Supplemental Materials

Resisting Emotional Interference: Brain Regions Facilitating Working Memory Performance During Negative Distraction

Alan Anticevic

Department of Psychology, Washington University in St. Louis

Grega Repovs

Department of Neurology, Washington University in St. Louis

Deanna M. Barch

Department of Psychology, Washington University in St. Louis

List of Supplemental Figures

Supplemental Methods

Permutation Resampling. As noted in the main text, one concern when conducting independent sample t-tests is that the observed difference may have occurred as a consequence of sampling two groups of subjects that show some difference that occurred by chance alone and having nothing to do with the particular independent variable of interest (i.e. task vs. resting state). We employed a permutation resampling approach that allowed us to ascertain if the observed differences (or any other) may have occurred by chance alone when considering the particular samples used. The aim of this computation was to demonstrate that when ignoring the task vs. resting-state split the observed differences occur with a very low likelihood (i.e. random sampling of subjects into two arbitrary groups not reflecting the independent variable of interest does not produce the observed differences). In other words, if the differences we observed between groups were truly due to a specific factor (i.e. task vs. resting-state) then computing a t-test on two pools of 21 subjects that were randomized independently of the factor in question should reveal no differences. Using this approach, we pooled the subjects from both resting-state and task-based functional connectivity samples into one pool of 42 subjects. Next, we randomly drew two groups of 21 subjects each and computed a difference in their amygdala seed-based functional connectivity maps. We carried out this procedure 100 000 times using an in-house Matlab algorithm. In every instance where, for any voxel in the brain, the difference in the task vs. resting-state t-test exceeded the one obtained by random sampling (in either positive or negative direction) the frequency count increased by 1. For instance, if there is a voxel where the difference observed by chance alone never exceeds the difference we obtained when comparing task and resting state then that voxel should receive a count of 100 000. In other words, if by chance alone for a given voxel the difference between two randomly sampled groups never exceeds the one we observed in task-based vs. resting-state functional connectivity difference then that voxel should receive a maximal count of 100 000. Figure S5D shows the results of the permutation sampling. The displayed voxels

exceeded the observed task-rest differences in only 0.1% of the simulations or less (equivalent to $p<0.001$). In addition, these voxels closely match the spatial configuration of differences in task-based vs. resting-state functional connectivity t-test map (Figure S5C). Thus, as also noted in the main text, these additional results strongly suggest that task-based vs. resting-state amygdala functional connectivity differences were not a product of sampling, but instead reflect a difference in the independent variable of interest.

Supplemental Figure Captions

Figure S1. **Functional activation ANOVA Z map.** (A) Results of the 2-way ANOVA [*distracter type* (emotional, neutral, task-related and no distracter) x *time* (15 frames)] interaction are shown. Cortical foci corresponding closely to the ones reported by Dolcos and colleagues (2006) are marked with black border outlines. All activations shown had to pass a whole-brain $p<0.05$ corrected ($Z>3$, $p<0.0015$ and a cluster size of at least 13 contiguous voxels).

Figure S2. **Group-based anatomical amygdala ROIs.** Binary bilateral anatomical amygdala ROIs derived from the current sample are shown, which were used to mask out amygdala-specific activation from the ANOVA map and extract per subject average signal used for individual difference analyses (see Method Section in main text for more details).

Figure S3. **Task-evoked and performance-related time courses for left lateral prefrontal cortical foci.** Event related time courses are shown for left (A) anterior prefrontal cortex, (B) dorso-lateral prefrontal cortex, and (C) ventro-lateral prefrontal cortex. The far left set of graphs show task-evoked signal for neutral (gray), emotional (red), task-related (green) and no distracter (black) conditions across the three ROIs. The middle panel shows performance-related time courses for the emotional condition. The far right panel shows performance-related time courses for the neutral condition. Correct and incorrect time courses are shown in blue and red respectively. Distracter onset is marked with a dotted vertical line ending in an arrow.

