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Supplementary Materials for

A meta-analysis suggests that tACS improves cognition in healthy, aging, and psychiatric populations

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The PDF file includes:

Other Supplementary Material for this manuscript includes the following:

Supplementary Materials and Methods

Categorization of effects in clinical studies. For some studies in clinical populations, effects could be categorized into one of the nine cognitive domains (for example, examination of working memory in schizophrenia). For other studies in clinical populations, the effect of interest is not explicitly categorizable into a single cognitive domain (for instance, examination of comprehensive neuropsychiatric assessments such as Montreal Cognitive Assessment scores in Parkinson's disease patients) or may reflect a characteristic symptom dimension unique to a clinical disorder (for example, auditory hallucination symptoms in schizophrenia). To maximize inclusivity in our assessment of the effectiveness of tACS, we included these effects under the umbrella of 'Neuropsychiatric Assessments' and 'Clinical Symptoms', respectively.

Grouping of effects for meta-analytic effect size estimation. The overall meta-analytic *Outcome-Based* and *Hypothesis-Based* effect sizes of tACS were determined across all effect sizes extracted during search. These included effects belonging to all nine cognitive domains in healthy populations, effects belonging to any cognitive domain in clinical populations, as well as clinical symptom and neuropsychiatric assessment measures in clinical populations. Results from these analyses are reported in the main

text. Exclusion of effects in clinical populations did not change the pattern of results in these omnibus analyses.

Grouping of effects when examining cognitive domains separately. When examining the effect size within the nine cognitive domains separately, we included effects in both healthy and clinical populations to maximize inclusivity. Exclusion of clinical studies did not significantly alter the pattern of results for these analyses, except reducing the significant effect of tACS on Attention Performance measures before outlier removal to a trend level (**Table S10**).

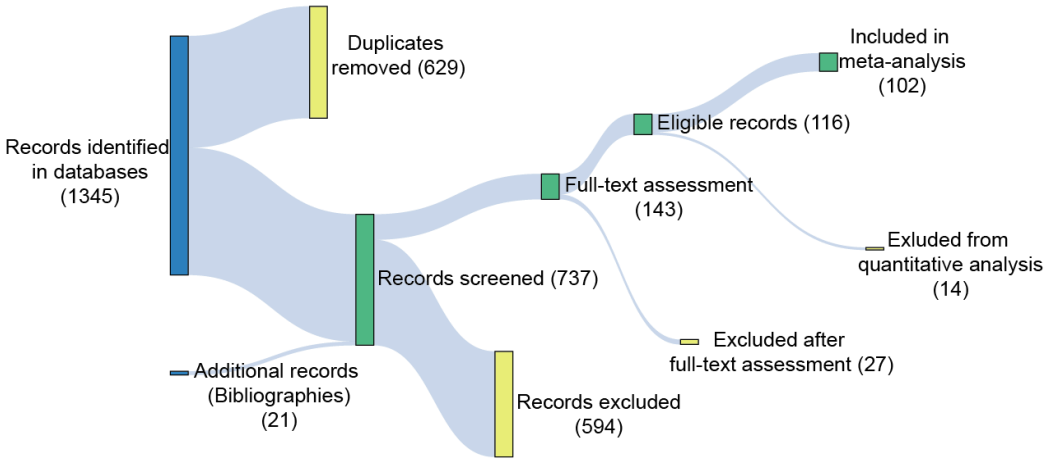
Grouping of effects for meta-regression analyses. Meta-regression analyses at the omnibus level included all extracted effects, including clinical effects. Exclusion of clinical effects did not significantly alter the pattern of results, except reducing the effect of Intensity on RT measures to a trend level (**Table S10**). Regression analyses could be performed for the working memory, long-term memory, attention, executive control and intelligence domains as these domains had sufficient numbers of effects (>= 10 per covariate, as recommended by *(31)*). For these domains, exclusion of effects in clinical populations produced the following changes: 1) they reduced the significant influence of modulation frequency on All working memory measures after outlier removal to a trend level (**Table S10**), and 2) the effect of modulation intensity on All, Performance and RT executive control measures after outlier removal became significant (**Table S10**).

Grouping of effects for subgroup analyses on phase. For examination of bidirectional effects of in-phase and anti-phase multisite tACS, all effects observed for experiments explicitly hypothesizing improvement of function with in-phase tACS and impairments in function with anti-phase tACS were included. No studies employing such protocols in clinical populations were identified.

Grouping of effects for subgroup analyses in older adults and clinical populations. Effects across healthy, older adults were separately analyzed to determine the effectiveness of tACS in older populations. In studies with clinical populations, effects on cognitive functions (belonging to any of the nine cognitive domains) and on clinical symptoms were separately analyzed. The effects on cognitive functions were examined together (“All”) as well as separately for performance-based effects (“Performance”) and RT-based effects (“RT”). Effects on neuropsychiatric symptoms were not analyzed quantitatively since they belonged to a single study but were included in the omnibus analyses (see above).

