Supplemental Inventory of Figures, Legends, Table and Videos

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Figure S11. Related to All Figures; synthesizes all data. Circuit diagram illustrating a proposed decision criterion circuit.

Table S1. Related to Figures 2 and 4. -z(FA rate) calculations for behavioral and neuronal activity data.
Table S2. Related to Figures 2, 4, and 7. Linear regression analyses of criterion (alpha) and d' (beta) interactions.

Video S1. Related to Figure 1. Movie of a 0% dynamic Glass pattern stimulus
Video S2. Related to Figure 1. Movie of a 100% dynamic Glass pattern stimulus

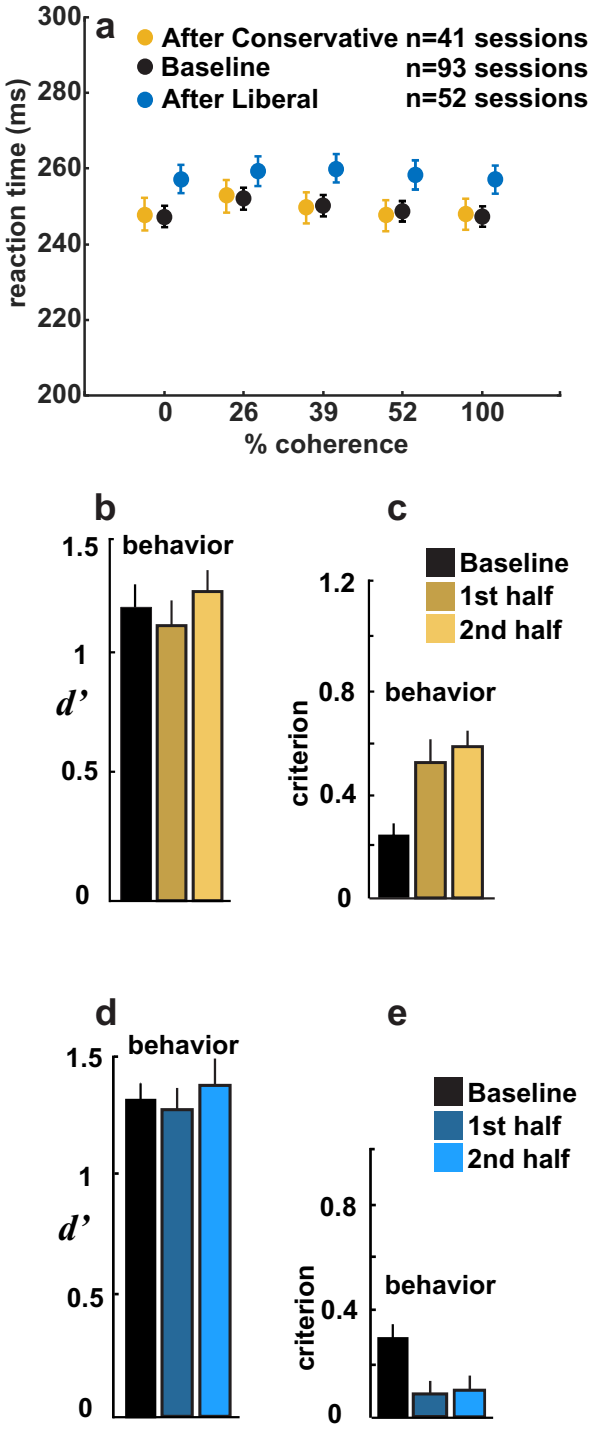


Figure S1. Related to Figure 2. Mean reaction times and temporal analysis of behavioral criterion and *d'*. **a**. Plotted as a function of coherence are mean reaction times (ms) and standard errors for the baseline, conservative and after liberal priming data. **b**. Behavioral d' for the baseline block preceding conservative priming and each temporal half of the after conservative priming block. '1st half' represents the first 100 trials of the after-priming block and 2nd half represents the remaining 100 trials. **c.** Behavioral criterion for the baseline block preceding conservative priming (n=41 sessions) and temporal halves of the conservative priming block. **d**. and **e**. Same conventions as **b** and **c** but for the liberal priming session data (n=52 sessions).

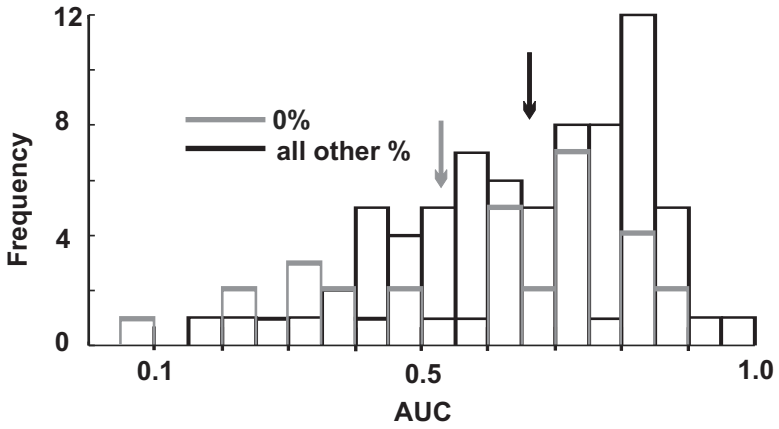


Figure S2. Related to Figure 3. AUC analysis of superior colliculus activity. Frequency is plotted against the area under the curve (AUC) calculated for all neurons in the baseline conditions for the 0% coherence condition (grey) and averaged across all coherence levels with structure: 26, 39, 52 and 100% (black). Grey-scaled arrows indicate the mean value of each distribution.

