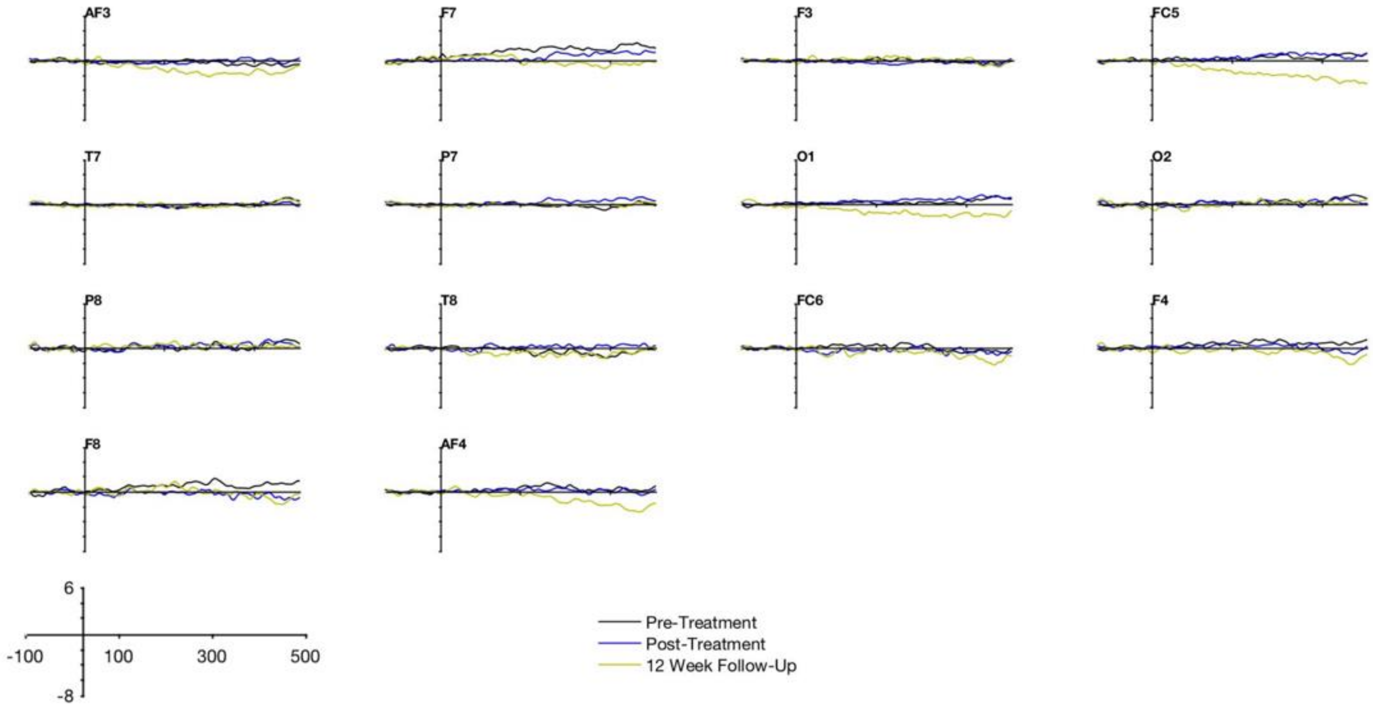
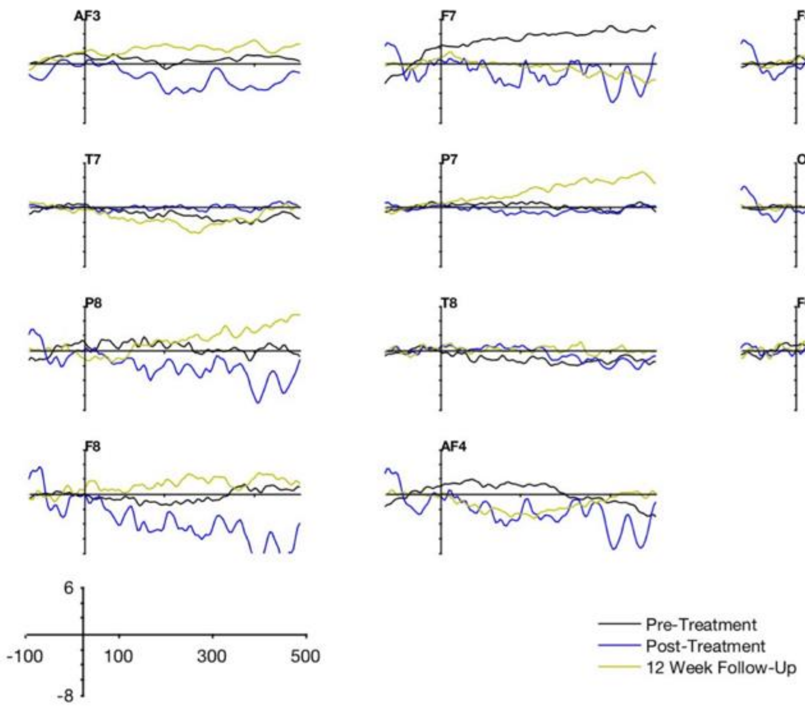
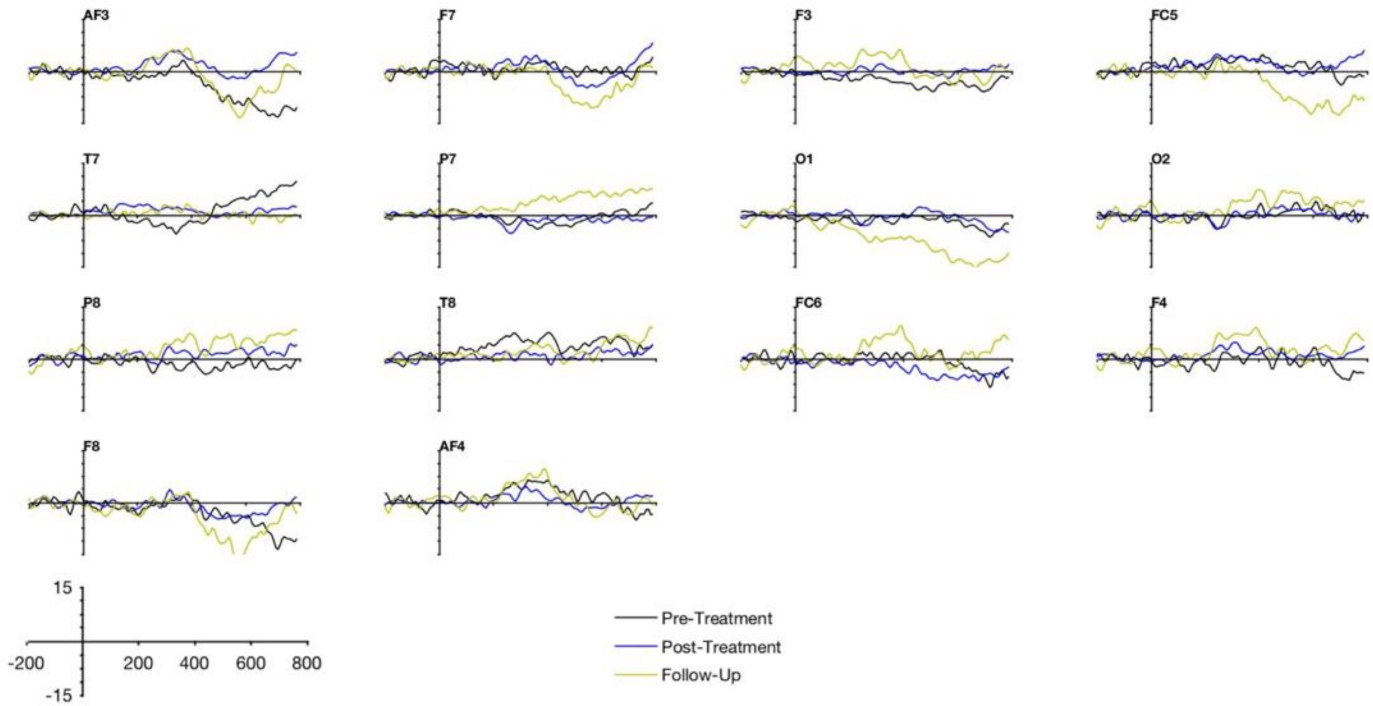
Supplementary Figure 1: Mismatch Negativity by Electrode Site in the Executive Training Condition



