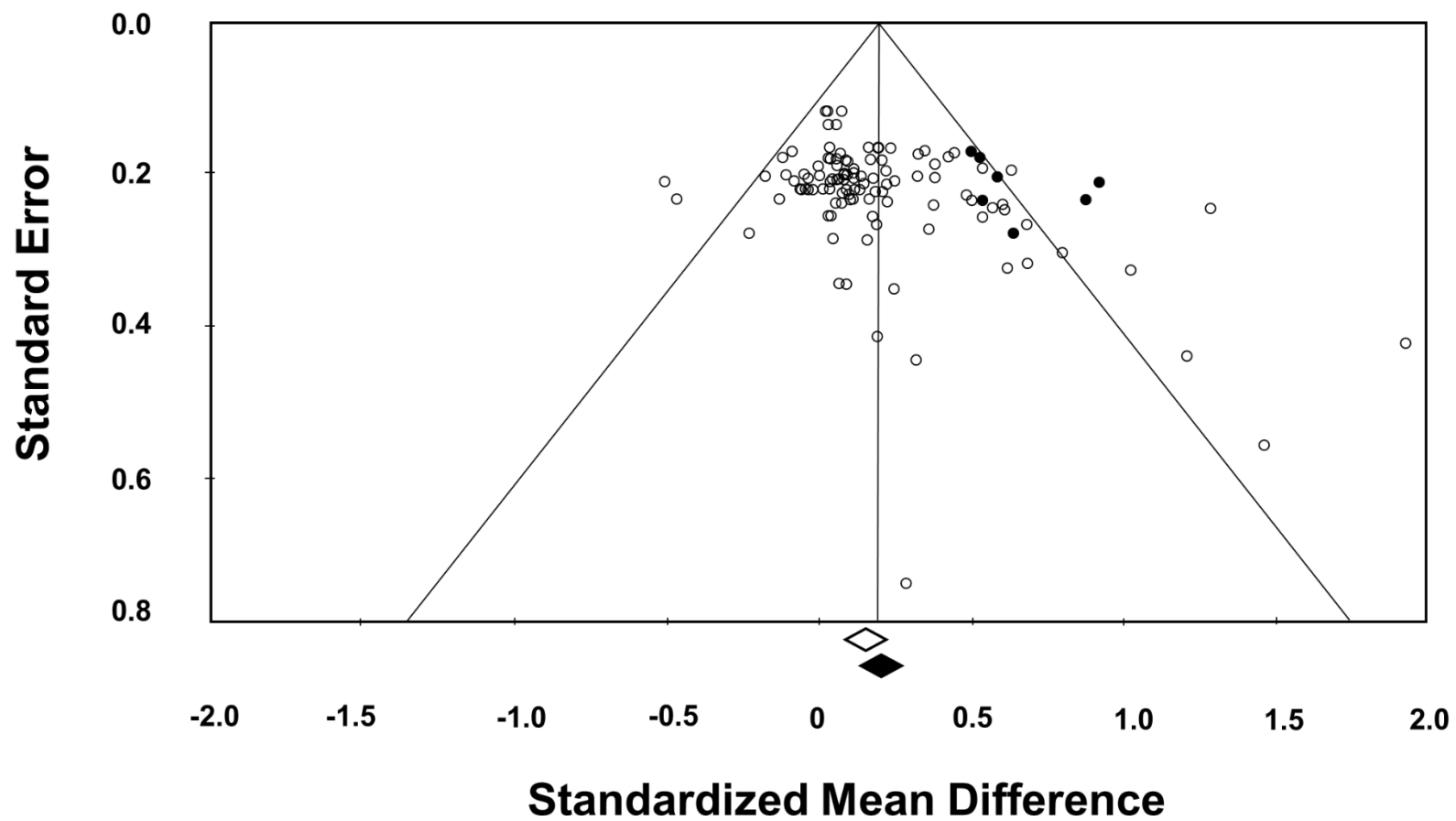
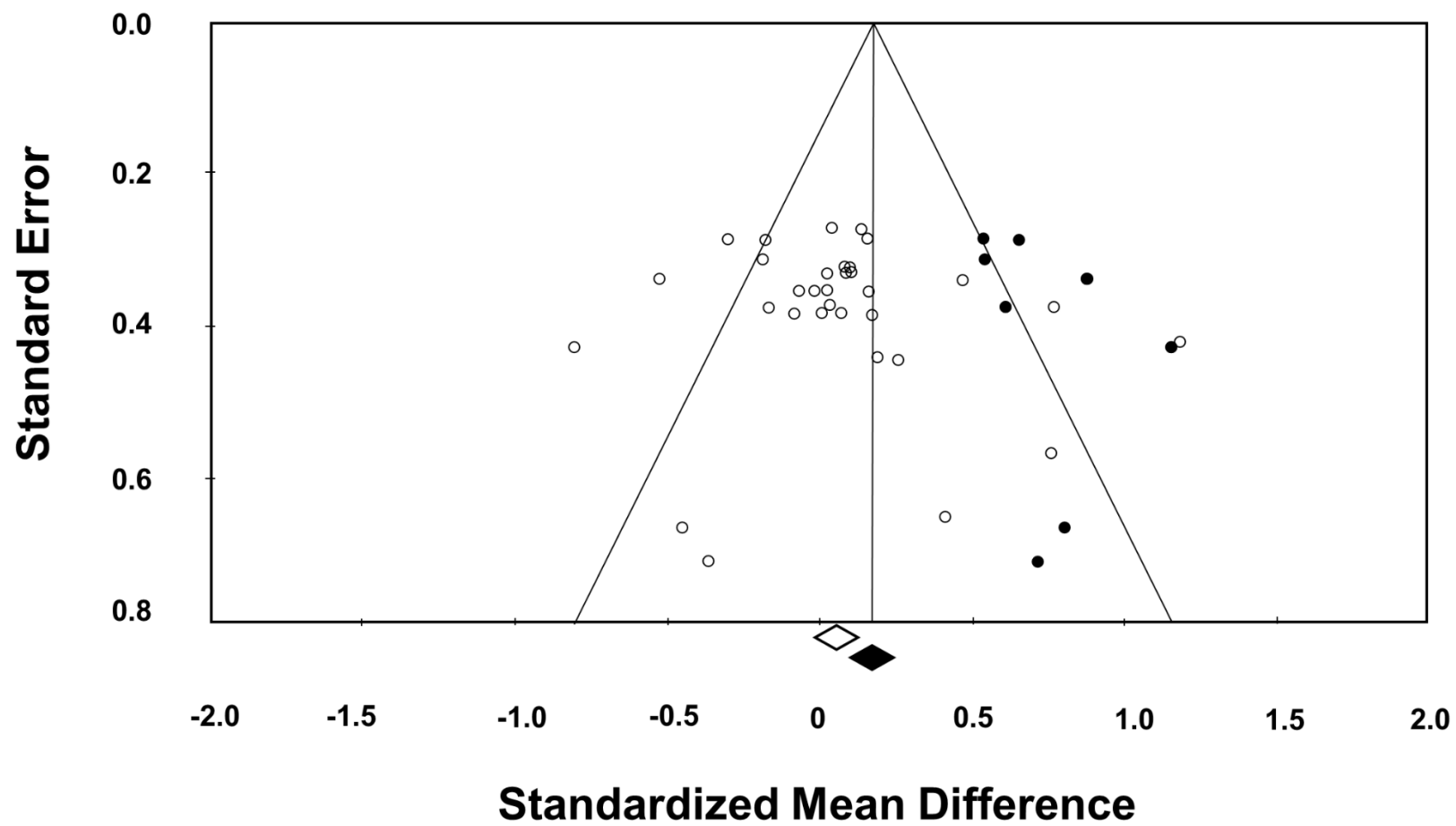