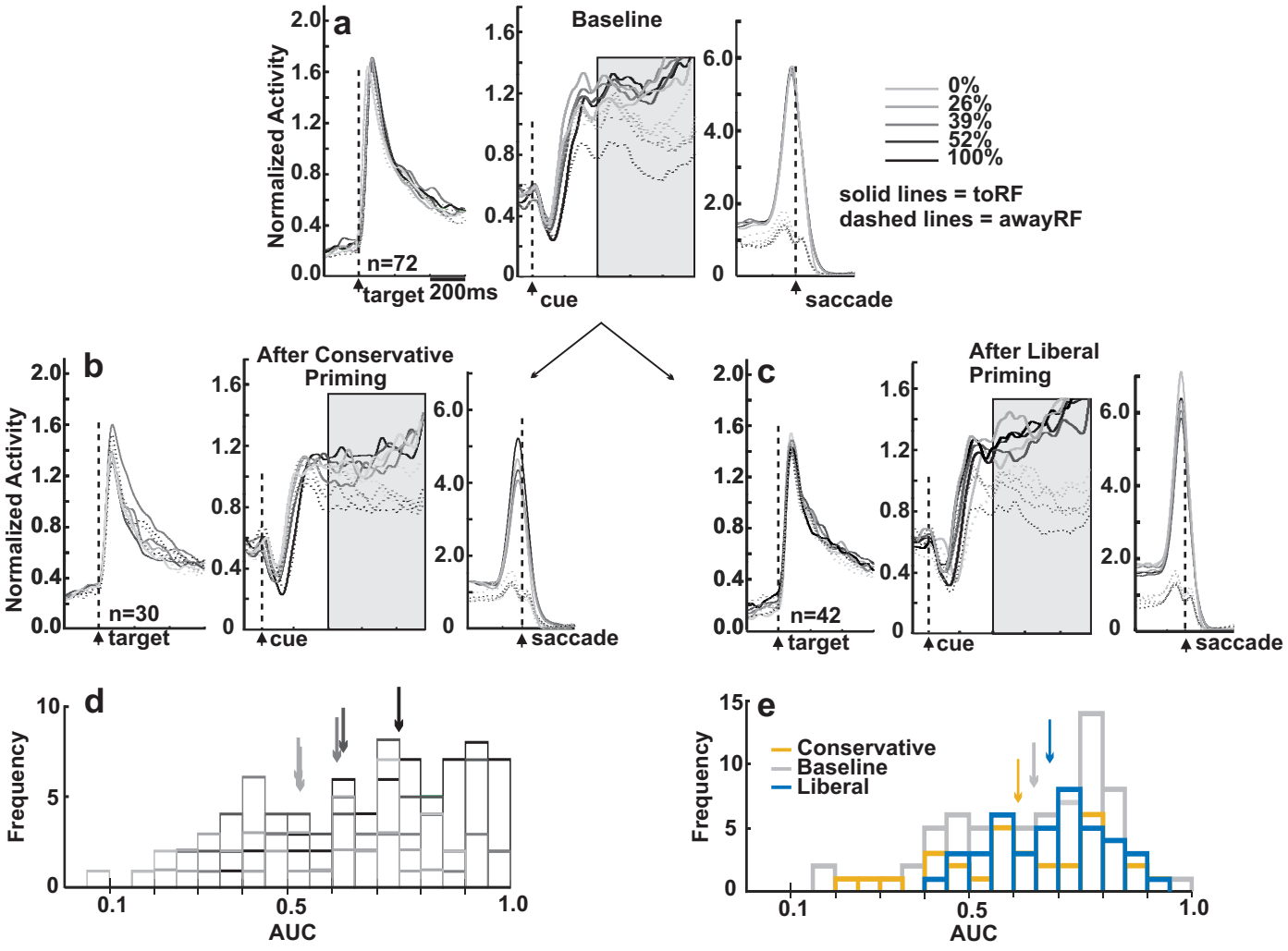


Figure S3. Related to Figure 3. Superior colliculus relative neuronal activity across all coherences and changes with priming a. Normalized spike density functions (sdf; σ = 10 ms) for the sample of neurons (n=72) recorded during the Baseline (before priming) block of trials for each session. Choices made ToRF are shown as solid lines and choices made AwayRF are shown as dashed lines. Grey scale indicates coherence. Data in left panel are aligned to choice target onset indicated by the upward arrow (target), in middle panel to Glass pattern onset (cue), and in right panel to beginning of saccade (saccade). Transparent gray rectangle indicates analysis bins used for all subsequent analyses. **b.** Same as in a for the subset of neurons tested during conservative priming sessions (n=30). **c.** Same as in a for the subset of neurons tested during liberal priming sessions (n=42). **d.** Frequency is plotted against the area under the curve (AUC) calculated between the 'Yes' choice ToRF activity and 'Yes' choice AwayRF activity for all the neurons in the baseline conditions for each coherence level, 0, 26, 39, 52 and 100%. **e.