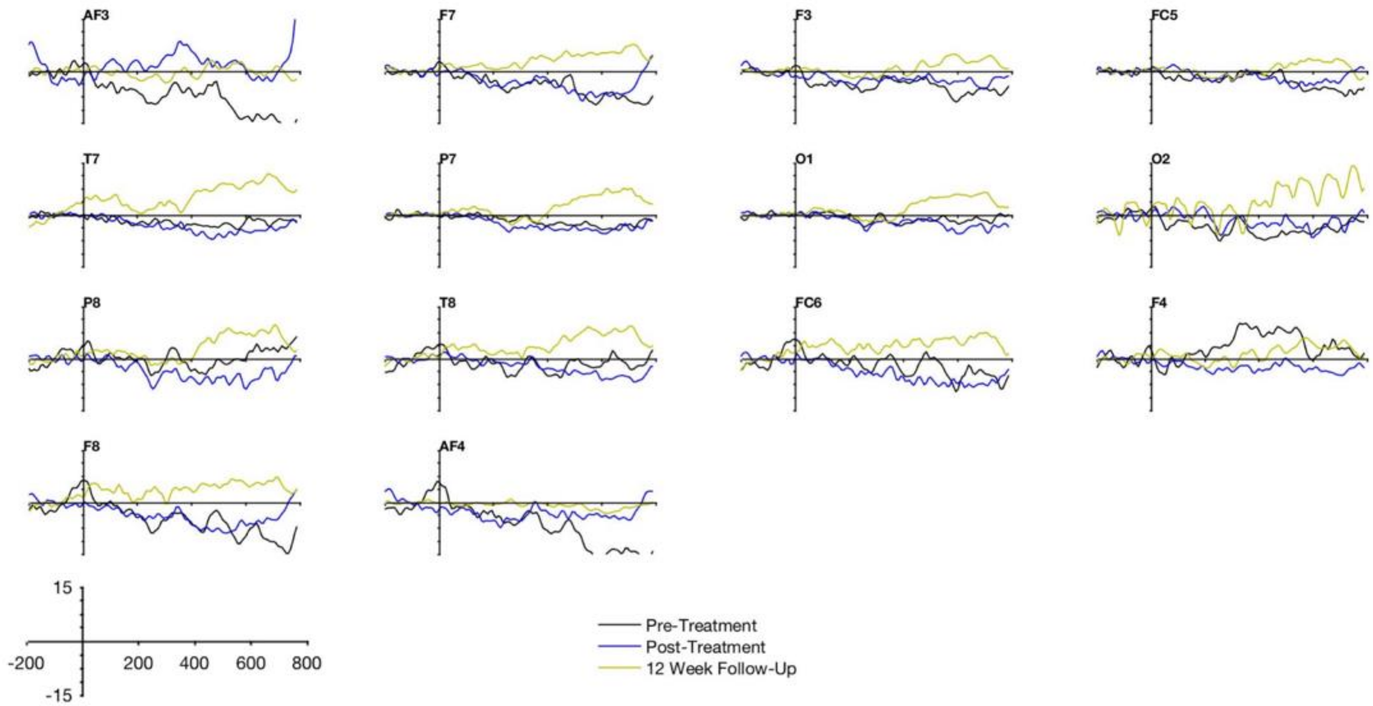
Supplementary Figure 2: Mismatch Negativity by Electrode Site in the Perceptual Training Condition