Figure S4. **Posterior cortical foci showing activation differences in response to various distracter types.** (A) Left and (B) right parietal cortex ROI as well as (C) left and (D) right inferior occipital regions corresponding closely to those reported in prior studies (Dolcos et al., 2006). Task-evoked signal is shown for neutral (gray), emotional (red), task-related (green) and no distracter (black) conditions.

Figure S5. **Amygdala resting-state and task-based functional connectivity with permutation resampling.** We show bilateral amygdala functional connectivity during (A) resting-state; (B) WM faced with emotional distraction and (C) t-test results comparing functional connectivity during resting-state vs. functional connectivity during emotional distraction. Blue and yellow colors mark regions showing more negative and positive coupling with amygdala respectively. All maps shown in A-C show whole-brain $p<0.05$ corrected results ($Z>3$, $p<0.0015$ & 3 contiguous voxels); (D) Maps show results of permutation resampling thresholded at $p<0.001$, showing regions that exceeded the task-rest difference in 0.1% or less of the random resamplings. The resampling results closely match differences observed in panel C, suggesting that the task-rest t-test differences are unlikely to have occurred by any random splitting of the subjects from task and resting-state samples; (E) Maps show results of a t-test directly comparing emotional vs. neutral condition amygdala trial-based functional connectivity following distracter presentation (average of frames 8 & 9). Yellow and blue colors respectively show regions that were more positively and negatively coupled with amygdala during emotional vs. neutral distraction. Results are presented for qualitative inspection at a lower threshold ($Z>2.5$, $p<0.0065$). Qualitatively, the map shown in panel E shows striking similarity to those showing task-rest differences (panel C), indicating that the amygdala task-rest functional connectivity differences may indeed be specific to emotional distraction. (F) Foci from emotional vs. neutral task-based amygdala functional

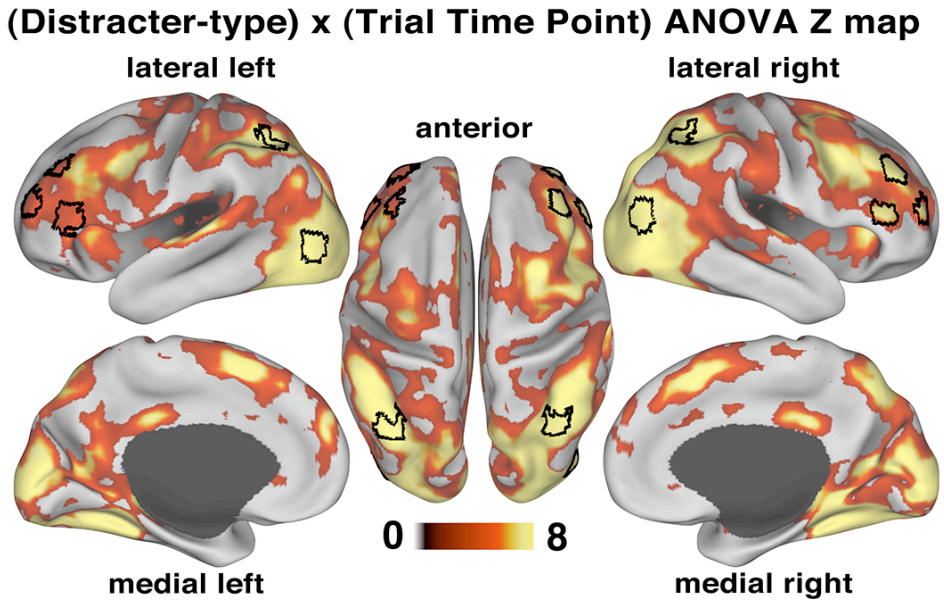
connectivity results meeting a whole-brain p<0.05 correction (i.e. Z>3, p<0.0015 & 13 contiguous voxels) also match prefrontal foci showing task-rest amygdala fcMRI differences.