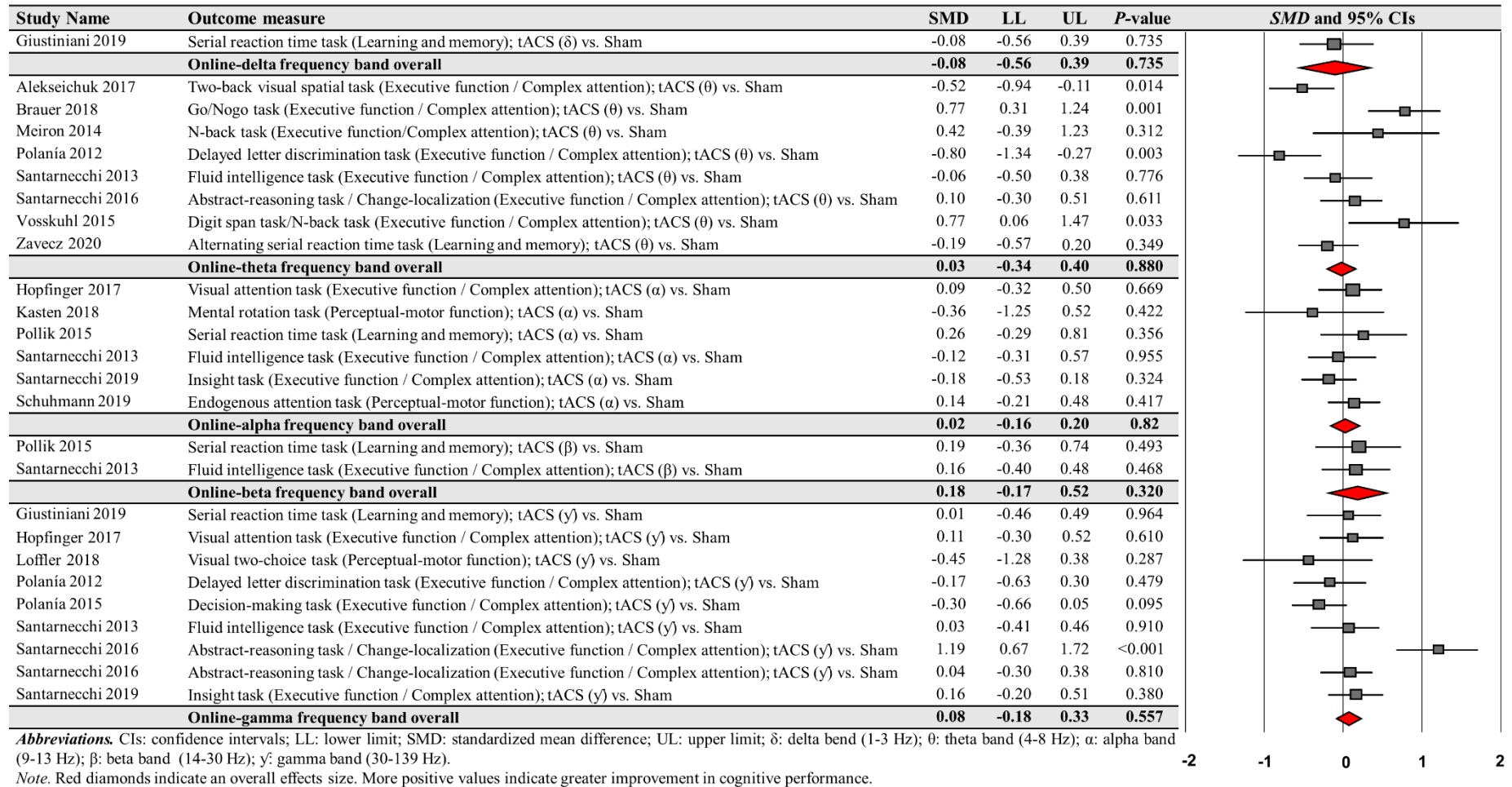