Supplementary Figure 3: P300 by Electrode Site in the Executive Training Condition



Supplementary Figure 4: P300 by Electrode Site in the Perceptual Training Condition.



Supplementary Table 1: Medication Use by Time and Treatment Condition

	Baseline				Post-Treatment				12 Weeks Post-Treatment			
	Executive Training	Perceptual Training	χ^2	p	Executive Training	Perceptual Training	χ^2	p	Executive Training	Perceptual Training	χ^2	p
First-Generation Antipsychotic	6.7%	7.4%	0.01	.913	4.3%	11.8%	0.78	.379	9.5%	13.3%	0.13	.720
Atypical Antipsychotic	90.0%	88.9%	0.02	.891	91.3%	88.2%	0.10	.749	90.5%	73.3%	1.85	.174
Mood Stabilizer	16.7%	14.8%	0.36	.547	13.0%	23.5%	0.16	.687	14.3%	13.3%	0.01	.935
Benzodiazepine	23.3%	22.2%	0.01	.920	17.4%	11.8%	0.24	.622	23.8%	20.0%	0.07	.786
Antidepressant	36.7%	29.6%	0.32	.574	34.8%	23.5%	0.59	.443	33.3%	40.0%	0.17	.681

Supplementary Table 2: Raw data of neurocognitive and functional competence tests at baseline by treatment condition.

	Executive Training		Perceptual Training	
	Mean	Standard Deviation	Mean	Standard Deviation
Hopkins Verbal Learning Test - Learning	20.34	5.55	21.23	5.53
Hopkins Verbal Learning Test - Recall	6.71	3.03	6.88	2.71
Brief Visual Memory Test - Learning	16.85	8.05	18.14	8.80
Brief Visual Memory Test - Recall	7.05	3.40	7.14	3.43
Trail Making Test A	41.97	32.22	33.61	16.02
Trail Making Test B	127.22	84.26	121.03	80.27
Spatial Span Test	13.77	4.74	14.11	4.51
Digit Symbol Coding	40.37	15.74	40.97	12.35
Letter Number Sequencing	11.65	3.53	10.85	5.01
Verbal Fluency	19.40	5.87	18.97	4.78
Delis-Kaplan Towers Test	14.82	5.04	14.64	4.77
Continuous Performance Test	1.96	0.88	1.83	0.84
Canadian Assessment of Life Skills – Time Management (Range 0 – 20)	15.12	4.72	14.61	4.96
Canadian Assessment of Life Skills – Domestic Activities (Range 0 – 20)	11.39	5.05	12.35	4.91
Canadian Assessment of Life Skills – Trip Planning (Range 0 – 20)	6.30	3.48	6.12	4.29
Canadian Assessment of Life Skills – Total (Range 0 – 60)	32.81	11.60	33.54	11.31
Canadian Assessment of Life Skills – Procedural Knowledge Routines (Range 0 – 26)	16.81	5.35	18.36	5.49

Canadian Assessment of Life Skills – Executive Operations (Range 0 – 34)	16.00	7.13	15.42	7.08

Supplementary Table 3: Demographic and Clinical Characteristics of Participants who Completed Treatment Compared to Participants who Discontinued Treatment

	Non-Completers		Completers			
	Mean	Standard Deviation	Mean	Standard Deviation	Test Statistic	p
Age	31.92	12.97	40.57	17.32	t = -2.37	**.021**
Gender (%) (Male : Female)	85 : 15		75 : 25		χ^2 = 0.90	.343
Years of Education	12.90	1.48	13.34	2.37	t = -0.95	.346
Current Employment Level⊥	5.73	3.05	7.02	1.76	t = -1.97	.056
Highest Employment Level⊥	4.68	2.17	4.80	2.05	t = -0.22	.825
Living Independently (%)	39.1%	–	54.5%	–	χ^2 = 1.44	.231
Wide Range Achievement Test Total t-score	44.58	5.99	46.55	6.09	t = -1.32	.193
Neurocognitive Composite	-1.17	0.89	-1.18	0.89	t = 0.05	.958
Canadian Objective Assessment of Life Skills						
Total	-1.99	1.87	-2.00	1.91	t = 0.02	.984
Procedural Knowledge Routines	-1.18	1.88	-1.34	1.63	t = 0.35	.727
Executive Operations	-1.92	1.81	-1.67	1.61	t = -0.59	.555
Specific Levels of Functioning Scale	80.53	11.26	83.16	9.41	t = -1.00	.319
Sheehan Disability Scale	47.69	23.11	41.15	24.29	t = 0.85	.399