Figure S6. **Individual differences in working memory performance as a function of prefrontal and amygdala signal computed on activity during accurate trials only.** Average WM performance (% correct) is shown as a function of average signal in PFC and amygdala ROIs computed on correct trials only. (A-C) aPFC ROI is shown for negative [r=-0.57, p=0.005, two-tailed], neutral [r=-0.09, NS] and task-related distracter [r=-0.08, NS] conditions; (D-F) DLPFC ROI is shown for negative [r=-0.64, p=0.002, two-tailed], neutral [r=-0.28, NS] and task-related distracter [r=-0.38, NS] conditions; (G-I) VLPFC ROI is shown for negative [r=-0.18, NS], neutral [r=-0.30, NS] and task-related distracter [r=-0.25, NS] conditions; (J-L) Bilateral amygdala is shown for negative [r=-0.30, NS], neutral [r=-0.47, p<0.035, two-tailed] and task-related distracter [r=-0.54, p<0.015, two-tailed] conditions. As in the main text, results are collapsed across low and high WM load given a similar same pattern at both loads.

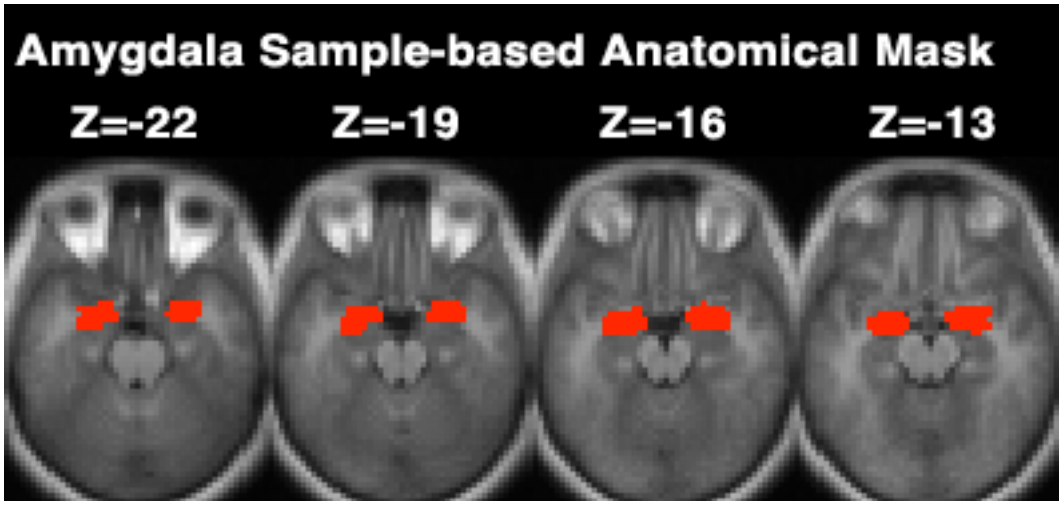
Figure S7. **Out-of-scanner behavioral results with distracter-free trials blocked.** Mean accuracy (expressed as % correct) is shown for task-related, emotional, neutral distracter conditions as well as distracter-free trials across two load levels (high load = 3 shapes, low load= 2 shapes). Results are shown for the out-of-scanner sample (N=25), which completed a version of the task where distracter-free trials were presented in a blocked fashion separately from the other distracter trials rather than being intermixed (as in the main text). Importantly, all the stimuli were identical to the ones used in the fMRI sample. In contrast to the mixed presentation, when subjects performed the blocked version of the task their performance on distracter-free was substantially better. Error bars represent +/- 1 standard error of the mean.

Table S1. **List of all ROIs showing activation differences in response to emotional versus neutral distraction.** The functional activation map was partitioned and each ROI was examined for differences in activation in response to emotional and neutral distracters. The table shows the complete list of ROIs showing activation differences between neutral and emotional distracters that exceeded the p<0.01 level. The corresponding t and p values are shown for each ROI.

