

Supporting Information

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SI Text

Mean Coordinates for the Three Sites. The mean coordinates for each site are presented in [Table S1](#).

Estimation of Stop-Signal Reaction Time. When the tracking procedure is used, the covert latency of the stop process (stop-signal reaction time; SSRT) can be estimated by subtracting the mean delay between the stop signal and go signal (SOA) from the mean go reaction time (goRT). However, this mean estimation method assumes that the probability of responding on a stop-signal trial is 0.50. Inspection of the data of each subject showed that this was not the case for all windows (average = 0.514, SD = 0.038, range: 0.41–0.72). Therefore, we used the integration method to estimate SSRT (see ref. 1 for a detailed discussion of the various estimation methods). SSRT was estimated by subtracting mean SOA from the finishing time of the stop process. The finishing time was determined by integrating the goRT distribution: RTs were rank-ordered, then the n th RT was selected, where n was obtained by multiplying the number of no-signal trials in the distribution by the probability of responding. For example, there were 72 no-signal trials per window; when $P(\text{respond}|\text{signal}) = 0.42$, then n th RT was the 30th fastest RT. To estimate SSRT, mean SOA was subtracted from the n th RT. We excluded trials on which subjects erroneously executed a dual response; such trials were considered incorrect dual-response trials (see error analyses below) rather than signal-respond trials.

Mean $P(\text{respond}|\text{signal})$ and mean SOA for each site are presented in [Table S2](#).

Linear Mixed Effect Models and Analyses of Switch Trials. We used linear mixed effects models to analyze the following behavioral measures:

- (i) Latency of the stop process on stop-signal trials (SSRT)
- (ii) Latency of the dual-response on dual-signal trials (DRT2)

- (iii) The interaction between DRT2 and SOA (i.e., the delay between the go and dual signals)
- (iv) Latency of the first response on dual-signal trials (DRT1)
- (v) Slowing on signal-ignore trials (RT signal-ignore trials minus goRT ignore no-signal trials)
- (vi) Latency of color response (goRT) on no-signal trials (context-repetitions only)
- (vii) Switch cost for no-signal trials (i.e., goRT Trial 1 of a run minus goRT Trial 2 of a run)

For each behavioral measure, we adopted the top-down model building approach for fitting LME models (2, 3). We started with a full model of the fixed effects (see also Materials and Methods). We then added the random effects that were necessary and determined the best pattern for the covariance of the residuals based on Restricted Maximum Likelihood estimation (REML estimation). Then we determined which fixed effects we needed to include based on Maximum Likelihood estimation (ML estimation; see ref. 2 for a discussion of when to use REML and ML estimations). Fixed effects were removed when the model with the fixed effect did not fit the data significantly better than the model without the fixed effect. When the fixed effects were determined, we refitted the final model with REML estimation and calculated the relevant contrasts.

For each behavioral measure, we present the three fitting steps below. For each fitted model, we present the log-likelihood (Log L.) of the model, the χ^2 for the relevant model comparison, and the corresponding p value for this model test. The final (contrast) table for each measure always shows the Intercept (in ms; the Intercept value corresponds to the value for Sham at the first time window). When the main effect of moment was significant, the table shows the increase (in ms) per moving window. When the main effect of cTBS site was significant, the table shows the difference between each site and the Intercept (thus, there are three contrasts: rIFG vs. Sham, rIFJ vs. Sham, and preSMA vs. Sham).

Stop Latency on Stop-Signal Trials (SSRT). SSRTs for each moving window and each site are presented in [Fig. S1](#).

Step1. Determine random structure and covariance structure

Model	Test	Random	Covariance	Log L.	Df	χ^2	P
1	Initial REML fit	1		-6516	10		
2	Random moment (1 vs. 2)	1 + moment		-6476	12	$\chi^2(1.5) = 80.7$	<0.0001
3	Autoregressive structure (2 vs. 3)	1 + moment	AR	-5546	13	$\chi^2(1) = 1860$	<0.0001

Decision test model 2: add random moment; decision test model 3: use autoregressive (AR) structure.

