-0.23, -0.14		20	-0.18	-0.23, -0.14	
7	20	-0.19	-0.23, -0.14		20	-0.18	-0.23, -0.14		20	-0.19	-0.23, -0.14	
8	20	-0.22	-0.26, -0.17		20	-0.22	-0.26, -0.17		20	-0.22	-0.26, -0.17	
9	20	-0.23	-0.27, -0.18		20	-0.23	-0.27, -0.18		20	-0.23	-0.28, -0.18	
10	20	-0.24	-0.28, -0.19		20	-0.23	-0.28, -0.19		20	-0.24	-0.28, -0.19	
11	20	-0.26	-0.30, -0.21		20	-0.26	-0.30, -0.21		20	-0.26	-0.31, -0.22	
12	20	-0.28	-0.32, -0.23		20	-0.28	-0.32, -0.23		20	-0.28	-0.33, -0.24	
13	20	-0.28	-0.32, -0.23		20	-0.28	-0.32, -0.23		20	-0.28	-0.33, -0.24	
14	20	-0.28	-0.33, -0.24		20	-0.28	-0.32, -0.23		20	-0.28	-0.33, -0.24	
15	20	-0.29	-0.33, -0.24		20	-0.29	-0.33, -0.24		20	-0.29	-0.33, -0.24	
16	20	-0.31	-0.35, -0.26		20	-0.31	-0.35, -0.26		20	-0.31	-0.35, -0.26	
group				0.064				>0.9				0.041
Active tACS	159	—	—		159	—	—		159	—	—	
Sham tACS	159	0.04	0.00, 0.09		159	0.00	-0.08, 0.08		159	0.05	0.00, 0.10	
stim_session * group	318			<0.001	318			<0.001	318			<0.001
2 * Sham tACS	10	-0.13	-0.20, -0.07		10	-0.14	-0.20, -0.07		10	-0.13	-0.19, -0.07	
3 * Sham tACS	10	-0.05	-0.12, 0.01		10	-0.06	-0.12, 0.01		10	-0.06	-0.12, 0.01	
4 * Sham tACS	10	0.00	-0.06, 0.06		10	-0.01	-0.07, 0.06		10	0.00	-0.07, 0.06	
5 * Sham tACS	10	-0.01	-0.08, 0.05		10	-0.02	-0.08, 0.05		10	-0.01	-0.08, 0.05	
6 * Sham tACS	10	-0.03	-0.09, 0.04		10	-0.03	-0.09, 0.03		10	-0.03	-0.09, 0.04	
7 * Sham tACS	10	-0.04	-0.11, 0.02		10	-0.05	-0.11, 0.01		10	-0.05	-0.11, 0.02	
8 * Sham tACS	10	-0.04	-0.10, 0.03		10	-0.04	-0.11, 0.02		10	-0.04	-0.10, 0.02	
9 * Sham tACS	10	0.00	-0.07, 0.06		10	-0.01	-0.07, 0.06		10	0.00	-0.07, 0.06	
10 * Sham tACS	10	0.01	-0.05, 0.07		10	0.00	-0.06, 0.07		10	0.01	-0.06, 0.07	
11 * Sham tACS	10	0.02	-0.04, 0.08		10	0.01	-0.05, 0.08		10	0.02	-0.05, 0.08	
12 * Sham tACS	10	0.03	-0.04, 0.09		10	0.02	-0.04, 0.08		10	0.02	-0.04, 0.09	
13 * Sham tACS	10	0.04	-0.03, 0.10		10	0.03	-0.03, 0.10		10	0.04	-0.03, 0.10	
14 * Sham tACS	10	0.04	-0.02, 0.10		10	0.03	-0.03, 0.10		10	0.04	-0.03, 0.10	
15 * Sham tACS	10	0.08	0.02, 0.14		10	0.07	0.01, 0.14		10	0.08	0.01, 0.14	
16 * Sham tACS	10	0.08	0.01, 0.14		10	0.08	0.02, 0.14		10	0.08	0.02, 0.14	
age					318	0.05	-0.03, 0.13	0.2				
MoCA_BL									318	-0.07	-0.23, 0.09	0.4
R ²		0.755				0.756				0.755		
Adjusted R ²		0.728				0.729				0.728		
AIC		-974				-973				-973		
σ		0.050				0.050				0.050		
Likelihood ratio test												
p-value						0.216				0.387		