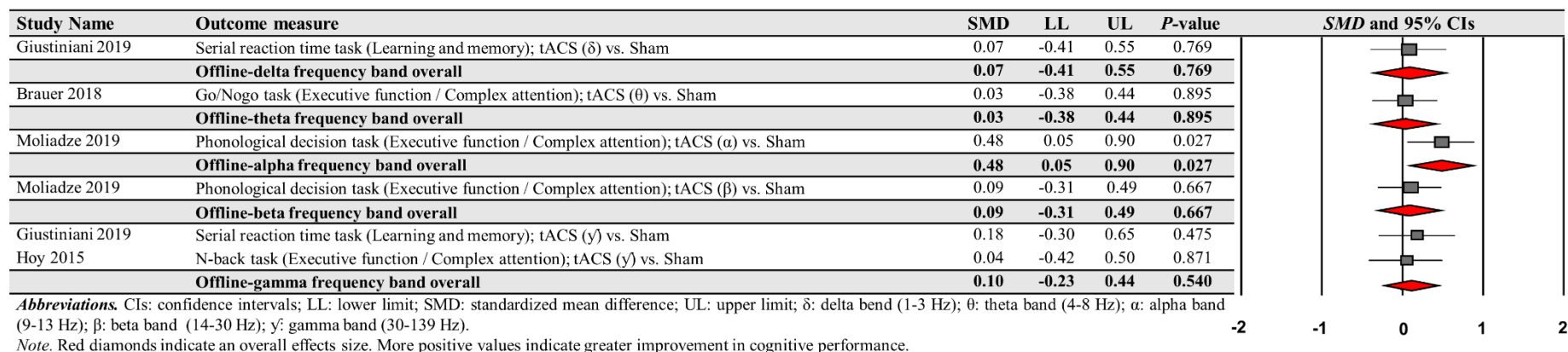
Supplementary Figure 1. A revised funnel plot for the cognitive performance comparisons.