Step2. Determine fixed effects

Model	Test	Fixed	Log L.	Df	χ^2	P
1	Initial ML fit	Site x moment	-5556	13		
2	Remove interaction (1 vs. 2)	Site + moment	-5558	10	$\chi^2(3) = 3.41$	0.33
3	Remove site (2 vs. 3)	Moment	-5570	7	$\chi^2(3) = 24.84$	<0.0001
4	Remove moment (2 vs. 4)	Site	-5561	9	$\chi^2(1) = 6.90$	<0.01

Decision test model 2: remove interaction; decision test model 3: keep site; decision test model 4: keep moment.

Step 3. Test final model

Effects	<i>F</i>		<i>P</i>
Moment	$F(1,1343) = 7.37$		<0.01
Site	$F(3,1343) = 8.37$		0.0001

Contrasts	<i>B</i>	<i>SE(B)</i>	<i>t</i>	<i>P</i>
Intercept	268.19	8.69	$t(1346) = 30.83$	<0.0001
Moment	0.78	0.28	$t(1346) = 2.75$	<0.01
Site: IFG	11.01	3.56	$t(1346) = 3.09$	<0.01
Site: IFJ	15.47	5.28	$t(1346) = 2.92$	<0.01
Site: preSMA	4.64	6.99	$t(1346) = 0.66$	0.50

Note: We did not only test the regular interaction. We also tried more sophisticated approaches, such as polynomial regression or 'broken-stick regression' (regression using splines). Broken-stick regression allows the size of the effect to differ across different time points (with two sticks, the effect could differ for the first and second part of the experiment, with three sticks, the effect could differ for the early, middle and late phase of the session, and so on...). We compared two-stick, three-stick and four-stick models with the basic model that we presented above. Even though these stick models were more complicated, they did not improve the fits.

Dual-Response Latency on Dual-Signal Trials (DRT2). DRT2 for each moving window and each site is presented in Fig. S2.

Step1. Determine random structure and covariance structure

Model	Test	Random	Covariance	Log L.	Df	χ^2	<i>P</i>
1	Initial REML fit	1		-6596	10		
2	Random moment (1 vs. 2)	1 + moment		-6593	12	$\chi^2(1.5) = 5.70$	<0.05
3	Autoregressive structure (2 vs. 3)	1 + moment	AR	-5498	13	$\chi^2(1) = 2189$	<0.0001

Decision test model 2: add random moment; decision test model 3: use autoregressive (AR) structure.

Step2. Determine fixed effects

Model	Test	Fixed	Log L.	Df	χ^2	<i>P</i>
1	Initial ML fit	Site x moment	-5509	13		
2	Remove interaction (1 vs. 2)	Site + moment	-5510	10	$\chi^2(3) = 2.47$	0.48
3	Remove site (2 vs. 3)	Moment	-5524	7	$\chi^2(3) = 27.33$	<0.0001
4	Remove moment (2 vs. 4)	Site	-5514	9	$\chi^2(1) = 7.76$	<0.01

Decision test model 2: remove interaction; decision test model 3: keep site; decision test model 4: keep moment.

Step 3. Test final model

Effects	<i>F</i>		<i>P</i>
Moment	$F(1,1346) = 9.53$		<0.01
Site	$F(3,1346) = 9.23$		<0.0001

Contrasts	<i>B</i>	<i>SE(B)</i>	<i>t</i>	<i>p</i>
Intercept	490.92	13.22	$t(1346) = 37.12$	<0.0001
Moment	0.74	0.26	$t(1346) = 2.90$	<0.01
Site: IFG	11.65	3.74	$t(1346) = 3.02$	<0.01
Site: IFJ	15.75	6.19	$t(1346)=2.54$	< 0.05
Site: preSMA	4.8	8.53	$t(1346)=0.56$	0.57

SOA-DRT2 Analyses for rIFG and rIFJ. The main analysis for dual-response RTs indicated that there was no effect of preSMA stimulation. Therefore, we excluded preSMA from the follow-up SOA analysis.