Supplementary Figures

Figure S1 | Flowchart of literature search and study selection.

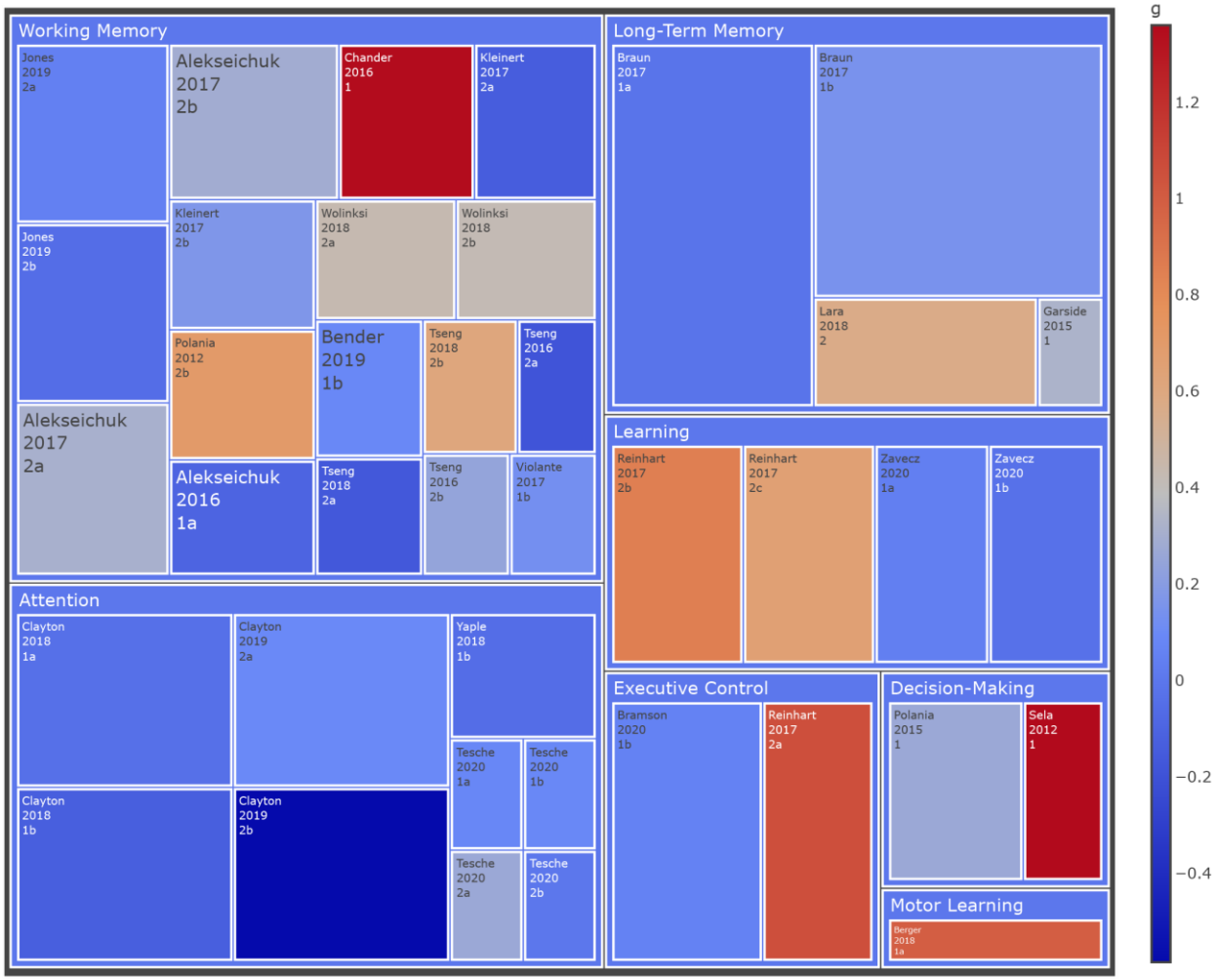


Of the 1345 records identified during search, 737 records remained after removing duplicates (same study appearing multiple times in different databases or with different search queries). Of these, 143 records qualified for a full-text assessment. 116 records were identified as eligible of which 102 records were included in the quantitative meta-analysis. 14 records were excluded due to data unavailability.