Supplementary Figure 2. A revised funnel plot for the cognition-related reaction time comparisons.



Supplementary Figure 3. Meta-analytic findings for the cognition-related reaction time on online-tACS protocols with specific frequency band comparisons.



Supplementary Figure 4. Meta-analytic findings for the cognition-related reaction time on offline-tACS protocols with specific frequency band comparison

Supplementary Table 1. Side effect information for participants.

Study	Presence of Side Effect	Total # of Participant	# of Participants with Side effects	Specific Side effects
Alekseichuk (2017) ⁵²	Not reported	25	—	—
Alekseichuk (2020) ⁸⁴	No	25	—	—
Ambrus (2015) ⁵³	Not reported	18	—	—
Antonenko (2016) ⁵⁴	Yes	12	12	Pain, tingling, itching, burning, tiredness, and loss of concentration
Brauer (2018) ⁵⁵	Yes	23	Exact number is not available	Tingling, itching, flickering, burning, pain, headache, fatigue, and loss of concentration
Braun (2017) ⁸⁵	Yes	Exp 1) 36 Exp 2) 36	36	Phosphenes
Brignani (2013) ⁵⁶	Yes	96	61	Itching and pinch
Deng (2019) ⁸⁶	Not reported	Exp 1) 20 Exp 2) 18	—	—
Feurra (2016) ⁴⁵	No	14	—	—
Fusco (2018) ⁵⁷	Yes	36	Exact number is not available	Itching, tingling, prickling, heat, burning, and flickering
Giustiniani (2019) ⁵⁸	No	17	—	—
Grabner (2018) ⁸⁷	Yes	22	22	Discomfort
Gutteling (2017) ⁸⁸	Yes	22	Exact number is not available	Tingling*
Hopfner (2017) ⁸⁹	No	23	—	—
Hoy (2015) ⁵⁹	Not reported	18	—	—
Janik (2015) ⁶⁰	Not reported	22	—	—
Jaušovec (2014, BP) ⁶¹	Not reported	24	—	—
Jaušovec (2014, AP) ⁶²	Not reported	36	—	—
Javadi (2017) ⁹⁰	Not reported	17	—	—
Kasten (2018) ⁹¹	Not reported	20	—	—
Laczó (2012) ⁹²	Yes	20	2	Headache
Lang (2019) ⁶³	Yes	37	Exact number is not available	Tingling, burning, and discomfort
Löffler (2018) ⁶⁴	Yes	23	23	tiring and difficulty to concentration
Luft (2018) ⁶⁵	Not reported	Exp 1) 29 Exp 2) 36	—	—
Lustenberger (2015) ⁶⁶	Yes	Exp 1) 19 Exp 2) 20	39	Flickering
Marchesotti (2020) ⁶⁷	Yes	15	Exact number is not available	Pain, warming, tingling and anxiety, fatigue, and difficulty to concentration
Meier (2019) ⁶⁸	No	26	—	—
Meiron (2014) ⁶⁹	No	24	—	—
Meng (2021) ⁷⁰	Yes	18	1	Discomfort

Abbreviations. AP: published in the Acta Psychologica; BP: published in the Biological Psychology; Exp: experiment. Note. Asterisk (*) indicates that side effects appeared at the initial stimulation and disappeared during experiments.