In the Fig. 6, SOA = 250 ms was included. We did not include SOA 250 ms in the SOA analyses because this SOA was intermediate and could therefore not help to distinguish between the different hypotheses. We note however that the crucial interaction between site and SOA remained significant when this intermediate SOA was included [$F(1,3043) = 15.2, P < 0.001$].*

Step 1. Determine random structure and covariance structure

Model	Test	Random	Covariance	Log L.	Df	χ^2	<i>P</i>
1	Initial REML fit	1		-10565	14		
2	Random moment (1 vs. 2)	1 + moment		-10563	16	$\chi^2(1.5) = 4.8$	<0.05
3	Autoregressive structure (2 vs. 3)	1 + moment	AR	-10551	17	$\chi^2(1) = 23.6$	<0.001

Decision test Model 2: add random moment.

Decision test Model 3: use autoregressive (AR) structure.

Step 2. Determine fixed effects

Model	Test	Fixed	Log L.	Df	χ^2	<i>P</i>
1	Initial ML fit	Site x moment x SOA	-10564	17		
2	Remove three-way interaction (1 vs. 2)	(Site + context + moment)^2	-10565	15	$\chi^2(2) = 2.2$	0.32
3	Remove site x moment interaction (2 vs. 3)		-10565	13	$\chi^2(2) = 0.24$	0.88
4	Remove site x SOA interaction (2 vs. 4)		-10583	13	$\chi^2(2) = 40.0$	<0.0001
5	Remove SOA x moment interaction (2 vs. 5)		-10565	14	$\chi^2(1) = 0.46$	0.49
6	Remove SOA x moment and site x moment (2 vs. 6)	Site + SOA + moment	-10565	12	$\chi^2(3) = 0.7$	0.87
7	Remove moment (6 vs. 7)	Site + SOA	-10568	11	$\chi^2(1) = 6.1$	<0.05

Decision test model 2: remove interaction; decision test model 3: remove interaction; decision test model 4: keep site x SOA interaction; decision test model 5: remove interaction; decision test model 6: remove interactions; decision test model 7: keep moment.

We did not test models without fixed effects for site and SOA because there was a fixed effect for two-way interaction between SOA x site.

Step 3. Test final model

Effects	<i>F</i>	<i>P</i>
Moment	$F(1,2028) = 7.6$	<0.01
Site	$F(2,2028) = 13.5$	<0.0001
SOA	$F(1,2028) = 4268.5$	<0.0001
Site: SOA	$F(1,2028) = 18.9$	<0.0001

Contrasts	<i>B</i>	SE(<i>B</i>)	<i>t</i>	<i>P</i>
Intercept	569	12.7	$t(2028) = 37.12$	<0.0001
Moment	0.60	0.23	$t(2028) = 2.6$	<0.01
SOA: 400	-111.4	2.8	$t(2028) = 39.5$	<0.0001
Site: IFG	8.8	3.17	$t(2028) = 2.7$	<0.01
Site: IFJ	3.1	3.17	$t(2028) = 0.98$	0.39
IFG: SOA	-3.3	3.99	$t(2028) = 0.84$	0.40
IFJ: SOA	19.30	3.98	$t(2028) = 4.85$	<0.0001

Latency for First Response on Dual-Signal Trials (DRT1). DRT1 for each moving window and each site is presented in Fig. S3.