Generalized Self-Efficacy Scale	2.76	0.62	2.73	0.51	t = 0.18	.857
Cognitive Failures Questionnaire	1.07	2.99	1.76	0.67	t = -0.86	.407
Need for Cognition Scale	3.20	0.43	3.15	0.49	t = 0.33	.743
Intrinsic Motivation Inventory	5.34	0.17	5.65	0.72	t = -0.72	.477
Perceived Competence Scale	6.67	0.58	5.53	1.36	t = 1.43	.162
Brief Psychiatric Rating Scale						
Affect	2.82	1.64	2.72	1.31	t = 0.23	.816
Positive	2.22	1.34	1.71	1.01	t = 1.69	.096
Negative	2.33	1.17	2.58	1.19	t = -0.78	.437
Resistance	1.90	0.84	1.65	0.85	t = 1.09	.281
Activation	1.48	0.69	1.30	0.48	t = 1.22	.228
Mismatch Negativity	0.07	1.10	0.17	1.34	t = -0.30	.763
1-Back Theta Power	3.18	2.35	3.26	2.85	t = -0.11	.913
2-Back Theta Power	3.54	2.18	3.32	2.21	t = 0.37	.710
P300	2.38	3.09	1.87	3.36	t = 0.52	.609
Age of First Hospitalization	20.53	5.18	21.40	8.30	t = -0.39	.698
Total Number of Hospitalizations	5.68	10.42	5.96	15.46	t = -0.07	.944
Total Months Hospitalized	3.93	6.80	20.51	76.96	t = -0.80	.427
Months Since Last Hospitalization	44.45	58.76	102.63	120.88	t = -2.39	**.020**

$^{\perp}$ Meansured using the Hollingshead Occupation Scale

Supplementary Table 4: Supplemental Outcome Measures by Time and Treatment Condition

	Baseline				Post-Treatment						12 Weeks Post-Treatment					
	Executive Training		Perceptual Training		Executive Training		Perceptual Training		Time*Group		Executive Training		Perceptual Training		Time*Group	
	EMM	SD	EMM	SD	EMM	SD	EMM	SD	F	p	EMM	SD	EMM	SD	F	p
Sheehan Disability Scale	45.46	25.60	39.91	25.09	43.52	25.70	33.95	30.18	0.17	.683	34.01	27.38	29.32	32.43	0.00	.971
Generalized Self-Efficacy Scale	2.72	0.53	2.74	0.51	2.78	0.53	2.85	0.56	0.18	.676	2.82	0.53	2.84	0.61	0.08	.775
Cognitive Failures Questionnaire	1.91	1.48	1.24	1.45	1.79	1.48	1.34	1.51	1.90	.176	1.79	1.48	1.18	1.51	0.18	.674
Need for Cognition Scale	3.15	0.47	3.15	0.46	3.05	0.47	3.23	0.56	1.93	.171	3.10	0.53	3.25	0.56	1.12	.296
Brief Psychiatric Rating Scale																
Affect	2.92	1.28	2.59	1.28	2.67	1.39	1.96	1.61	1.51	.225	2.32	1.39	2.08	1.61	0.38	.539
Positive	1.86	1.06	1.88	1.06	2.02	1.11	1.57	1.33	1.73	.195	1.49	1.17	1.49	1.39	0.03	.870
Negative	2.50	1.06	2.52	1.11	1.95	1.17	2.26	1.39	0.83	.367	1.95	1.22	1.96	1.45	0.02	.889
Resistance	1.69	0.78	1.77	0.78	1.64	0.84	1.83	1.00	0.21	.646	1.69	0.89	1.67	1.00	0.00	.998
Activation	1.32	0.45	1.40	0.50	1.27	0.50	1.31	0.61	0.02	.881	1.19	0.56	1.38	0.67	0.24	.626

Supplementary Appendix 1: Description of Perceptual and Executive Training Interventions