Figure S2 | Treemap of outcome-based effects included in the meta-analysis

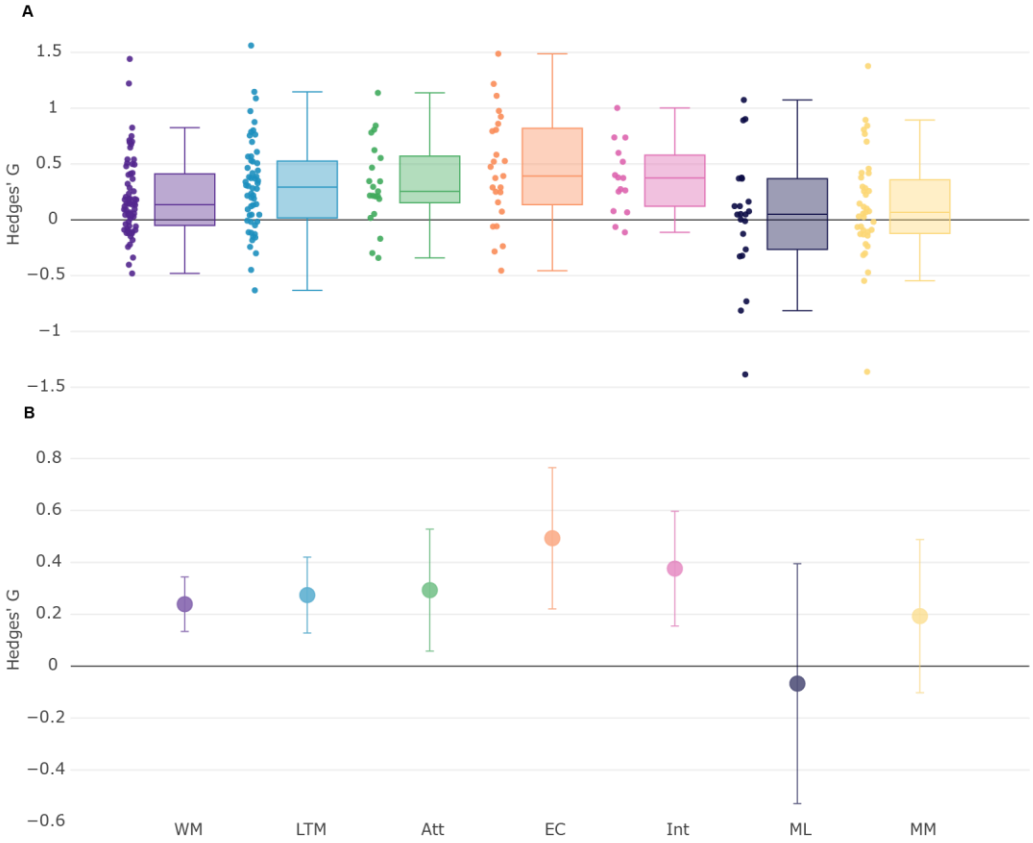
Each box represents an experiment, the color of the box reflects the effect size Hedges' g, the size of the box represents the sample size. The Hedges' g visualized here reflects the outcome-based effect size for 265 out of the 304 experiments. These experiments were either exploratory or explicitly tested whether tACS improved a cognitive outcome. Accordingly, positive values of Hedges' g here reflect an improvement in cognitive function, while negative values reflect an impairment. The remaining 39 experiments tested whether tACS disrupts cognitive function. Effect sizes for these "hypothesized disruption" experiments are provided in **Figure S3** in the **Supplementary Materials**. The experimental and tACS parameters for each experiment can be accessed in **Data File S1**.

Figure S3 | Treemap of experiments hypothesizing disruption in cognitive function.



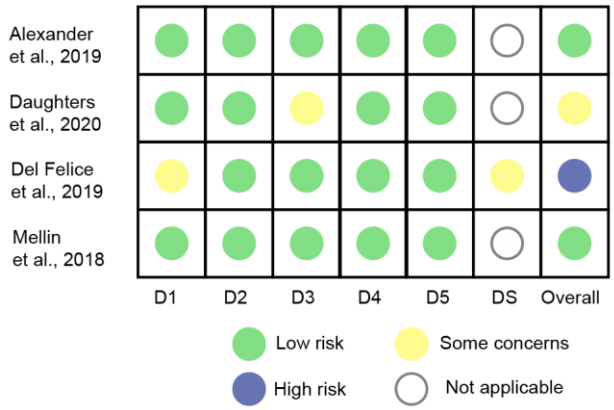
Each box represents an experiment, the color of the box reflects the effect size Hedges' g, the size of the box represents the sample size. The Hedges' g visualized here reflects the hypothesized-based effect size for 39 out of the 304 experiments, which explicitly hypothesized a disruption in cognitive function. Positive values reflect the degree of agreement with the hypothesis. In other words, a positive effect size reflects an impairment in cognitive function, as hypothesized, while a negative effect size reflects an improvement in cognitive function, contrary to the hypothesis. For the other 265 experiments which were either exploratory in nature or which explicitly hypothesized an improvement in cognitive function, both outcome-based and hypothesis-based analyses yield the same values, and these are reported in **Figure S2.** The experimental and tACS design parameters for each experiment can be accessed in **Data File S1**.