Step 1. Determine random structure and covariance structure

Model	Test	Random	Covariance	Log L.	Df	χ^2	<i>P</i>
1	Initial REML fit	1		-5876	10		
2	Random moment (1 vs. 2)	1 + moment		-5869	12	$\chi^2(1.5) = 13.58$	<0.001
3	Autoregressive structure (2 vs. 3)	1 + moment	AR	-5058	13	$\chi^2(1) = 1621$	<0.0001

Decision test model 2: add random moment; decision test model 3: use autoregressive (AR) structure.

*We also note that the average of the estimates reported in this analysis do not fully correspond to the reported estimates in the main analyses (see *SI Text*; see also comparison of A and B with C in Fig. 6 in the main text). This is expected because LME estimates were based on different numbers of trials per condition in the two analyses (i.e., we collapsed across all SOAs in the main analysis) and because different predictors were included in the final models (i.e., the fixed effect for SOA and the interaction between SOA and site were included only in this analysis).

Step 2. Determine fixed effects

Model	Test	Fixed	Log L.	Df	χ^2	P
1	Initial ML fit	Site x moment	-5056	13		
2	Remove interaction (1 vs. 2)	Site + moment	-5066	10	$\chi^2(3) = 0.82$	0.84
3	Remove site (2 vs. 3)	Moment	-5070	7	$\chi^2(3) = 7.75$	0.05
4	Remove moment (2 vs. 4)	Site	-5069	9	$\chi^2(1) = 5.61$	<0.05

Decision test model 2: remove interaction; decision test model 3: keep site; decision test model 4: keep moment.

Step 3. Test final model

Effects	F	P
Moment	$F(1,1346) = 9.68$	<0.01
Site	$F(3,1346) = 2.59$	0.05

Contrasts	B	SE(B)	t	P
Intercept	446.71	7.15	$t(1346) = 62.43$	<0.0001
Moment	0.46	0.19	$t(1346) = 2.46$	<0.05
Site: IFG	-4.66	2.27	$t(1346) = -2.05$	<0.05
Site: IFJ	-8.05	3.13	$t(1346) = -2.56$	<0.05
SITE: preSMA	-6.08	3.98	$t(1346) = -1.52$	0.13

Ignore Slowing on Signal-Ignore Trials. Ignore slowing for each moving window and each site is presented in [Fig. S4](#).

Step 1. Determine random structure and covariance structure

Model	Test	Random	Covariance	Log L.	Df	χ^2	P
1	Initial REML fit	1		-5684	10		
2	Random moment (1 vs. 2)	1 + moment		-5561	12	$\chi^2(1.5) = 58.04$	<0.0001
3	Autoregressive structure (2 vs. 3)	1 + moment	AR	No fit	-	-	-
4	Remove random moment, use autoregressive structure (1 vs. 4)	1	AR	-5131	11	$\chi^2(1) = 1111$	<0.0001

Decision test model 2: add random moment; decision test model 3: N/A; decision test model 4: use autoregressive (AR) structure.

Step 2. Determine fixed effects

Model	Test	Fixed	Log L.	Df	χ^2	P
1	Initial ML fit	Site x moment	-5138	11		
2	Remove interaction (1 vs. 2)	Site + moment	-5139	8	$\chi^2(3) = 1.25$	0.74
3	Remove site (2 vs. 3)	Moment	-5139	5	$\chi^2(3) = 1.33$	0.72
4	Remove moment (3 vs. 4)	Intercept only	-5141	4	$\chi^2(1) = 3.91$	<0.05

Decision test model 2: remove interaction; decision test model 3: remove site; decision test model 4: keep moment.

Step 3. Test final model

Effects	F	P
Moment	$F(1,1349) = 3.91$	<0.05

Contrasts	B	SE(B)	t	P
Intercept	4.57	1.34	$t(1349) = 3.39$	<0.001
Moment	-0.15	0.078	$t(1346) = -1.97$	<0.05

Latency No-Signal Response (goRT) for No-Signal Repetition Trials. goRT data for each moving window and each site are presented in Fig. S5.