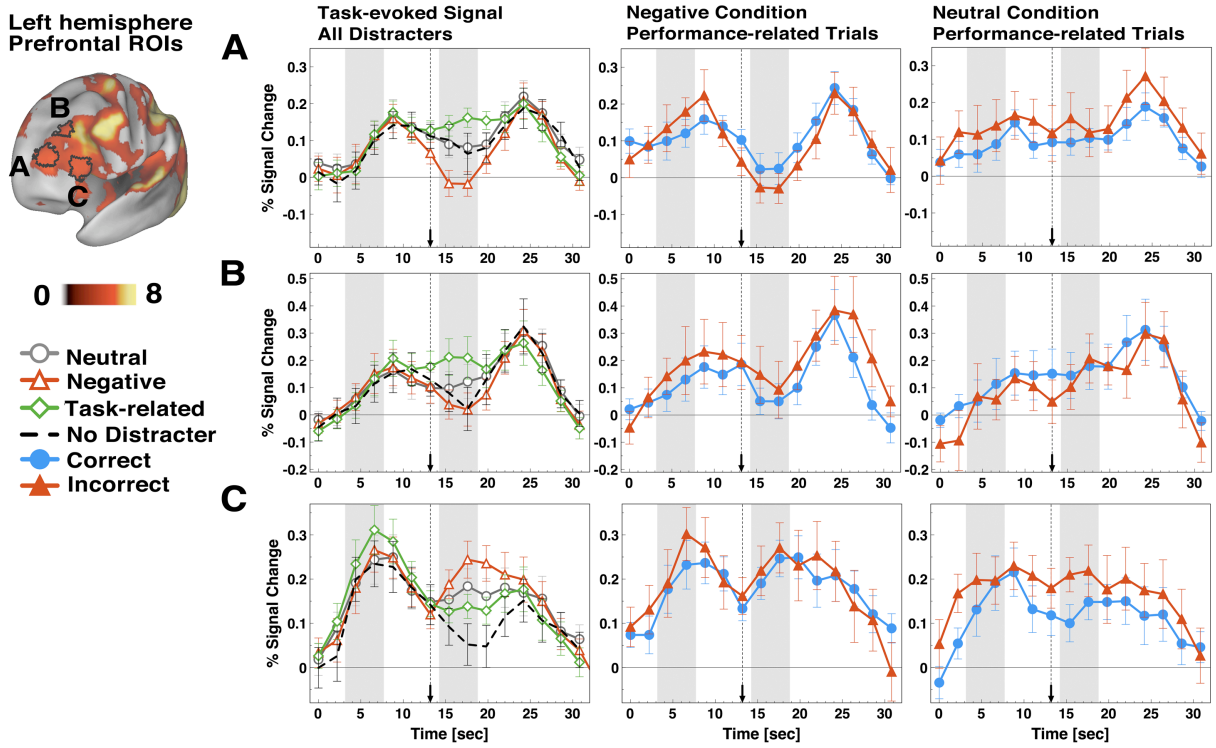
Supplemental Figure S1.



Supplemental Figure S2.



Supplemental Figure S3.