Figure S4 | Summary of effects on All outcomes in cognitive domains before outlier removal



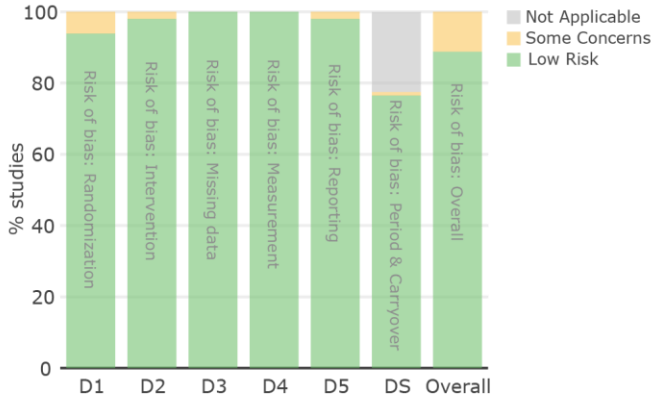
(A) Box plots of outcome-based effect size estimates in cognitive domains. Individual points represent individual effect size point estimates for each experiment within a specific domain. **(B)** Overall effect size estimates in cognitive domains with the corresponding 95% confidence intervals. All plots show data before outlier removal. Boxplot center, median; box limits, upper and lower quartiles; whiskers, maximum and minimum values. WM, working memory; LTM, long-term memory; Att, attention; EC, executive control; Int, intelligence; ML, motor learning; MM, motor memory.

Figure S5: Risk of bias assessments for randomized controlled trials



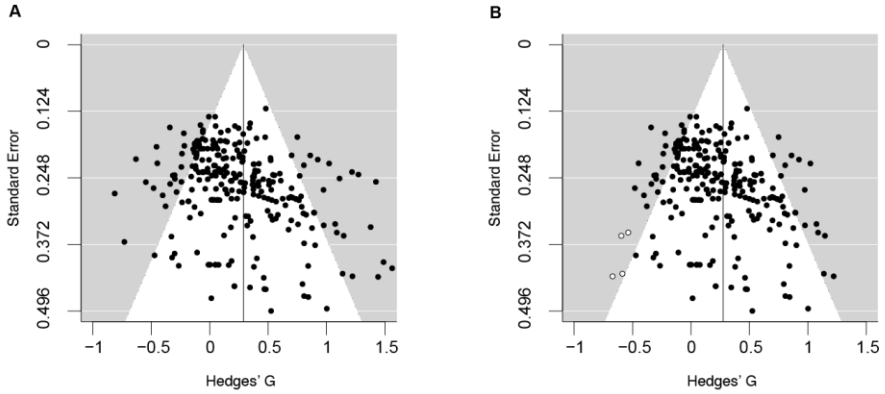
For each randomized controlled trial, the risk of bias in each of the six possible domains and overall risk determined using the Cochrane Risk of Bias tool (RoB 2.0; see **Methods**) is shown. D1: Risk of bias arising from the randomization process; D2:Risk of bias due to deviations from the intended interventions; D3: Missing outcome data; D4: Risk of bias in measurement of the outcome; D5: Risk of bias in selection of the reported result; DS: Risk of bias arising from period and carryover effects in crossover trials (not applicable to studies with between-subjects designs). For risk of bias assessment of non-RCTs, please see **Figure S6**.

Figure S6 | Risk of bias assessment summary plot for non-RCTs



The bars represent the percentage of non-RCT studies in each risk category in five risk of bias domains and overall risk of bias assessment determined using the accommodated version of the Cochrane Risk of Bias tool (RoB 2.0; see **Methods**). D1: Risk of bias arising from the randomization process; D2: Risk of bias due to deviations from the intended interventions; D3: Missing outcome data; D4: Risk of bias in measurement of the outcome; D5: Risk of bias in selection of the reported result; DS: Risk of bias arising from period and carryover effects in crossover trials (not applicable to studies with between-subjects designs).

Figure S7 | Publication bias funnel plots



(A) Funnel plot of effect sizes against their standard errors. **(B)** Funnel plot of effect sizes against their standard errors after exclusion of the outliers and trim-and-fill procedure. Black filled dots represent individual effect sizes included in the meta-analysis, empty dots represent the effect sizes imputed by the trim-and-fill procedure. The line in the center of the funnel represents the overall effect size estimate.