Step 1. Determine random structure and covariance structure

Model	Test	Random	Covariance	Log L.	Df	χ^2	P
1	Initial REML fit	1		-18763	26		
2	Random moment (1 vs. 2)	1 + moment		-18739	28	$\chi^2(1.5) = 48.75$	<0.0001
3	Autoregressive structure (2 vs. 3)	1 + moment	AR	-18644	29	$\chi^2(1) = 189.85$	<0.0001

Decision test model 2: add random moment; decision test model 3: use autoregressive (AR) structure.

Step 2. Determine fixed effects

Model	Test	Fixed	Log L.	Df	χ^2	P
1	Initial ML fit	Site x context x moment	-18653	29		
2	Remove three-way interaction (1 vs. 2)	(Site + context + moment)^2	-18660	23	$\chi^2(6) = 13.06$	0.042*
3	Remove site x moment interaction (2 vs. 3)		-18662	20	$\chi^2(3) = 4.19$	0.24
4	Remove site x context interaction (2 vs. 4)		-18662	17	$\chi^2(6) = 3.90$	0.68
5	Remove context x moment interaction (2 vs. 5)		-18662	21	$\chi^2(2) = 4.22$	0.12
6	Remove all two-way interactions (2 vs. 6)	Site + context + moment	-18666	12	$\chi^2(11) = 12.33$	0.33
7	Remove moment (6 vs. 7)	Site + context	-18674	11	$\chi^2(1) = 16.92$	<0.0001
8	Remove site (6 vs. 8)	Context + moment	-18674	9	$\chi^2(3) = 16.29$	<0.01
9	Remove context (6 vs. 9)	Site + moment	-19757	10	$\chi^2(2) = 2182$	<0.0001

Decision test model 2: remove interaction; decision test model 3: remove interaction; decision test model 4: remove interaction; decision test model 5: remove interaction; decision test model 6: remove interactions; decision test model 7: keep moment; decision test model 8: keep site; decision test model 9: keep context. *Even though the three-way interaction was significant, it was not analyzed any further because none of the two-way interactions were significant.

Step 3. Test final model

Effects	F	P
Context	$F(2,4080) = 1705$	<0.0001
Moment	$F(1,4080) = 26.66$	<0.0001
Site	$F(3,4080) = 5.46$	<0.001

Contrasts	B	SE(B)	t	P
Intercept	419.49	4.68	$t(4080) = 89.56$	<0.0001
Context: dual	12.88	0.76	$t(4080) = 16.74$	<0.0001
Context: stop	43.76	0.77	$t(4080) = 56.82$	<0.0001
Moment	0.74	0.14	$t(4080) = 5.15$	<0.0001
Site: IFG	-3.15	1.26	$t(4080) = -2.50$	<0.05
Site: IFJ	-4.95	1.26	$t(4080) = -3.92$	<0.001
SITE: preSMA	-3.53	1.26	$t(4080) = -2.79$	<0.01

Switch Cost for No-Signal Trials. Context-switch costs for each moving window and each site are presented in Fig. S6.

Step 1. Determine random structure and covariance structure

Model	Test	Random	Covariance	Log L.	Df	χ^2	P
1	Initial REML fit	1		-20202	26		
2	Random moment (1 vs. 2)	1 + moment		-20182	28	$\chi^2(1.5) = 39.95$	<0.0001
3	Autoregressive structure (2 vs. 3)	1 + moment	AR	-18266	29	$\chi^2(1) = 3832$	<0.0001

Decision test model 2: add random moment; decision test model 3: use autoregressive (AR) structure.