Table S1.2.3: Model optimization for predicting 2-back C at stimulation sessions. We fitted different linear models to predict the response bias C in the 2-back task with Stimulation Session (1–16), Group (Active tACS vs. Sham tACS), age, and baseline Montreal Cognitive Assessment

(MoCA) score. The table contains full results of the predictors and model metrics (R^2 , adjusted R^2 , AIC, sigma σ). Models were compared using the likelihood ratio test (*model.comparison* in R), assessing the significant impact of a specific term added to the model (adapted model) versus the model without this term (current best model). The p-value of the likelihood ratio test refers to the comparison between the new, adapted model with the last best model (from left to right). $p \leq 0.05$ indicates statistical significance (highlighted in bold). For the prediction of 2-back C, this optimization process resulted in the following best model: $C \sim \text{Stimulation Session} \times \text{Group}$. tACS = transcranial alternating current stimulation; CI = confidence interval; AIC = Akaike Information Criteria.

Stimulation session	Effect	EMMeans Difference	lower.CI	upper.CI	p-value	Cohen's d effect size
1	Active tACS - Sham tACS	-0.04	-0.09	0.00	0.064	-0.88
2	Active tACS - Sham tACS	0.09	0.04	0.13	< 0.001	1.77
3	Active tACS - Sham tACS	0.01	-0.03	0.05	0.653	0.20
4	Active tACS - Sham tACS	-0.04	-0.09	0.00	0.054	-0.87
5	Active tACS - Sham tACS	-0.03	-0.08	0.01	0.152	-0.64
6	Active tACS - Sham tACS	-0.02	-0.06	0.03	0.409	-0.37
7	Active tACS - Sham tACS	0.00	-0.04	0.04	0.983	0.01
8	Active tACS - Sham tACS	-0.01	-0.05	0.04	0.753	-0.14
9	Active tACS - Sham tACS	-0.04	-0.09	0.00	0.062	-0.84
10	Active tACS - Sham tACS	-0.05	-0.10	-0.01	0.016	-1.08
11	Active tACS - Sham tACS	-0.06	-0.11	-0.02	0.005	-1.27
12	Active tACS - Sham tACS	-0.07	-0.11	-0.03	0.002	-1.39
13	Active tACS - Sham tACS	-0.08	-0.12	-0.04	< 0.001	-1.63
14	Active tACS - Sham tACS	-0.08	-0.13	-0.04	< 0.001	-1.70
15	Active tACS - Sham tACS	-0.12	-0.17	-0.08	< 0.001	-2.46
16	Active tACS - Sham tACS	-0.12	-0.17	-0.08	< 0.001	-2.45

Table S1.2.4: Post hoc pairwise comparisons based on the optimized model predicting 2-back C at stimulation sessions. Based on the optimized model to predict the response bias C in the 2-back task (see table S1.2.3), we calculated estimated marginal means (EMMs) and performed post hoc pairwise comparisons between the Active tACS and the Sham tACS group at each stimulation session. The p-values have been Bonferroni-corrected. $p \leq 0.05$ indicates statistical significance

(highlighted in bold). Effect sizes were computed utilizing Cohen's d. tACS = transcranial alternating current stimulation; CI = confidence interval.