Supplementary Tables

Table S1: Sensitivity to correlation between dependent effects

	Outcome-Based Analysis				Hypothesis-Based Analysis			
r	**Hedges' G**	**Std. Error**	**Tau.sq**	***p***	**Hedges' G**	**Std. Error**	**Tau.sq**	***p***
Overall Effect								
0	0.2887	0.0387	0.1129	<0.0001	0.3155	0.0386	0.0976	<0.0001
0.2	0.2887	0.0387	0.1129	<0.0001	0.3156	0.0386	0.0977	<0.0001
0.4	0.2887	0.0387	0.113	<0.0001	0.3156	0.0386	0.0977	<0.0001
0.6	0.2887	0.0387	0.113	<0.0001	0.3156	0.0386	0.0978	<0.0001
0.8	0.2887	0.0387	0.1131	<0.0001	0.3156	0.0386	0.0979	<0.0001
1	0.2887	0.0387	0.1131	<0.0001	0.3156	0.0386	0.0979	<0.0001
Performance								
0	0.2999	0.0434	0.1097	<0.0001	0.3079	0.0432	0.0881	<0.0001
0.2	0.2999	0.0434	0.1098	<0.0001	0.3079	0.0432	0.0882	<0.0001
0.4	0.2999	0.0434	0.1098	<0.0001	0.3079	0.0432	0.0882	<0.0001
0.6	0.2999	0.0434	0.1099	<0.0001	0.308	0.0432	0.0883	<0.0001
0.8	0.2999	0.0434	0.1099	<0.0001	0.308	0.0432	0.0884	<0.0001
1	0.2999	0.0434	0.11	<0.0001	0.308	0.0432	0.0884	<0.0001
Reaction Time								
0	0.1857	0.0601	0.0874	0.004	0.1891	0.0656	0.0979	0.007
0.2	0.1857	0.0601	0.0875	0.004	0.1891	0.0656	0.098	0.007
0.4	0.1857	0.0601	0.0876	0.004	0.1891	0.0656	0.098	0.007
0.6	0.1857	0.0601	0.0877	0.004	0.1892	0.0656	0.0981	0.007
0.8	0.1857	0.0601	0.0878	0.004	0.1892	0.0656	0.0982	0.007
1	0.1857	0.0601	0.0878	0.004	0.1892	0.0656	0.0983	0.007

Std. Err., standard error of Hedges'g; Tau.sq, tau sqaured.

Table S2: Sensitivity to correlation between conditions in within-subjects experiments

	Hedges' g	**CIL**	**CIU**	***df***	***p***	**I²**
r = 0.3						
Outcome-Based All	0.287	0.209	0.366	95	<0.0001	57.63
Hypothesis-Based All	0.308	0.229	0.387	82	<0.0001	56.22
Outcome-Based Performance	0.298	0.21	0.386	79	<0.0001	57.16
Hypothesis-Based Performance	0.304	0.215	0.393	69	<0.0001	54.9
Outcome-Based RT	0.183	0.061	0.304	32	0.005	51.31
Hypothesis-Based RT	0.183	0.049	0.317	27.6	0.009	54.52
r = 0.7						
Outcome-Based All	0.284	0.209	0.359	95	<0.0001	76.66
Hypothesis-Based All	0.302	0.225	0.379	82	<0.0001	76.31
Outcome-Based Performance	0.297	0.212	0.381	73	<0.0001	76.26
Hypothesis-Based Performance	0.296	0.209	0.383	69	<0.0001	75.16
Outcome-Based RT	0.188	0.065	0.311	32.1	0.004	74.5
Hypothesis-Based RT	0.193	0.059	0.327	28	0.006	77.82

CIL, 95% confidence interval lower bound; CIU, 95% confidence interval upper bound; df, degrees of freedom; RT, reaction time.

Table S3: Summary of Hypothesis-based analysis results

Analysis	Hedges' g	CIL	CIU	*df*	*p*	I^2	N	k
All	0.316	0.239	0.392	82	<0.0001	64.4	83	213
All (outliers removed)	0.304	0.236	0.373	82	< 0.0001	54.83	83	201
Performance	0.308	0.222	0.394	69	<0.0001	62.81	70	155
Performance (outliers removed)	0.289	0.211	0.367	69	<0.0001	56.59	70	146
Reaction Time	0.189	0.055	0.323	27.8	0.007	65.67	30	53
Reaction Time (outliers removed)	0.146	0.049	0.243	22.5	0.005	20.98	27	48

CIL, 95% confidence interval lower bound; CIU, 95% confidence interval upper bound; df, degrees of freedom; N, number of studies; k, number of experiments; RT, reaction time.