Step 2. Determine fixed effects

Model	Test	Fixed	Log L.	Df	χ^2	P
1	Initial ML fit	Site x context x moment	-18329	29		
2	Remove three-way interaction (1 vs. 2)	(Site + context + moment)^2	-18332	23	$\chi^2(6) = 4.48$	0.61
3	Remove site x moment interaction (2 vs. 3)		-18333	20	$\chi^2(3) = 2.81$	0.42
4	Remove site x context interaction (2 vs. 4)		-18335	17	$\chi^2(6) = 5.54$	0.47
5	Remove context x moment interaction (2 vs. 5)		-18332	21	$\chi^2(2) = 0.55$	0.75
6	Remove all two-way interactions (2 vs. 6)	Site + context + moment	-18336	12	$\chi^2(11) = 8.44$	0.67
7	Remove moment (6 vs. 7)	Site + context	-18336	11	$\chi^2(1) = 0.81$	0.36
8	Remove site (7 vs. 8)	Context	-18338	8	$\chi^2(3) = 3.69$	0.29
9	Remove context	Intercept only	-18388	6	$\chi^2(2) = 99.41$	<0.0001

Decision test model 2: remove interaction; decision test model 3: remove interaction; decision test model 4: remove interaction; decision test model 5: remove interaction; decision test model 6: remove interactions; decision test model 7: remove moment; decision test model 8: remove site; decision test model 9: keep context.

Step 3. Test final model

Effects	F	P
Context	$F(2,4084) = 50.37$	<0.0001

Contrasts	B	SE(B)	t	P
Intercept	15.72	2.32	$t(4084) = 6.76$	<0.0001
Context: dual	12.62	2.03	$t(4084) = 6.20$	<0.0001
Context: stop	21.4	2.14	$t(4084) = 9.97$	<0.0001

Error Data Due to multiple empty cells, error rates were too low to warrant inferential statistical analyses. Table S3 lists the percentage of incorrect responses on no-signal trials (go errors; e.g., when subjects pressed the left key instead of a right

key), missed responses on no-signal trials (go misses), incorrectly stopped responses on signal-ignore trials and dual-signal trials, and incorrect dual responses on signal-ignore and stop-signal trials.

1. Verbruggen F, Logan GD (2009) Models of response inhibition in the stop-signal and stop-change paradigms. *Neurosci Biobehav Rev* 33:647–661.
2. Pinheiro JC, Bates DM (2000) *Mixed-Effects Models in S and S-PLUS* (Springer, New York).

3. West BT, Welch KB, Galecki AT (2007) *Linear Mixed Models: A Practical Guide Using Statistical Software* (Chapman Hall/CRC, Boca Raton, FL).

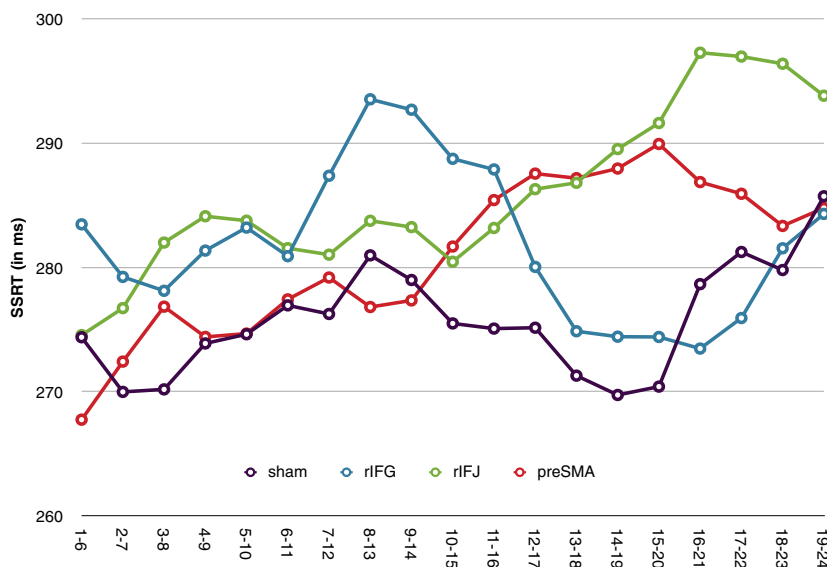


Fig. S1. Stop-signal latency (SSRT) for each moving window (6 blocks per window) and each site. SE of means: Sham = 10 ms, rIFG = 11 ms, rIFJ = 12 ms, preSMA = 10 ms. SE of LME difference scores: Sham-rIFG = 3.56 ms, Sham-rIFJ = 5.28 ms, Sham-preSMA = 6.99 ms.