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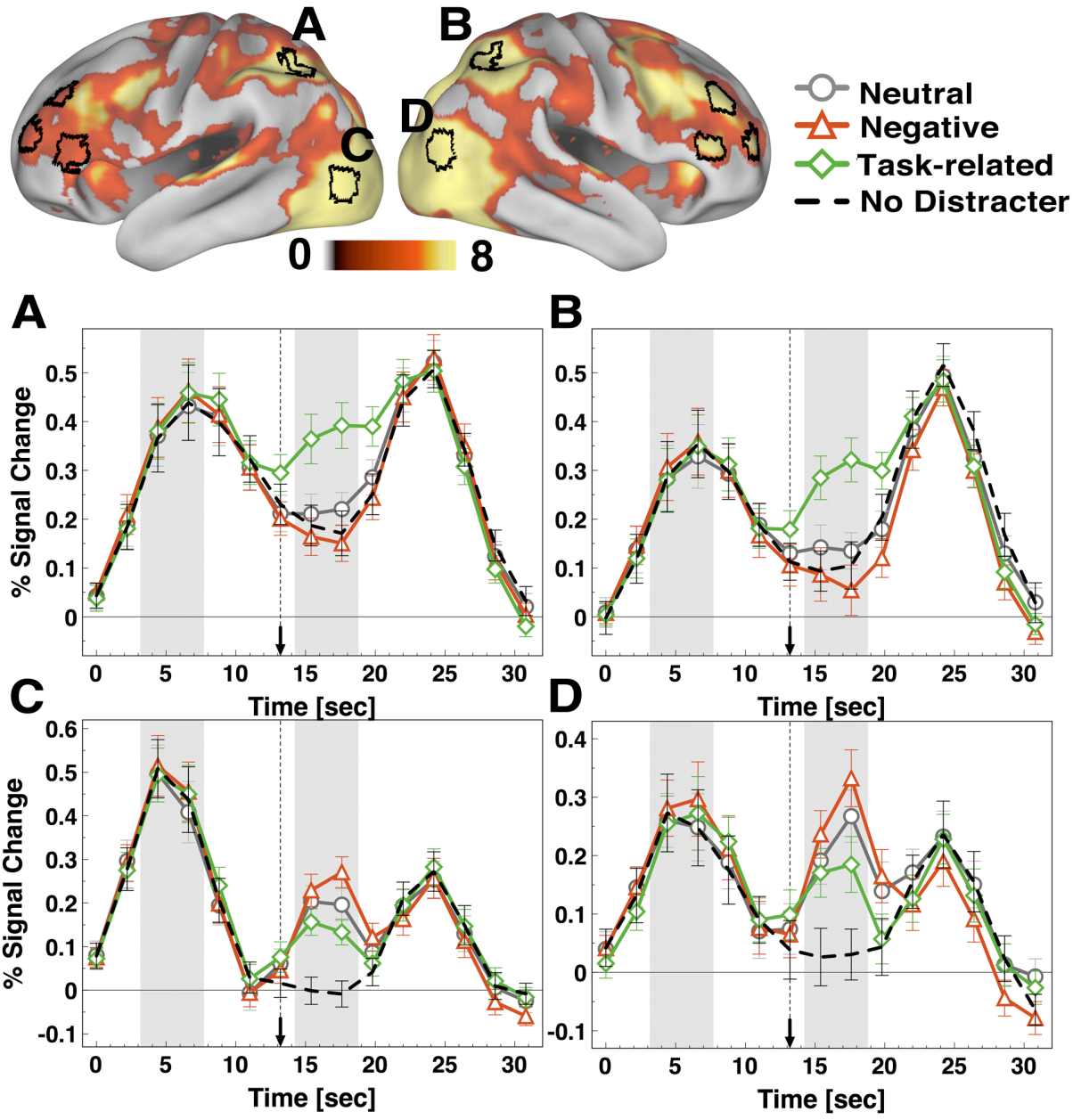