Table S4: Effects of tACS on All outcomes by cognitive domains

Domain	Hedges' g	CIL	CIU	*df*	*p*	I^2	N	k
Before outlier removal								
Working Memory	0.239	0.134	0.344	19.77	0.0001	48.4	22	67
Long-Term Memory	0.274	0.128	0.42	25.2	0.001	63.31	27	56
Attention	0.293	0.058	0.528	6.1	0.022	50.53	8	21
Executive Control	0.493	0.221	0.765	13.71	0.002	80.55	15	25
Intelligence	0.376	0.156	0.597	5.34	0.007	26.68	7	15
Motor Learning	-0.067	-0.528	0.395	7.84	0.747	74.19	9	22
Motor Memory	0.193	-0.101	0.488	10.8	0.176	74.74	12	39
Learning	0.624	-0.728	1.976	3	0.238	91.43	4	7
Decision-Making	-0.071	-0.413	0.27	1	0.23	0	2	2
After outlier removal								
Working Memory	0.197	0.106	0.288	19.18	0.0002	30.44	22	63
Long-Term Memory	0.256	0.132	0.38	23.81	0.0003	49.99	26	52
Attention	0.318	0.151	0.486	4.98	0.005	20.45	8	20
Executive Control	0.563	0.318	0.808	12.56	0.0003	74.01	14	24
Intelligence	0.38	0.18	0.590	5.26	0.004	16.73	7	14
Motor Learning	-0.06	-0.321	0.202	5.48	0.591	48.48	7	19
Motor Memory	0.192	-0.004	0.388	10.44	0.054	53.16	12	37

CIL, 95% confidence interval lower bound; CIU, 95% confidence interval upper bound; df, degrees of freedom; N, number of studies; k, number of experiments. Further testing with outlier removal was not performed in the Learning and Decision-Making domains due to the low degrees of freedom..

Table S5: Effects of tACS on Performance outcomes by cognitive domains

Domain	Hedges' g	CIL	CIU	*df*	*p*	I^2	N	k
Before outlier removal								
Working Memory	0.265	0.128	0.402	18.13	0.001	56.92	20	53
Long-Term Memory	0.28	0.131	0.43	25.23	0.001	64.07	27	55
Attention	0.319	-0.002	0.64	6.45	0.051	63.71	8	14
Executive Control	0.505	0.124	0.885	9.83	0.015	83.38	11	15
Intelligence	0.364	-0.064	0.792	3.63	0.076	51.69	5	11
Motor Learning	0.034	-0.589	0.658	2.85	0.868	42.79	4	10
Motor Memory	0.223	0.003	0.442	5.42	0.048	18.52	7	15
Learning	0.624	-0.728	1.976	3	0.238	91.43	4	7
Decision-Making	-0.071	-0.413	0.27	1	0.23	0	2	2
After outlier removal								
Working Memory	0.216	0.093	0.339	17.16	0.002	45.14	19	50
Long-Term Memory	0.262	0.135	0.389	23.87	0.0003	51.42	26	51
Attention	0.361	0.118	0.605	5.54	0.012	35.85	8	13
Executive Control	0.608	0.265	0.951	8.72	0.003	75.72	10	14
Motor Memory	*no outliers detected*							

CIL, 95% confidence interval lower bound; CIU, 95% confidence interval upper bound; df, degrees of freedom; N, number of studies; k, number of experiments. Further testing with outlier removal was not performed in the Intelligence, Motor Learning, Learning and Decision-Making domains due to the low degrees of freedom..

Table S6: Effects of tACS on Reaction Time outcomes by cognitive domains

Domain	Hedges' g	CIL	CIU	*df*	*p*	I^2	N	k
Before outlier removal								
Working Memory	0.069	-0.058	0.195	7.46	0.243	0	10	14
Attention	0.238	0.114	0.361	1.78	0.016	0	4	7
Executive Control	0.315	-0.084	0.713	4.9	0.098	72.69	6	10
Intelligence	0.368	0.087	0.648	1.97	0.03	0	3	4
Motor Learning	-0.12	-0.87	0.629	4.93	0.696	80.35	6	12
Motor Memory	0.202	-0.253	0.657	7.93	0.336	82.44	9	24
After outlier removal								
Working Memory	*no outliers detected*							
Executive Control	0.193	0.221	-0.182	0.569	54.007	3.759	5	9
Motor Learning	0.077	0.735	-0.519	0.673	72.316	3.883	5	10
Motor Memory	0.124	-0.152	0.4	6.8	0.321	64.13	8	22

CIL, 95% confidence interval lower bound; CIU, 95% confidence interval upper bound; df, degrees of freedom; N, number of studies; k, number of experiments. The Long-term Memory, Learning and Decision-Making domains did not have sufficient number of RT effects for analysis. Further testing for outlier removal was not performed for Attention and Intelligence domains due to low degrees of freedom.