** AUC changes following priming. Same as in **d**, but with all coherences pooled. Orange shows Conservative priming and blue shows Liberal priming. Grey-scaled and colored arrows indicate the mean value of each distribution. Orange shows Conservative priming and blue shows Liberal priming. Colored arrows indicate the mean value of each distribution. Kruskal-Wallis, df=(2,141), X^2=2.06, p=0.36

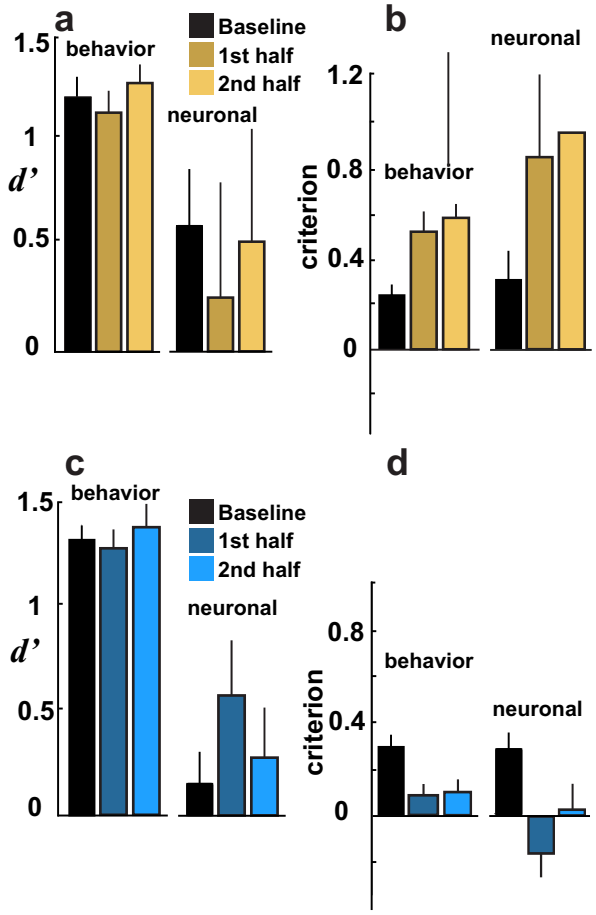
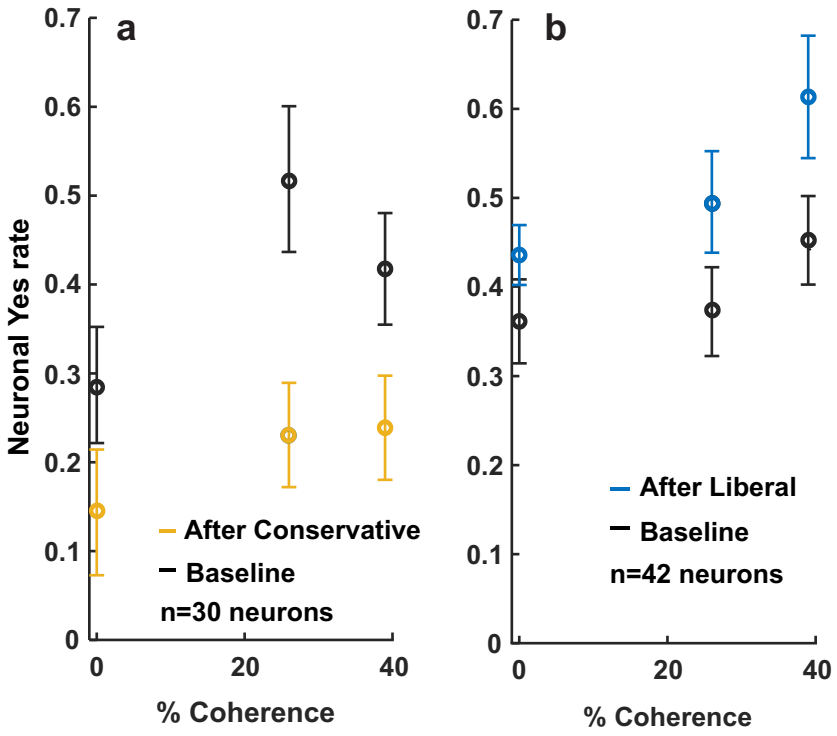


Figure S4. Related to Figures 2 and 4. Temporal analysis of neuronal criterion and *d'*. *a.* Neuronal d' for the baseline block preceding conservative priming (n=30 neurons) and each temporal half of the after conservative priming block that followed shown at right. Behavioral d' from Supplemental Figure 1 co-plotted at left for comparison. '1st half' represents the first 100 trials of the after-priming block and 2nd half represents the remaining 100 trials. **b.** Neuronal criterion for the baseline block preceding liberal priming (n=42 neurons) and temporal halves of the conservative priming block that followed. Behavioral criterion from Supplemental Figure 1 co-plotted for comparison. **c**. and **d**. Same conventions as **a** and **b** but for the liberal priming session data.