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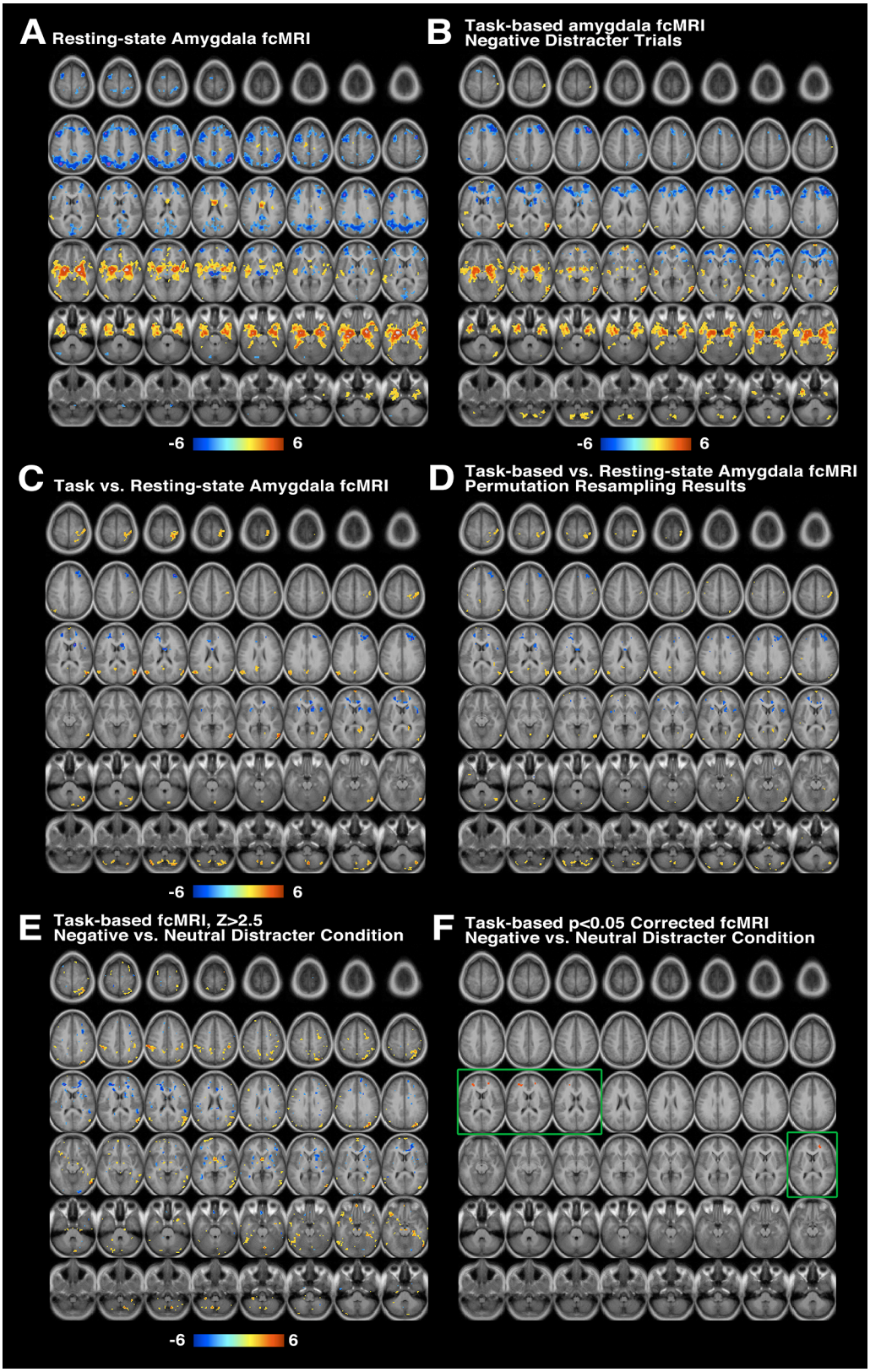