Supplementary Table 1. Side effect information for participants (Continued).

Study	Presence of Side Effect	Total # of Participant	# of Participants with Side effects	Specific Side effects
Moliadze (2019) ⁹³	Yes	24	24	Tiredness, itching, flickering, concentration problems, headache, and shock-like sensations
Neubauer (2017) ⁹⁴	Not reported	20	—	Not reported
Nomura (2019) ⁷¹	No	36	—	—
Pahor (2014) ⁷²	Not reported	28	—	—
Pahor (2016) ⁹⁵	Not reported	18	—	—
Polanía (2012) ⁷³	Yes	36	36	Itching*
Polanía (2015) ⁷⁴	Not reported	86	—	—
Pollok (2015) ⁷⁵	Yes	13	11	Itching, tingling, and flickering
Reinhart (2017) ⁹⁶	Not reported	Exp 1) 30 Exp 2) 30 Exp 3) 30	—	—
Riecke (2015) ⁹⁷	Not reported	20	—	—
Riecke (2018) ⁹⁸	Not reported	20	—	—
Santaracchi (2013) ⁷⁶	Yes	20	4	Tingling* and flickering
Santaracchi (2016) ⁷⁷	Yes	Exp 1) 24 Exp 2) 34	2	Tingling* and flickering
Santaracchi (2019) ⁷⁸	Not reported	31	—	—
Schuhmann (2019) ⁷⁹	Not reported	34	—	—
Sela (2012) ⁸⁰	Yes	27	Exact number is not available	Itching*
Strüber (2014) ⁹⁹	No	Exp 1) 17 Exp 2) 13 Exp 3) 15	—	—
Tseng (2016) ¹⁰⁰	No	Exp 1) 20 Exp 2) 20	—	—
Tseng (2018) ¹⁰¹	No	Exp 1) 24 Exp 2) 24	—	—
Violante (2017) ⁸¹	No	10	—	—
Vosskuhl (2015) ⁴⁶	Not reported	33	—	—
Wischnewski (2016) ⁸²	Yes	50	7	Itching*
Wöstmann (2018) ¹⁰²	Yes	20	20	Tingling, difficulty in concentration, and tiredness
Wynn (2020) ⁸³	Yes	54	13	Tingling, itching, dizziness, and headache
Zavec (2020) ¹⁰³	Not reported	26	—	—
Zoefel (2018) ¹⁰⁴	Yes	17	Exact number is not available	Not reported
Zoefel (2020) ¹⁰⁵	Not reported	Exp 1) 27 Exp 2) 19	—	—

Abbreviations. AP: published in the Acta Psychologica; BP: published in the Biological Psychology; Exp: experiment. Note. Asterisk (*) indicates that side effects appeared at the initial stimulation and disappeared during experiments.

Supplementary Table 2. Online-tACS and cognitive performances for different targeted brain regions.

Comparison Name	Comparison Number	SMD	SE	LL	UL	Z-score	P-values
Delta frequency band							
PFC	1	0.447	0.175	0.104	0.790	2.557	0.011
TC	3	0.061	0.118	-0.170	0.292	0.516	0.606
Theta frequency band							
TC	2	0.102	0.159	-0.209	0.414	0.644	0.519
Multi	2	-0.140	0.364	-0.854	0.575	-0.383	0.702
Alpha frequency band							
PFC	5	0.013	0.092	-0.048	0.314	1.443	0.149
PPC	7	-0.037	0.089	-0.212	0.138	-0.415	0.678
TC	2	0.093	0.146	-0.193	0.380	0.638	0.523
Multi	1	-0.040	0.224	-0.478	0.399	-0.178	0.859
Beta frequency band							
PFC	3	0.107	0.105	-0.098	0.312	1.024	0.306
PPC	2	0.459	0.538	-0.595	1.514	0.854	0.393
Gamma frequency band							
PFC	10	0.108	0.066	-0.022	0.237	1.633	0.102
TC	1	0.636	0.197	0.250	1.022	3.229	0.001
Multi	5	0.184	0.094	0.000	0.367	1.963	0.050

Abbreviations. LL: lower limb; Multi: multiple regions; PFC: prefrontal cortex; PPC: posterior parietal cortex; SE: standard error; SMD: standardized mean difference, TC: temporal cortex; UL: upper limb.