S5. Neuronal Yes Rates before and after priming. a. Neuronal Yes rates plotted as a function of % coherence for the 30 neurons recorded during the 26 conservative priming sessions plotted in Figure 4a. Note that data for the 52% and 100% coherence conditions not shown due to insufficient number of miss trials occurring on these conditions. See Methods. Data in black show the baseline neuronal performance, before conservative priming. Data in orange show the after conservative priming neuronal performance. **b.** Same as in a for 36 Liberal priming sessions in which neuronal activity (n=42) was recorded at the same time as behavior was measured.

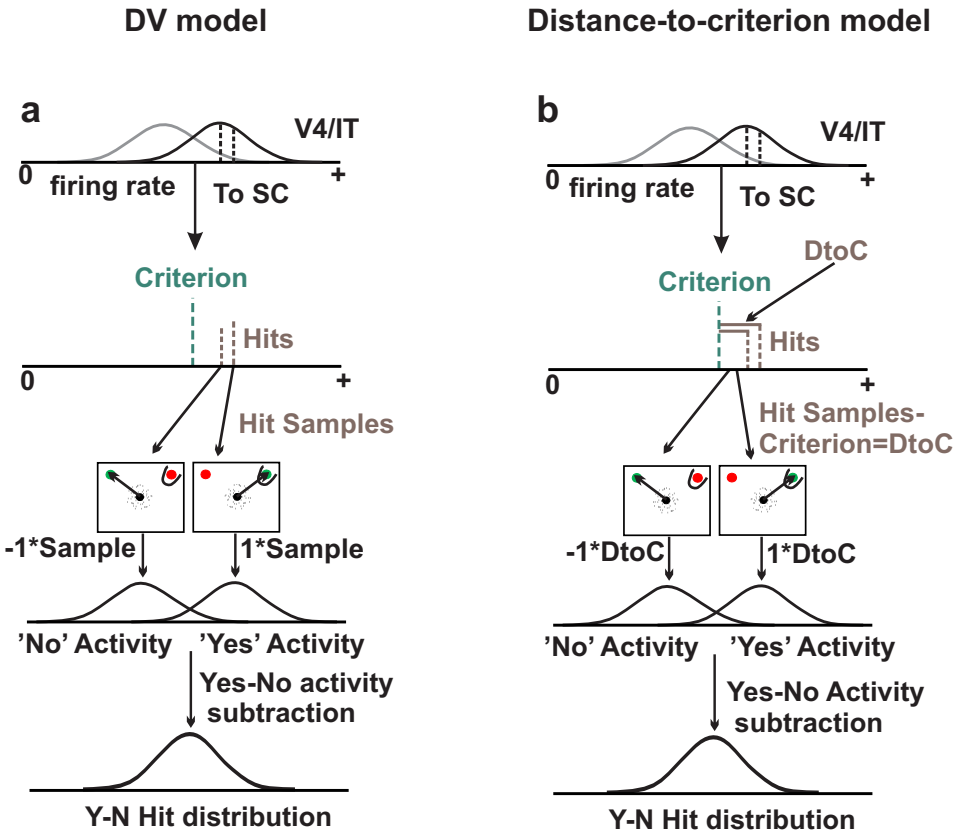


Figure S6. Related to Figures 5 and 6. Decision variable (DV) and distance-to-criterion models. a. The DV model. Two sensory area distributions are plotted at top. Two samples (vertical lines) from the Structure distribution are compared to the criterion shown in light green, and signed (-1 or +1) depending on the target in the model RF. The two squares illustrate task configuration on Hit trials in which the 'Yes' target is in the RF and trials in which the 'No' target is in the RF, respectively. Distributions below the task panels represent activity for the 'No' and 'Yes' choice targets on *Hit* trials. The difference between the two distributions is taken, resulting in a 'Y-N' *Hit* trial distribution illustrated at bottom. Similar procedures were carried out for the Miss, FA, and CR trial. **b**. The Distance-to-criterion model. Data simulation was identical to that described in a for the DV model with the exception of a criterion distance calculation shown at top. Horizontal lines indicate distance of drawn samples from the criterion.