Predictor	RT ~ Stim. session × group				...+ age				...+ age + MoCA_BL			
	N	Beta	95% CI	p-value	N	Beta	95% CI	p-value	N	Beta	95% CI	p-value
stim_session				<0.001				<0.001				<0.001
1	637	—	—		637	—	—		637	—	—	
2	728	-0.13	-0.19, -0.08		728	-0.13	-0.18, -0.08		728	-0.13	-0.18, -0.08	
3	752	-0.23	-0.29, -0.18		752	-0.24	-0.29, -0.18		752	-0.24	-0.29, -0.19	
4	761	-0.27	-0.32, -0.21		761	-0.27	-0.32, -0.22		761	-0.27	-0.32, -0.22	
5	764	-0.34	-0.40, -0.29		764	-0.35	-0.40, -0.30		764	-0.35	-0.40, -0.30	
6	767	-0.39	-0.44, -0.34		767	-0.40	-0.45, -0.35		767	-0.40	-0.45, -0.35	
7	769	-0.43	-0.48, -0.38		769	-0.44	-0.49, -0.39		769	-0.44	-0.49, -0.39	
8	768	-0.46	-0.51, -0.41		768	-0.47	-0.52, -0.42		768	-0.47	-0.52, -0.42	
9	767	-0.50	-0.55, -0.45		767	-0.51	-0.56, -0.46		767	-0.51	-0.56, -0.46	
10	768	-0.52	-0.58, -0.47		768	-0.53	-0.59, -0.48		768	-0.54	-0.59, -0.49	
11	770	-0.57	-0.62, -0.52		770	-0.58	-0.63, -0.53		770	-0.58	-0.63, -0.53	
12	768	-0.58	-0.63, -0.52		768	-0.59	-0.64, -0.54		768	-0.59	-0.64, -0.54	
13	769	-0.61	-0.66, -0.56		769	-0.62	-0.67, -0.57		769	-0.63	-0.68, -0.58	
14	770	-0.64	-0.69, -0.58		770	-0.65	-0.70, -0.60		770	-0.65	-0.70, -0.60	
15	769	-0.64	-0.69, -0.59		769	-0.65	-0.70, -0.60		769	-0.66	-0.71, -0.61	
16	754	-0.66	-0.72, -0.61		754	-0.68	-0.73, -0.63		754	-0.68	-0.73, -0.63	
group				0.073				0.2				0.2
Active tACS	5,956	—	—		5,956	—	—		5,956	—	—	
Sham tACS	6,125	0.05	0.00, 0.11		6,125	0.03	-0.02, 0.09		6,125	0.04	-0.02, 0.09	
stim_session * group	12,081			0.068	12,081			0.084	12,081			0.066
2 * Sham tACS	369	-0.02	-0.10, 0.05		369	-0.02	-0.10, 0.05		369	-0.02	-0.09, 0.05	
3 * Sham tACS	380	-0.01	-0.09, 0.06		380	-0.01	-0.08, 0.06		380	-0.01	-0.08, 0.06	
4 * Sham tACS	386	-0.03	-0.11, 0.04		386	-0.03	-0.10, 0.04		386	-0.03	-0.10, 0.04	
5 * Sham tACS	389	-0.06	-0.13, 0.02		389	-0.06	-0.13, 0.02		389	-0.06	-0.13, 0.01	
6 * Sham tACS	388	-0.10	-0.18, -0.03		388	-0.09	-0.17, -0.02		388	-0.09	-0.16, -0.02	
7 * Sham tACS	390	-0.08	-0.15, 0.00		390	-0.07	-0.14, 0.00		390	-0.07	-0.14, 0.00	
8 * Sham tACS	390	-0.09	-0.16, -0.01		390	-0.08	-0.16, -0.01		390	-0.08	-0.15, -0.01	
9 * Sham tACS	388	-0.09	-0.17, -0.02		388	-0.09	-0.16, -0.02		388	-0.09	-0.16, -0.02	
10 * Sham tACS	390	-0.09	-0.16, -0.01		390	-0.08	-0.15, -0.01		390	-0.08	-0.15, -0.01	
11 * Sham tACS	390	-0.09	-0.16, -0.01		390	-0.08	-0.15, -0.01		390	-0.08	-0.15, -0.01	
12 * Sham tACS	389	-0.12	-0.19, -0.04		389	-0.11	-0.18, -0.04		389	-0.11	-0.18, -0.04	
13 * Sham tACS	390	-0.06	-0.14, 0.01		390	-0.05	-0.13, 0.02		390	-0.05	-0.12, 0.02	
14 * Sham tACS	390	-0.05	-0.13, 0.02		390	-0.04	-0.12, 0.03		390	-0.04	-0.11, 0.03	
15 * Sham tACS	389	-0.08	-0.16, -0.01		389	-0.07	-0.14, 0.00		389	-0.07	-0.14, 0.00	
16 * Sham tACS	381	-0.07	-0.14, 0.01		381	-0.06	-0.13, 0.01		381	-0.06	-0.13, 0.01	
age					12,081	0.01	0.01, 0.01	<0.001	12,081	0.01	0.01, 0.01	<0.001
MoCA_BL									12,081	-0.01	-0.01, -0.01	<0.001
Nagelkerke's R ²		0.29				0.34				0.35		
AIC		188,607				187,659				187,593		
Deviance		1,319				1,221				1,214		
Likelihood ratio test												
p-value						<0.001				<0.001		

Table S1.2.5: Model optimization for predicting 2-back reaction time at stimulation sessions.