The executive training and perceptual training interventions were structurally identical. Each session included practice of computerized exercises (75%) and strategy monitoring using a worksheet and discussion with the therapist (25%). Computer exercises utilized principles of errorless learning and parametrically increased in difficulty as participants' performance improved to maintain approximately 80% accuracy. In the first four sessions, participants were introduced to two new cognitive exercises each session. Participants spent 10 minutes independently practicing the first computer exercise, then spent 5-10 minutes developing strategies. Therapists instructed clients in the completion of strategy development worksheets that guided participants to first identify the strategies they had been using during the computerized exercise, then to brainstorm new strategies they could try, and finally to identify which strategies worked best given different task demands. Therapists facilitated discussion among group members to encourage use of multiple strategies. Participants then completed another 10 minutes of computer practice to test out their new strategies before being introduced to the second computer exercise of the session following the same structure.

The final four sessions focused on consolidation of learning and participants practiced whichever exercises they desired and completed strategy monitoring worksheets twice throughout the session. In addition to training sessions, participants were given access to the computerized exercises and strategy worksheets at home for continued practice.

The only difference between perceptual training and executive training were the cognitive domains targeted by the computerized exercises. Each included an equal number of tasks across the two software.

Interventions were delivered by one of two Ph.D. students in clinical psychology with a minimum of two years cognitive remediation experience and supervised by CRB. Both therapists delivered each intervention. Fidelity was ensured through weekly supervision meetings with a licensed clinical psychologist and review of the duration of computerized cognitive training completed. Homework was tracked using each online training platform, and strategy worksheets completed at home were reviewed prior to the beginning of each session.

Perceptual Training Exercises

Perceptual training utilized four computerized exercises from Happy Neuron (sbtpro.com). *Private Eye* requires participants to search for a target symbol within a grid of distractors. *Ancient Writing* requires participants to quickly identify whether symbols are the same or different. *Sound Check* requires participants to identify sounds based on length, pitch, and volume. *Under Pressure* requires participants to identify whether a target appears above or below a previously shown stimulus on the screen. This group also used four computerized exercises from BrainHQ (brainhq.com). *Visual Sweeps* requires participants to identify whether vertical lines are "sweeping" inwards or outwards; *Divided Attention* requires participants to quickly identify whether two shapes share an identical feature; *Sound Sweeps* requires participants to identify whether brief sounds are rising or falling in pitch. *Fine Tuning* requires participants to visually identify verbally presented syllables.

Executive Training Exercises

Executive training utilized four computerized exercises from Happy Neuron. *Secret Files* requires participants to sort words into superordinate categories and discover the categories through trial and error, holding the category in working memory. *Basketball in New York* requires participants to mentally manipulate a series of basketballs in nets to match a template series of nets. *Hurray for Change* requires participants to connect a series of words and numbers based on increasing alphabetical and numerical order. *You've Got Voicemail* requires participants to listen to a series of voicemail messages and recall relevant information from the messages. This group also used four computerized exercises from BrainHQ. *Auditory Ace* requires participants to hold a series of sounds in memory to determine whether a current sound is the same as a sound presented previously. *Syllable Stacks* requires participants to listen to a series of syllables and recall the order in which they appear. *Card Shark* requires participants to hold a series of playing cards in memory to determine whether a current card matches a card that was presented previously. *Mind Bender* requires participants to respond to two sets of paired stimuli based on different rules.

Supplementary Appendix 2: EEG Recording and Analysis

EEG was recorded using the Emotiv EPOC system (SR1). The Emotiv system consists of a flexible plastic headset with 14 electrode sites corresponding to locations AF3, F7, F3, FC5, T7, P7, O1, O2, P8, T8, FC6, F4, F8, and AF4 in the 10-20 system. EEG data were recorded referenced to two mastoid electrodes (M1 and M2) at a sampling rate of 128 samples/s. EEG data were processed offline using EEGLab (SR2) and the Fully Automated Statistical Thresholding for EEG Artifact Rejection toolbox (FASTER; [SR3]). The signal was high-pass filtered at 0.1 Hz and low pass filtered at 30 Hz. Data were then visually inspected and segments with movement artifacts or signal discontinuities were removed. Data were then cleaned using FASTER, which uses independent component analysis to identify and remove artefactual components from the EEG signal. Independent component analysis is effective at correcting for non-neuronal artifacts (SR4), and FASTER has demonstrated good reliability with manual and semi-automatic cleaning procedures (SR3). After being processed with FASTER, data were visually inspected again to ensure the algorithm was successful at removing artifacts and then re-referenced to an average reference. Any participants with more than 40% unusable data were excluded from the analyses.