To provide intuition for how this simulation was performed, imagine two distributions of neuronal activity, one representing activity associated with structured Glass pattern stimuli (black) and one representing activity associated with no-structure Glass patterns (grey), hypothetically in sensory area V4 or IT. The black vertical lines represent two draws from the structure distribution, each of which occurred on each simulated trial: one for trials when the 'Yes' choice target is in the RF of the simulated SC neuron and one when the 'No' target is in the RF of the simulated SC neuron. These draws are then compared to the position of the decision criterion (light green vertical line). Since the samples of this illustration are to the right of the criterion, they are deemed Hit trials. The samples were then signed to ensure that choices toward the RF were positive and choices reported away from the RF were negative (see Methods). Note that to simulate CR and Miss trial 'Y-N' activity (plotted in Figure 6), saccades to the RF are 'No' choices, resulting in + for 'No' target activity and - for 'Yes' target activity. Drawing multiple times yields two distributions, one for the 'Yes' target activity and one for 'No' target activity. Subtracting 'No' from 'Yes' yields a single distribution for a single SDT trial type. This was repeated for each of the 4 possible trial types, resulting in 4 'Y-N' distributions (Figure 5). For the distance-to-criterion model (panel b), everything is the same with the exception that for each draw from the sensory distributions, we first subtracted the criterion value from the sample value and took the absolute value to calculate the distance-to-criterion. This distance value was then signed and placed in the appropriate 'Yes' or 'No' distribution and the Yes-No operation performed. The direction of the modeled 'Y-N' changes were then compared qualitatively to the directionality of the actual 'Y-N' changes.

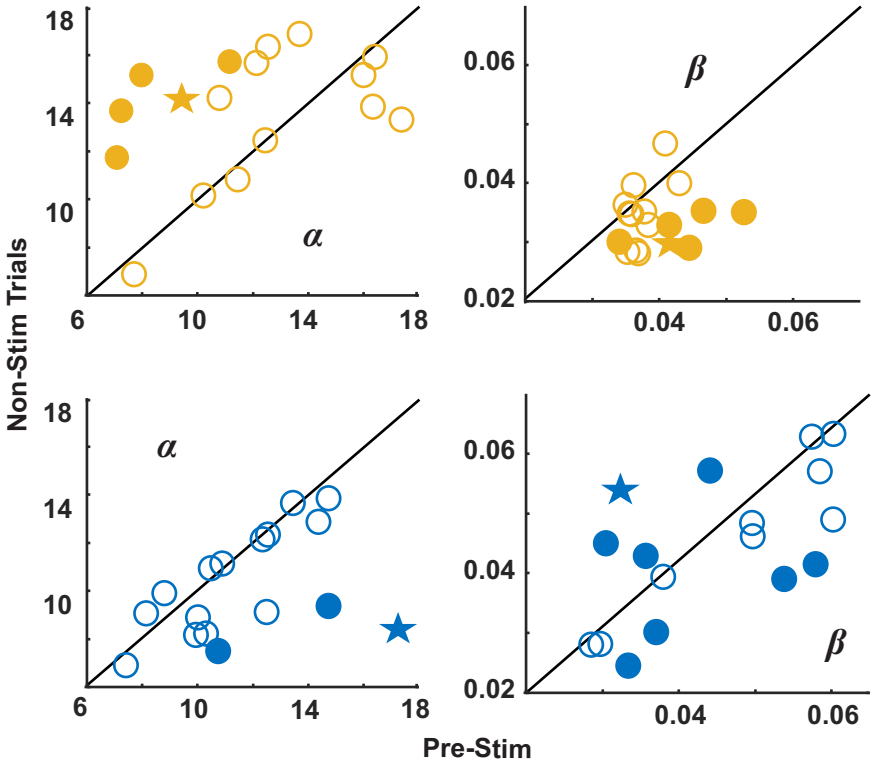


Figure S7. Related to Figure 7. α and β parameter values with and without stimulation. a. α and β parameters for trials not stimulated (Non-Stim Trials) during the stimulation block are plotted against the fitted parameters for the baseline (Pre-Stim) block of trials for each stimulation session. Solid circles show statistically significant changes in parameter values (permutation test, $p<0.05$) and open circles show those with differences failing to reach statistical significance ($p>0.05$). Stars show the examples from Figure 8. Orange data are from conservative stimulation sessions and blue are from liberal stimulation sessions.