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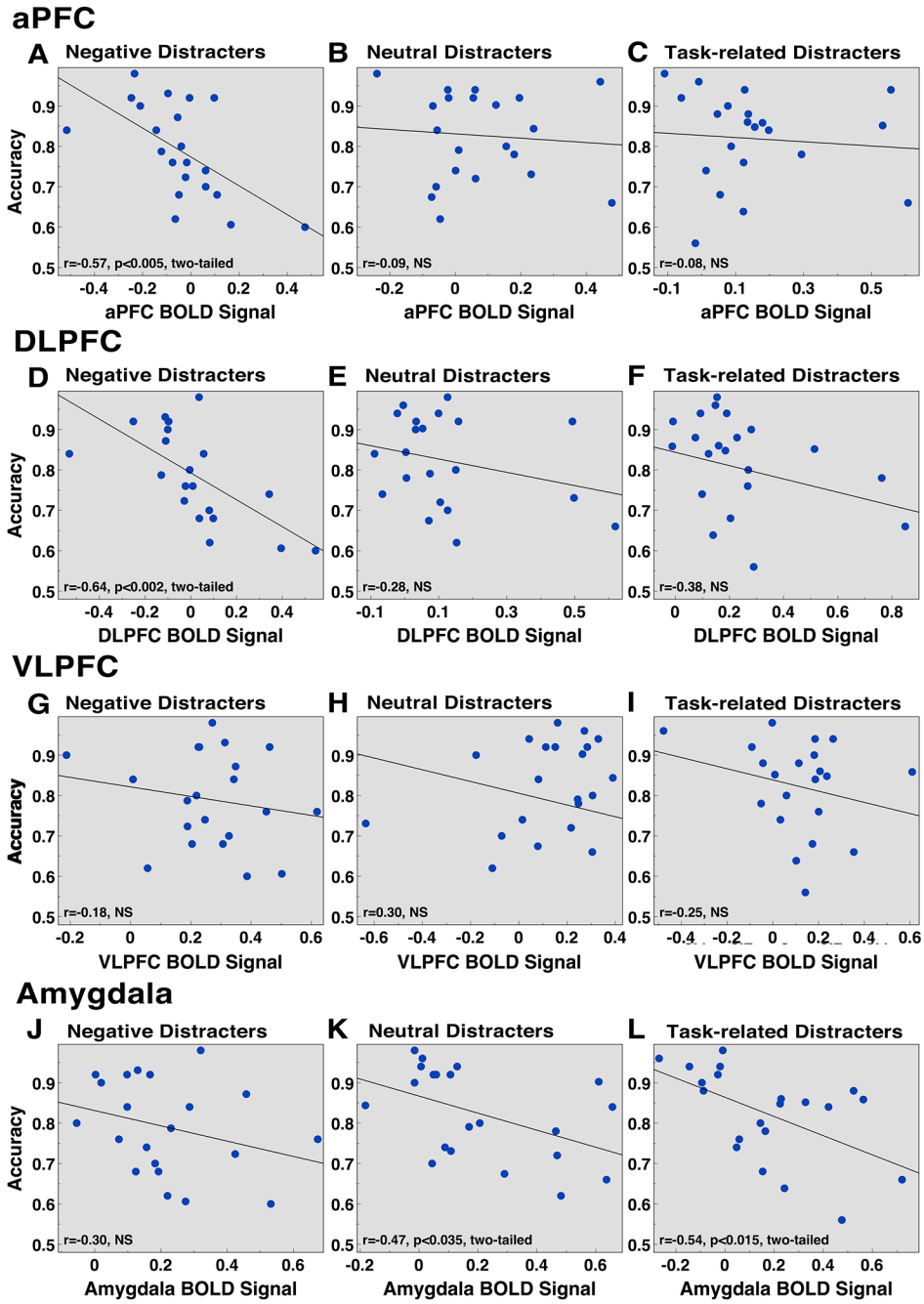
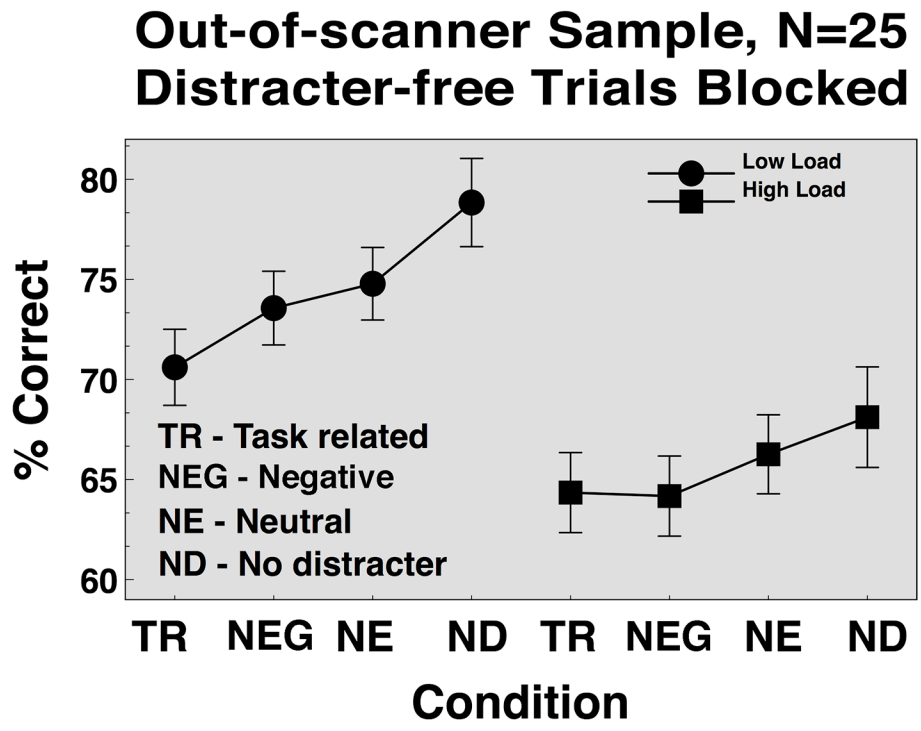