Supplementary Table 3. Online-tACS and cognitive performances for different cognitive domains.

Comparison Name	Comparison Number	SMD	SE	LL	UL	Z-score	P-values
Delta frequency band							
Executive function / complex attention	4	0.178	0.106	-0.030	0.387	1.675	0.094
Theta frequency band							
Perceptual-motor function	5	0.048	0.105	-0.157	0.254	0.463	0.644
Learning and memory	4	0.202	0.170	-0.007	0.411	1.892	0.059
Alpha frequency band							
Perceptual-motor function	3	-0.032	0.141	-0.308	0.243	-0.229	0.819
Learning and memory	1	0.059	0.136	-0.208	0.326	0.436	0.663
Executive function / complex attention	11	0.058	0.069	-0.078	0.193	0.837	0.403
Beta frequency band							
Perceptual-motor function	1	-0.048	0.204	-0.448	0.352	-0.236	0.814
Executive function / complex attention	4	0.255	0.165	-0.068	0.579	1.546	0.122

Abbreviations. LL: lower limb; SE: standard error; SMD: standardized mean difference, UL: upper limb.

Supplementary Table 4. Offline-tACS and cognitive performances for different targeted brain regions.

Comparison Name	Comparison Number	SMD	SE	LL	UL	Z-score	P-values
Theta frequency band							
PPC	6	0.179	0.106	-0.029	0.387	1.689	0.091
TC	1	0.572	0.247	0.087	1.057	2.310	0.021
Alpha frequency band							
PFC	2	0.131	0.155	-0.173	0.435	0.845	0.398
PPC	1	-0.055	0.224	-0.493	0.384	-0.244	0.807
TC	1	-0.047	0.236	-0.509	0.415	-0.200	0.842
Beta frequency band							
PPC	1	0.077	0.204	-0.324	0.478	0.377	0.706
Gamma frequency band							
PFC	3	0.066	0.143	-0.213	0.345	0.463	0.644
TC	1	0.041	0.258	-0.465	0.547	0.158	0.874

Abbreviations. LL: lower limb; PFC: prefrontal cortex; PPC: posterior parietal cortex; SE: standard error; SMD: standardized mean difference, TC: temporal cortex; UL: upper limb.

Supplementary Table 5. Offline-tACS and cognitive performances for different targeted brain regions.

Comparison Name	Comparison Number	SMD	SE	LL	UL	Z-score	P-values
Theta frequency band							
Perceptual-motor function	2	0.335	0.231	-0.119	0.788	1.446	0.148
Learning and memory	1	0.162	0.291	-0.408	0.731	0.557	0.577
Alpha frequency band							
Executive function / complex attention	4	0.044	0.112	-0.175	0.264	0.394	0.693
Beta frequency band							
Executive function / complex attention	1	0.077	0.204	-0.324	0.478	0.377	0.706
Gamma frequency band							
Learning and memory	1	0.288	0.747	-1.176	1.751	0.385	0.700
Executive function / complex attention	3	0.054	0.127	-0.195	0.302	0.423	0.672

Abbreviations. LL: lower limb; SE: standard error; SMD: standardized mean difference, UL: upper limb.

Supplementary Table 6. Online-tACS and cognition-related reaction time for different targeted brain regions.