We fitted different generalized linear models to predict the reaction time (RT) in the 2-back task with Stimulation Session (1–16), Group (Active tACS vs. Sham tACS), age, and baseline Montreal Cognitive Assessment (MoCA) score. The table contains full results of the predictors and model

metrics (Nagelkerke's R^2 , AIC, deviance). Models were compared using the likelihood ratio test (*model.comparison* in R), assessing the significant impact of a specific term added to the model (adapted model) versus the model without this term (current best model). The p-value of the likelihood ratio test refers to the comparison between the new, adapted model with the last best model (from left to right). $p \leq 0.05$ indicates statistical significance (highlighted in bold). For the prediction of 2-back RT, this optimization process resulted in the following best model: $RT \sim \text{Stimulation Session} \times \text{Group} + \text{age} + \text{MoCA}_{\text{baseline}}$. tACS = transcranial alternating current stimulation; CI = confidence interval; AIC = Akaike Information Criteria.

Stimulation session	Effect	EMMeans Difference	lower.CI	upper.CI	p-value	Cohen's d effect size
1	Active tACS - Sham tACS	-0.04	-0.09	0.02	0.18	-0.11
2	Active tACS - Sham tACS	-0.01	-0.06	0.04	0.58	-0.04
3	Active tACS - Sham tACS	-0.03	-0.07	0.02	0.28	-0.08
4	Active tACS - Sham tACS	-0.01	-0.05	0.04	0.85	-0.01
5	Active tACS - Sham tACS	0.02	-0.03	0.07	0.41	0.06
6	Active tACS - Sham tACS	0.06	0.01	0.10	0.02	0.18
7	Active tACS - Sham tACS	0.04	-0.01	0.08	0.14	0.11
8	Active tACS - Sham tACS	0.05	0.00	0.09	0.049	0.15
9	Active tACS - Sham tACS	0.05	0.01	0.10	0.03	0.17
10	Active tACS - Sham tACS	0.05	-0.00	0.09	0.06	0.14
11	Active tACS - Sham tACS	0.04	-0.00	0.09	0.07	0.14
12	Active tACS - Sham tACS	0.07	0.03	0.12	0.002	0.23
13	Active tACS - Sham tACS	0.02	-0.03	0.07	0.45	0.06
14	Active tACS - Sham tACS	0.01	-0.04	0.06	0.71	0.03
15	Active tACS - Sham tACS	0.04	-0.01	0.08	0.12	0.12
16	Active tACS - Sham tACS	0.02	-0.03	0.07	0.36	0.07

Table S1.2.6: Post hoc pairwise comparisons based on the optimized model predicting 2-back reaction time at stimulation sessions. Based on the optimized model to predict the reaction time (RT) in the 2-back task (see table S1.2.5), we calculated estimated marginal means (EMMs) and performed post hoc pairwise comparisons between the Active tACS and the Sham tACS group at each stimulation session. The p-values have been Bonferroni-corrected. $p \leq 0.05$ indicates statistical significance (highlighted in bold). Effect sizes were computed utilizing Cohen's d. tACS = transcranial alternating current stimulation; CI = confidence interval.

S2. Side Effects and Adverse Effects

	Active tACS (n = 38)	Sham tACS (n = 39)	p-value
Side effects			
Phosphenes	6 (1%)	9 (1%)	0.69
Skin irritation	3 (<1%)	10 (2%)	0.22
Tingling	377 (62%)	404 (65%)	0.72
Adverse effects			
Headache	5 (<1%)	3 (<1%)	0.50
Nervousness	3 (<1%)	0	0.32
Tiredness	8 (1%)	14 (2%)	0.35
Vertigo	2 (<1%)	0	0.16

Table S2: Detailed list of reported side effects and adverse effects as well as comparisons between intervention groups. The data comprises the total counts and corresponding percentages (in parentheses) of reported side effects and adverse effects in both the Active and Sham transcranial alternating current stimulation (tACS) groups. Statistical comparisons between groups were conducted using unpaired two-sided t-tests, with a significance threshold set at a p-value of ≤ 0.05 .

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