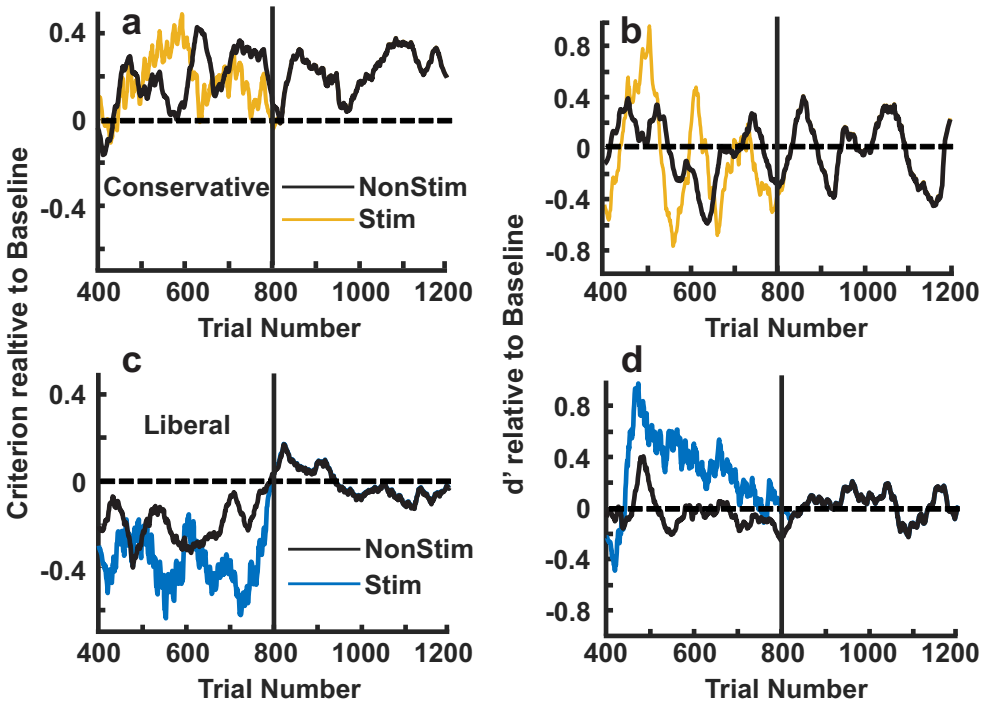


Figure S8. Related to Figure 7. Time-course of criterion and *d'* during and after SC stimulation. a. Baseline-subtracted mean criterion plotted as a function of within session trial number for the middle and third blocks of the conservative stimulation sessions. Black curve shows the mean of the trials in which no stimulation occurred and the orange lines show the mean of the trials in which stimulation occurred. **b**. Baseline-subtracted mean d' as a function of within-session trial number with and without conservative stimulation. Same conventions as **a**. **c**. Baseline-subtracted mean criterion as a function of within-session trial number for the Liberal stimulation sessions. Blue lines show the means of the stimulation trials. **d,** Baseline-subtracted mean d' for the liberal stimulation sessions. Same conventions as **c**.

During the stimulation block, the criterion on both Non-StimTrials (black traces) and StimTrials (orange traces) underwent positive deflections that surprisingly were sustained for the following After block (Panel a). *d'*, in contrast, fluctuated around no net change from baseline (Panel b). During liberal stimulation, the criterion on both Non-StimTrials (black traces) and StimTrials (blue traces) quickly dropped below the mean baseline value and returned to baseline levels during the After block (Panel c). In contrast to what we found for conservative stimulation, *d'* showed an increase for StimTrials but little change on NonStimTrials (Panel d).

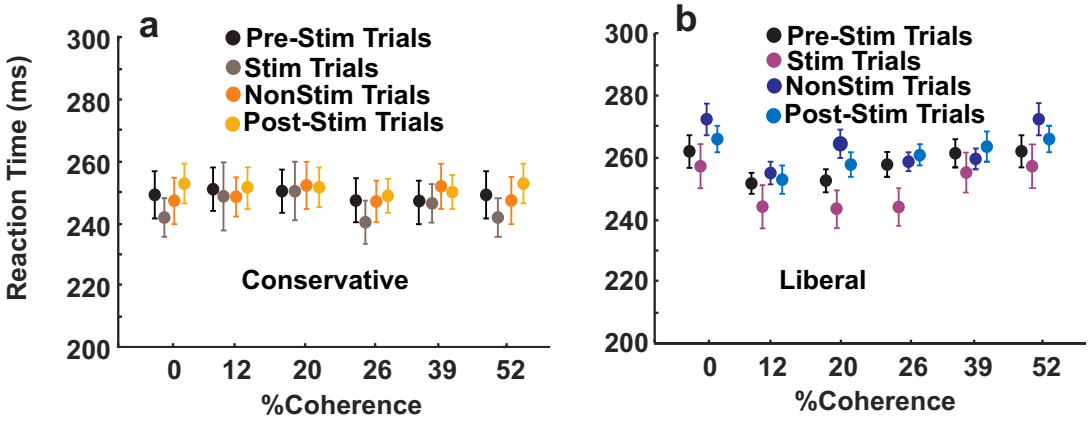


Figure S9. Related to Figure 7. Reaction time is unaffected by SC stimulation. a. Mean reaction time (ms) for trials collected from the 3 blocks of the Conservative stimulation sessions plotted as a function of Glass pattern coherence. **b.** Mean reaction time for trials collected during the 3 blocks of the Liberal stimulation sessions.