Supplemental Figure S7.



Supplemental Table 1.

	REGION NAME	HEMISPHERE	X	Y	X	average t (negative - neutral)	average p (negative - neutral)
1	Sup. Frontal Gyrus (BA 6)	L	-6	-3	63	-2.91	0.0087
2	BA 7	L	-12	-73	45	-3.07	0.0060
3	Postcentral Gyrus (BA 3)	L	-13	-37	66	-5.68	0.0000
4	Sup. Frontal Gyrus (BA 8)	L	-15	37	52	3.19	0.0046
5	Posterior Caudate	L	-19	1	27	-3.31	0.0035
6	Caudate	L	-21	17	21	-3.28	0.0038
7	Anterior Caudate	L	-21	31	6	-3.19	0.0046
8	Parietal Cortex (BA 5)	L	-29	-43	58	-4.88	0.0001
9	Precentral Gyrus (BA 6)	L	-30	-15	58	-5.35	0.0000
10	aPFC (BA 10)	L	-31	46	16	-5.65	0.0000
11	DLPFC	L	-34	36	39	-2.87	0.0095
12	Parietal Cortex	L	-36	-58	44	-2.95	0.0078
13	Postcentral Gyrus	L	-43	-28	52	-3.05	0.0064
14	Inferior Parietal Lobule (BA 40)	L	-46	-45	48	-3.47	0.0024
15	Superior Temporal Gyrus	L	-51	-44	16	-4.41	0.0003
16	Precentral Gyrus (BA 4)	L	-57	-5	20	-3.17	0.0049
17	Superior Temporal Gyrus (BA 22)	L	-57	-17	2	-3.17	0.0048
18	Superior Temporal Gyrus (BA 42)	L	-61	-30	8	-4.43	0.0003
19	Orbitofrontal Cortex (BA 12)	R	2	22	-1	3.27	0.0038
20	Right Brainstem	R	6	-29	-6	3.27	0.0038
21	Precentral Gyrus (BA 6)	R	8	-28	65	-5.17	0.0000
22	Superior Parietal Cortex	R	16	-45	61	-3.76	0.0012
23	Superior Frontal Gyrus (BA 6)	R	21	14	56	-4.91	0.0001
24	Caudate	R	21	26	17	-3.72	0.0014
25	Superior Precentral Gyrus	R	26	-23	60	-3.96	0.0008
26	Inferior Frontal Cortex	R	32	33	-3	3.05	0.0063
27	Inferior Parietal Cortex (BA 40)	R	37	-55	47	-3.18	0.0047
28	aPFC (BA 10)	R	37	52	15	-4.50	0.0002
29	DLPFC (BA 9)	R	40	34	33	-5.53	0.0000
30	VLPFC (BA 45/46)	R	51	33	14	2.83	0.0100
31	Superior Temporal Gyrus (BA 42)	R	60	-22	12	-3.13	0.0053