Table S7: Effects of tACS along the hypothesized direction on All outcomes by cognitive domains

Domain	Hedges' g	CIL	CIU	*df*	*p*	I^2	N	k
Before outlier removal								
Working Memory	0.267	0.133	0.401	16.94	0.001	57.76	19	64
Long-Term Memory	0.275	0.138	0.413	23.59	< 0.001	58.04	26	48
Attention	0.064	-0.164	0.293	6.12	0.519	49.94	8	22
Executive Control	0.549	0.260	0.837	10.69	0.002	76.88	12	22
Intelligence	0.341	0.096	0.585	4.38	0.017	30.69	6	13
Motor Learning	0.129	-0.966	1.225	2.99	0.731	84.73	4	6
Motor Memory	0.434	0.121	0.746	4.87	0.016	53.80	6	14
Learning	0.605	-0.566	1.777	3	0.199	90.80	4	9
Decision-Making	0.332	-3.369	4.033	1	0.458	74.92	2	4
After outlier removal								
Working Memory	0.192	0.091	0.292	15.06	0.001	37.28	17	58
Long-Term Memory	0.205	0.094	0.317	20.61	0.001	40.11	24	44
Attention	0.092	-0.096	0.280	4.32	0.252	2.05	8	21
Executive Control	0.549	0.260	0.837	10.69	0.002	76.88	12	22
Intelligence	0.353	0.143	0.563	4.27	0.009	16.37	6	12
Motor Learning	0.129	-0.966	1.225	2.99	0.731	84.73	4	6
Motor Memory	0.354	0.174	0.534	4.68	0.004	7.93	6	13

CIL, 95% confidence interval at lower bound; CIU, 95% confidence interval at upper bound; df, degrees of freedom; N, number of studies; k, number of experiments; Outlier detection was not performed for Learning and Decision-Making domains due to low degrees of freedom (< 4).

Table S8: Effects of tACS along the hypothesized direction on Performance outcomes by cognitive domains

Domain	Hedges' g	CIL	CIU	*df*	*p*	I^2	N	K
Before outlier removal								
Working Memory	0.297	0.140	0.455	15.07	0.001	60.46	17	47
Long-Term Memory	0.282	0.141	0.422	23.65	< 0.001	59.06	26	47
Attention	0.141	-0.077	0.360	5.25	0.159	26.24	8	12
Executive Control	0.576	0.191	0.961	7.75	0.009	77.28	9	13
Intelligence	0.296	-0.296	0.887	2.69	0.198	55.82	4	9
Motor Learning	-0.154	-4.247	3.938	1	0.715	59.13	2	3
Motor Memory	0.357	0.063	0.777	2.78	0.072	16.54	4	6
Learning	0.596	-0.593	1.785	3	0.209	91.17	4	8
Decision-Making	0.332	-3.369	4.033	1	0.458	74.92	2	4
After outlier removal								
Working Memory	0.228	0.094	0.362	13.38	0.003	45.24	15	42
Long-Term Memory	0.213	0.098	0.328	20.81	0.001	42.86	24	43
Attention	0.141	-0.077	0.360	5.25	0.159	26.24	8	12
Executive Control	0.576	0.191	0.961	7.75	0.009	77.28	9	13

CIL, 95% confidence interval at lower bound; CIU, 95% confidence interval at upper bound; df, degrees of freedom; N, number of studies; k, number of experiments; Outlier detection was not performed for Intelligence. Motor Learning, Motor Memory, Learning and Decision-Making domains due to low degrees of freedom (< 4).

Table S9: Effects of tACS along the hypothesized direction on Reaction Time outcomes by cognitive domains

Domain	Hedges' g	CIL	CIU	*df*	*p*	I^2	N	K
Before outlier removal								
Working Memory	0.051	-0.093	0.194	7.14	0.434	7.64	9	17
Attention	-0.051	-0.484	0.383	4.49	0.770	57.42	6	10
Executive Control	0.282	-0.235	0.800	3.93	0.203	75.72	5	9
Intelligence	0.368	0.087	0.648	1.97	0.030	0	3	4
Motor Memory	0.540	-0.254	1.334	2.98	0.119	73.55	4	8
After outlier removal								
Working Memory	0.038	-0.082	0.159	7.029	0.474	0	9	16

CIL, 95% confidence interval at lower bound; CIU, 95% confidence interval at upper bound; df, degrees of freedom; N, number of studies; k, number of experiments; Prior to outlier removal, only one study examined RT measures in the Long-Term Memory, Motor Learning and Learning domains, while no study examined such metrics within the Decision-Making domain. Given the scarce data, these domains could not be examined. Among the domains examined, Executive Control, Intelligence and Motor Memory yielded low degrees of freedom (< 4), and were not subjected to further outlier removal. Within the Attention domain, 9 out of 10 effects were not identified as outliers, and the standardized residual procedure failed in computing the residual for the remaining effect. Given the absence of this information, as well as borderline acceptability of the degrees of freedom prior to outlier removal (df = 4.49), this domain was also not subjected to outlier removal.

Table S10: Significant effects which become nonsignificant depending on whether clinical studies are included or not.