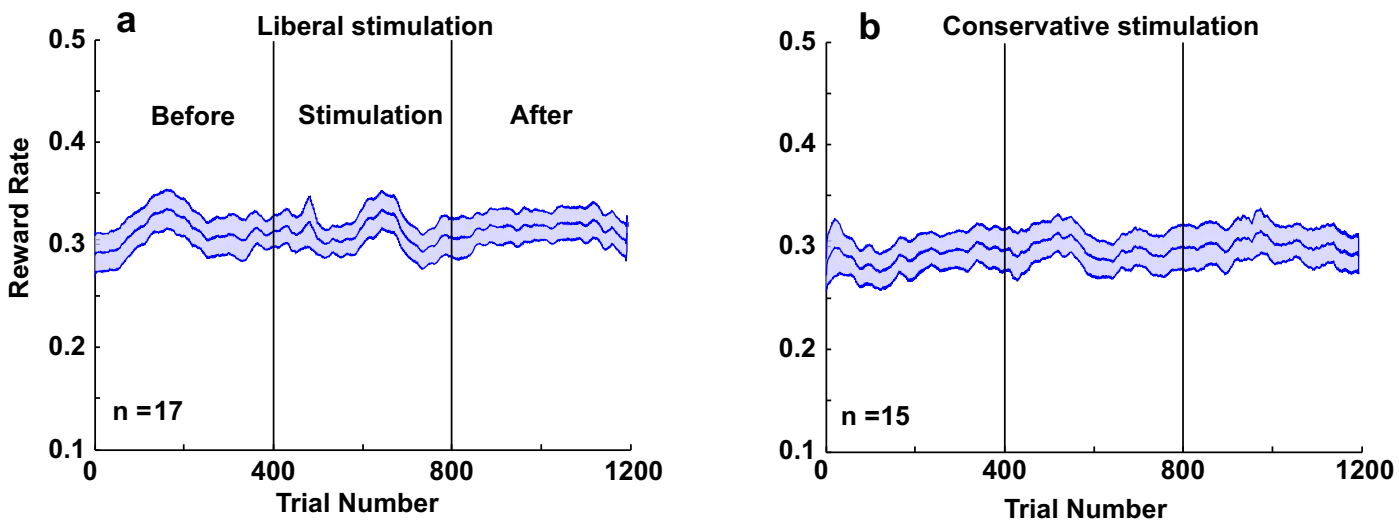


Figure S10. Related to Figure 7. Electrical manipulation of the SC leaves reward rate unchanged. a. Mean and standard error of the reward rate across trial number for all significant liberal stimulation sessions. Black vertical lines indicate block start and stop times. One-way ANOVA revealed no difference in reward rate as a function of stimulation ($F(2,32)=0.36$, $p=0.70$). **b.** Reward rate for the significant conservative stimulation sessions. One-way ANOVA revealed no difference in reward rate as a function of stimulation ($F(2,28)=0.07$, $p=0.93$). Same conventions as panel **a**. Filled regions show standard errors of the mean.