Comparison Name	Comparison Number	SMD	SE	LL	UL	Z-score	P-values
Delta frequency band							
PFC	1	-0.082	0.243	-0.558	0.394	-0.338	0.735
Theta frequency band							
PPC	4	0.285	0.201	-0.109	0.679	1.418	0.156
Multi	4	-0.233	0.268	-0.758	0.292	-0.869	0.385
Alpha frequency band							
PFC	2	0.093	0.175	-0.251	0.436	0.530	0.596
PPC	4	-0.005	0.104	-0.210	0.199	-0.05	0.960
Beta frequency band							
PPC	2	0.175	0.175	-0.169	0.518	0.995	0.320
Gamma frequency band							
PFC	4	0.297	0.256	-0.204	0.799	1.162	0.245
PPC	2	-0.050	0.250	-0.541	0.440	-0.201	0.841
TC	1	0.159	0.181	-0.196	0.513	0.878	0.380
Multi	2	-0.253	0.144	-0.534	0.029	-1.757	0.079

Abbreviations. LL: lower limb; Multi: multiple regions; PFC: prefrontal cortex; PPC: posterior parietal cortex; SE: standard error; SMD: standardized mean difference, TC: temporal cortex; UL: upper limb.

Supplementary Table 7. Online-tACS and cognition-related reaction time for different cognitive domains.

Comparison Name	Comparison Number	SMD	SE	LL	UL	Z-score	P-values
Delta frequency band							
Learning and memory	1	-0.082	0.243	-0.558	0.394	-0.338	0.735
Theta frequency band							
Learning and memory	1	-0.186	0.198	-0.574	0.201	-0.943	0.346
Executive function / complex attention	7	0.068	0.224	-0.370	0.507	0.305	0.760
Alpha frequency band							
Perceptual-motor function	2	0.062	0.182	-0.295	0.419	0.339	0.735
Learning and memory	1	0.260	0.282	-0.292	0.813	0.923	0.356
Executive function / complex attention	3	-0.050	0.117	-0.279	0.179	-0.427	0.669
Beta frequency band							
Learning and memory	1	0.192	0.280	-0.357	0.740	0.685	0.493
Executive function / complex attention	1	0.163	0.225	-0.278	0.605	0.726	0.468
Gamma frequency band							
Perceptual-motor function	1	-0.450	0.423	-1.278	0.379	-1.064	0.287
Learning and memory	1	0.011	0.243	-0.464	0.486	0.045	0.964
Executive function / complex attention	7	0.127	0.153	-0.173	0.427	0.829	0.407

Abbreviations. LL: lower limb; SE: standard error; SMD: standardized mean difference, UL: upper limb.

Supplementary Table 8. Offline-tACS and cognition-related reaction time for different brain regions.

Comparison Name	Comparison Number	SMD	SE	LL	UL	Z-score	P-values
Delta frequency band							
PFC	1	0.071	0.243	-0.405	0.547	0.294	0.769
Theta frequency band							
PFC	1	0.028	0.209	-0.381	0.436	0.133	0.895
Alpha frequency band							
PFC	1	0.475	0.215	0.053	0.897	2.208	0.027
Beta frequency band							
PFC	1	0.088	0.205	-0.313	0.489	0.431	0.667
Gamma frequency band							
PFC	2	0.104	0.170	-0.229	0.437	0.613	0.540

Abbreviations. LL: lower limb; PFC: prefrontal cortex; PPC: posterior parietal cortex; SE: standard error; SMD: standardized mean difference, UL: upper limb.

Supplementary Table 9. Offline-tACS and cognition-related reaction time for different cognitive domains.

Comparison Name	Comparison Number	SMD	SE	LL	UL	Z-score	P-values
Delta frequency band							
Learning and memory	1	0.071	0.243	-0.405	0.547	0.294	0.769
Theta frequency band							
Executive function / complex attention	1	0.028	0.209	-0.381	0.436	0.133	0.895
Alpha frequency band							
Executive function / complex attention	1	0.475	0.215	0.053	0.897	2.208	0.027
Beta frequency band							
Executive function / complex attention	1	0.088	0.205	-0.313	0.489	0.431	0.667
Gamma frequency band							
Learning and memory	1	0.175	0.244	-0.304	0.653	0.714	0.475
Executive function / complex attention	1	0.038	0.236	-0.424	0.500	0.162	0.871

Abbreviations. LL: lower limb; SE: standard error; SMD: standardized mean difference, UL: upper limb.