	With clinical studies	Without clinical studies
Analysis: Effect Size Computation		
Effect size for Performance measures, in the attention domain, before outlier removal	Hedges' g = 0.319, p = 0.051 (Table S5)	Hedges' g = 0.275, p = 0.09 (Data File S09)
Analyses: Meta-regression		
Influence of modulation intensity on RT measures, across all cognitive domains, after outlier removal	Beta = - 0.148, p = 0.048 (Data File S04)	Beta = - 0.126, p = 0.120 (Data File S09)
Influence of modulation frequency on All measures, in the working memory domain, after outlier removal	Beta = - 0.006, p = 0.032 (Data File S06)	Beta = - 0.005, p = 0.065 (Data File S09)
Influence of modulation intensity on All measures, in the executive control domain, after outlier removal	Beta = - 0.136, p = 0.556 (Data File S08)	Beta = - 0.722, p = 0.036 (Data File S09)
Influence of modulation intensity on Performance measures, in the executive control domain, after outlier removal	Beta = - 0.212, p = 0.61 (Data File S08)	Beta = - 0.814, p = 0.043 (Data File S09)
Influence of modulation intensity on RT measures, in the executive control domain, after outlier removal	Beta = - 0.362, p = 0.307 (Data File S08)	Beta = - 0.966, p = 0.03 (Data File S09)

Table S11: Effects of in-phase and anti-phase tACS

Analysis	Hedges' g	CIL	CIU	*df*	*p*	I^2	N	k
Before outlier removal								
All (In-, Anti-Phase)	0.35	0.169	0.531	20.1	0.0006	72.42	22	62
All In-Phase*	0.317	0.103	0.531	17.3	0.006	75.89	19	41
All Anti-Phase†	0.314	0.082	0.546	7.48	0.015	52.91	9	14
Performance (In-, Anti-Phase)	0.323	0.1	0.546	15.6	0.007	75.86	17	46
Performance In-Phase*	0.27	-0.007	0.547	12.8	0.055	80.27	14	29
Performance Anti-Phase†	0.307	0.047	0.567	5.55	0.028	51.57	7	10
RT (In-, Anti-Phase)	0.231	-0.063	0.525	6.79	0.105	63.58	8	13
RT In-Phase*	0.217	-0.079	0.514	6.75	0.126	60.88	8	9
RT Anti-Phase†	0.242	-0.322	0.805	2.94	0.263	53.18	4	4
After outlier removal								
All (In-, Anti-Phase)	0.329	0.166	0.492	19.9	0.0004	67.61	22	59
All In-Phase*	0.293	0.102	0.484	17.2	0.005	71.29	19	38
All Anti-Phase†	0.302	0.087	0.517	7.31	0.013	45.22	9	13
Performance (In-, Anti-Phase)	0.298	0.101	0.495	15.5	0.006	70.83	17	43
Performance In-Phase*	0.252	-0.002	0.506	12.8	0.052	77.69	14	27
Performance Anti-Phase†	0.292	0.057	0.527	5.37	0.024	39.86	7	9
RT (In-, Anti-Phase)	0.11	-0.093	0.314	5.26	0.224	20.37	7	12
RT In-Phase*	0.079	-0.104	0.261	4.95	0.316	0	7	8

CIL, 95% confidence interval lower bound; CIU, 95% confidence interval upper bound; df, degrees of freedom; N, number of studies; k, number of experiments. * In-phase tACS effect in experiments using modulation to improve functional outcome; † Anti-phase tACS effect in experiments using modulation to disrupt functional outcome.

Table S12: Summary of results in older adults and clinical populations

Analysis	Hedges' g	CIL	CIU	*df*	*p*	I^2	N	k
Older Adults								
Before outlier removal								
All	0.37	0.121	0.619	10.8	0.008	73.84	12	28
Performance	0.422	0.14	0.704	9.79	0.008	72.99	11	19
RT	0.059	-0.372	0.491	2.95	0.689	56.77	4	9
After outlier removal								
All	0.393	0.166	0.62	10.7	0.003	69.04	12	26
Performance	0.434	0.167	0.701	9.75	0.005	69.88	11	18
Clinical Populations								
Before outlier removal								
Symptoms	0.493	0.462	0.524	2.71	< 0.0001	0	4	11
All (excluding symptoms)	0.475	0.143	0.806	7.66	0.01	54.81	9	27
Performance	0.518	0.11	0.926	6.76	0.02	61.49	8	19
RT	0.244	-0.744	1.23	1.63	0.3	0	3	8
After outlier removal								
All (excluding symptoms)	0.473	0.199	0.748	7.39	0.004	29.06	9	25
Performance	0.467	0.11	0.825	6.66	0.02	51.47	8	18

CIL, 95% confidence interval lower bound; CIU, 95% confidence interval upper bound; df, degrees of freedom; N, number of studies; k, number of experiments; RT, reaction time. Further testing for outlier removal was not performed for RT effects due to low degrees of freedom.