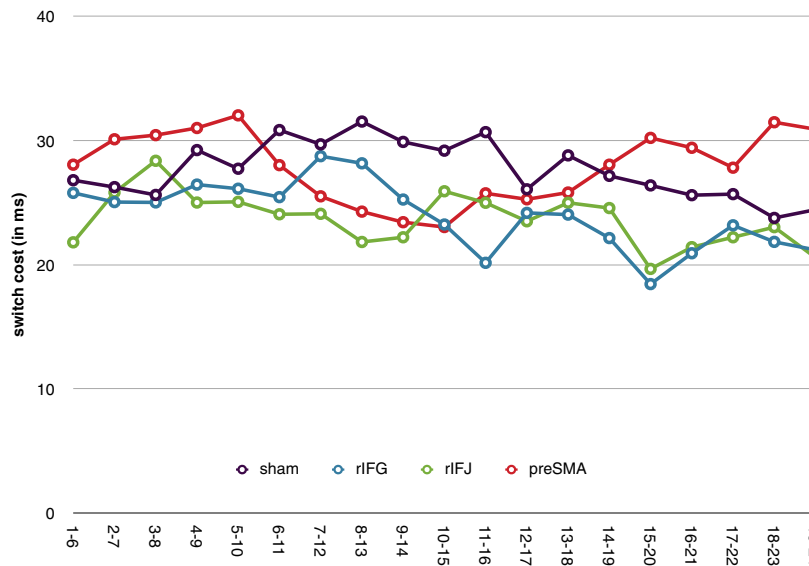


Fig. 56. Context-switch costs (goRT trial 1 of run – goRT trial 2 of run) for each moving window (6 blocks per window) and each site. Switch costs are collapsed across contexts. SE of means: Sham = 10 ms, rIFG = 9 ms, rIFJ = 9 ms, preSMA = 9 ms. SE of LME intercept = 2.32.

Table S1. Mean coordinates for the three cTBS sites according to the Montreal Neurological Institute (MNI) brain atlas

	rIFG			rIFJ			preSMA		
	x	y	z	x	y	z	x	y	z
Mean	58	18	4	56	16	33	-1	31	66
95% CI	0.9	1.8	1.9	1.3	1.7	2.6	0.5	2.4	1.5

Table S2. Mean and SEM for probability of responding [p(respond | signal)] and SOA collapsed across windows for the four sessions

	p(respond signal)	SOA
Sham	0.508 (0.008)	202 (12)
rIFG	0.513 (0.009)	194 (12)
rIFJ	0.521 (0.011)	190 (15)
preSMA	0.514 (0.008)	195 (13)

Table S3. Mean percentages and SEM collapsed over windows for the different sessions (SEs between parentheses)

	Go error	Go miss	Incorrect stops		Incorrect dual resp.	
	No signal	No signal	Signal ign.	Dual signal	Signal ign.	Stop signal
Sham	2.7 (0.3)	0.1 (0.1)	0.1 (0.1)	0.1 (0.1)	0.4 (0.3)	1.2 (0.5)
rIFG	2.7 (0.3)	0.01 (0.004)	0.1 (0.1)	0.1 (0.1)	0.4 (0.3)	1.4 (0.6)
rIFJ	3.1 (0.5)	0.01 (0.005)	0.2 (0.3)	0.3 (0.2)	0.1 (0.2)	1.4 (0.5)
preSMA	3.1 (0.4)	0.004 (0.003)	0.2 (0.2)	0.1 (0.1)	0.5 (0.3)	1.8 (0.8)