For the resting state and n-back tasks, power spectral density was calculated using EEGLAB's spectopo function (SR2), using Welch's method. Each recording was segmented into 1 second epochs with 50% overlap, and a Hamming window was applied prior to calculation of the power spectral density. Theta power was examined in the frequency window of 4.5 – 7.5 Hz.

Theta power fluctuations associated with working memory tasks tend to be greatest over frontal electrode sites (SR5). Therefore, theta power was examined as the average of six frontal electrode sites (AF3, F3, F7, F4, F8. AF4). The limited number of electrode sites of the

EMOTIV headset does not allow for source estimation, and broad estimates of power density are the most appropriate analysis technique.

After pre-processing with FASTER as described above, the mismatch negativity and P300 were analyzed using ERPLAB (SR6). Mismatch negativity data were segmented into 600ms segments beginning 100ms prior to stimulus onset and baseline corrected to the 100ms prior to stimulus onset. P300 data were segmented into 1000ms segments beginning 200ms prior to stimulus onset and baseline corrected to the 200ms prior to stimulus onset. Any segments still containing movement or eye artifacts were excluded from further analyses as were any segments containing more than 20% bad channels. Any participants who had more than 40% of trials excluded were excluded from the analyses. Due to the temporal imprecision of event markers sent using the Emotiv EEG system, both event-related potentials were analyzed as mean amplitude and we were unable to examine event-related potential latency. The mismatch negativity was analyzed as the mean amplitude between 200ms – 300ms post-stimulus onset, and the P300 was analyzed as the mean amplitude between 200ms – 400ms post-stimulus onset. Event-related potential amplitude was averaged over frontal electrode sites (AF3, F3, F7, F4, F8, AF4) for analyses.

Supplementary Appendix 3: Descriptions of EEG tasks

For all EEG tasks E-prime 2.0 was used for stimulus presentation. The n-back is a visual working memory task consisting of a low working memory load task (1-back) and a high working memory load task (2-back). Single-digit numbers were visually presented in a random order fixed for all participants. In the 1-back task participants were asked to respond whenever the number presented was the same as the number presented immediately previously. In the 2-back task, participants were asked to respond whenever they saw a number presented that had been presented two numbers previously – requiring greater working memory resources. Two hundred stimuli were presented in each n-back task for 500ms with a 2500ms inter-stimulus interval during which a fixation cross was presented and participants could respond yes / no as to whether the number was presented *n* numbers previously. Power in the theta frequency band over frontal electrode sites was extracted across each n-back task and resting state theta power was subtracted from active theta power as an index of engagement of neural resources associated with working memory. Greater theta power is associated with greater engagement of working memory-associated resources.

The P300 task was a visual P300 task (SR7) to index visual attention. The letter 'X' and the letter 'O' were presented sequentially and participants were asked to respond when the letter 'X' was presented. There were 300 trials, and the target stimulus (X) was presented on 20% of trials. Stimuli were presented for 100ms with a 1200ms inter-stimulus interval. The P300 was analyzed as the mean amplitude difference between target and non-target stimuli across frontal-midline electrodes between 200ms and 400ms post-stimulus onset. Greater amplitude is associated with a stronger P300 response and indicates better engagement of attentional resources.

The mismatch negativity task (SR8) was used to index auditory perceptual ability. Participants watched a nature documentary video without sound while they listened to a series of tones presented binaurally in noise-cancelling earphones. Standard (50-millisecond duration) tones were presented on 90% of trials and deviant (100-millisecond duration) tones were presented on 10% of trials. The mismatch negativity was analyzed as the mean amplitude difference between deviant and standard trials across frontal electrode sites between 100ms – 300ms post-stimulus onset. Greater negative amplitude is associated with a stronger mismatch negativity response and indicates better auditory perceptual abilities.

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