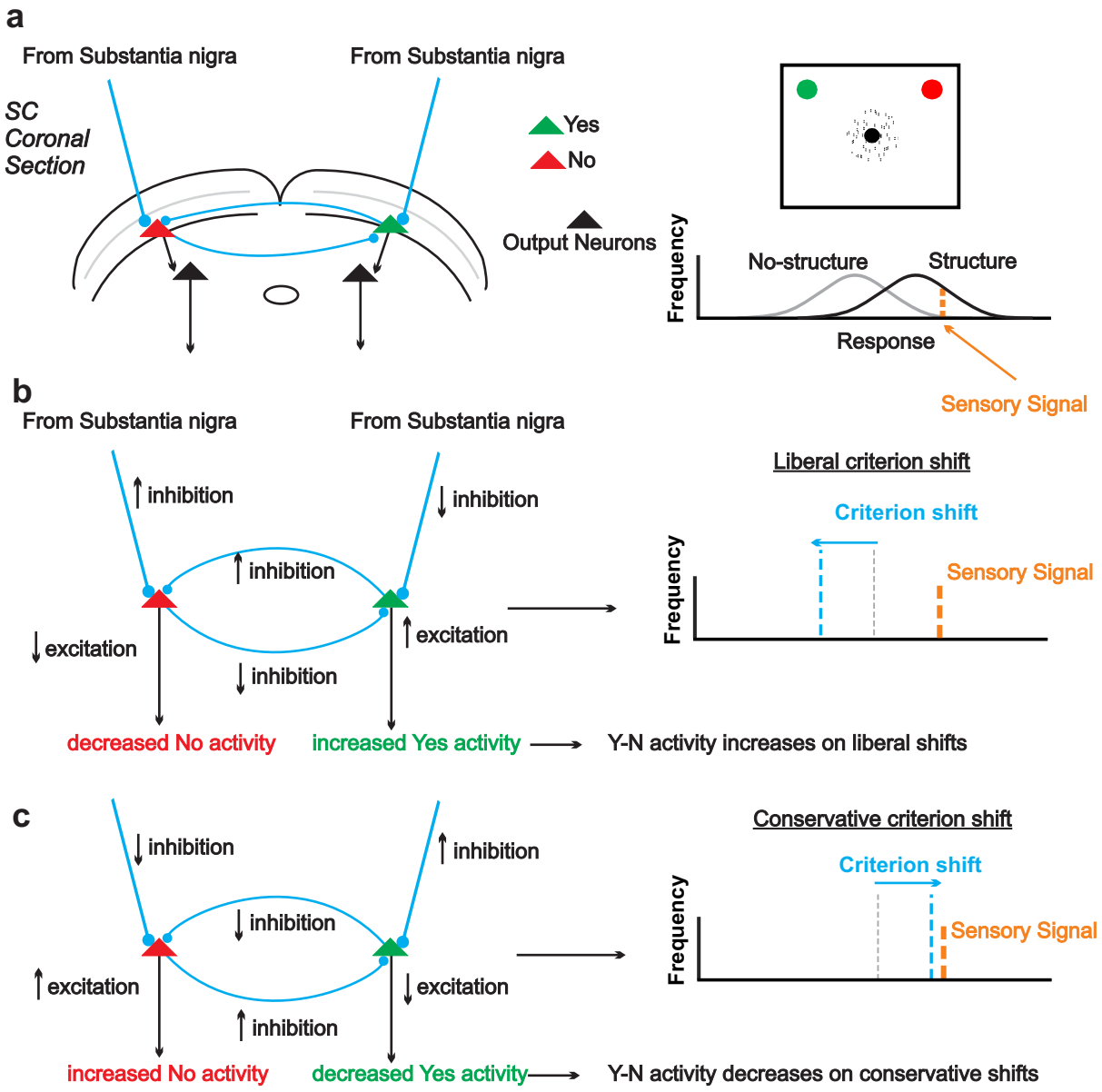


Figure S11. Related to All Figures. A proposed decision criterion circuit. a. Shown at left is a schematic of a coronal section through the SC with internal inhibitory connectivity and inhibitory inputs from the substantia nigra pars reticulata (cyan). Neurons with the 'Yes' target and 'No' target in their RFs, referenced here as 'Yes' neurons and 'No' neurons, respectively, are represented as green and red triangles. Neurons receiving input from the 'Yes' and 'No' neurons are shown in black. Right panel shows the task configuration for an illustrative Hit trial and two sensory area distributions with a draw from the structure distribution shown as an orange vertical line. **b**. Liberal criterion shift. Shown are changes occurring to inhibition and excitation during liberal criterion shifts. During liberal changes, inhibitory inputs to the 'Yes' neurons are proposed to decrease while inhibitory inputs to the 'No' neurons increase. This translates to an increase in excitation for the 'Yes' neurons and a decrease in excitation for the 'No' neurons. Taking the difference between the 'Yes' and 'No' activity ('Y-N') results in an increase in 'Y-N' activity. Behaviorally this is manifest as a leftward shift in the criterion, shown at right. **c**. For conservative criterion shifts, the changes in inhibition and excitation are reversed compared to liberal criterion shifts. Inhibition to the 'Yes' neurons may increase while inhibition to the 'No' neurons may decrease. This results in increased excitation for the 'No' neurons and decreased excitation for the 'Yes' neurons translating to a decrease in 'Y-N' activity. Behaviorally this is accompanied by a rightward shift of the criterion.

	-z(FA) mean (standard error)			pairwise comparisons	
	Before Priming	**Conservative**	**Liberal**	**Before vs. Conservative**	**Before vs. Liberal**
Figure 2 Behavior	0.94 (0.04)	1.18 (0.04)	0.71 (0.05)	p=0.00003	p=0.002
Figure 4 Behavior	Before Conservative Priming: 0.83 (0.06)	1.15 (0.05)		p=0.00007	
	Before Liberal Priming: 0.95 (0.06)		0.76 (0.07)		p=0.03
Figure 4 Neurons	Before Conservative Priming: 0.48 (0.18)	1.09 (0.39)		p=0.08	
	Before Liberal Priming: 0.37 (0.14)		0.16 (0.09)		p=0.10

Table S1. Related to Figures 2 and 4. -z(FA rate) calculations for behavioral and neuronal activity data

Figure	Condition	Model y = a + b + (a*b)	Interaction Term	Interaction Coefficient	StD	t	p
2a	Conserv. Priming	Y=alpha$_{after}$ a=alpha$_{before}$ b= beta$_{difference}$	*a*b*	-52.32	64.1	-0.81	0.41
2a	Liberal Priming	Y=alpha$_{after}$ a=alpha$_{before}$ b=beta$_{difference}$	*a*b*	-5.49	29.1	-0.19	0.85
2d	Conserv. Priming	Y=criterion$_{after}$ a=criterion$_{before}$ b=d'$_{difference}$	*a*b*	-0.12	0.15	-0.81	0.40
2d	Liberal Priming	Y=criterion$_{after}$ a=criterion$_{before}$ b=d'$_{difference}$	*a*b*	0.05	0.09	0.62	0.54
4c	Conserv. Priming Behavior	Y=criterion$_{after}$ a=criterion$_{before}$ b=d'$_{difference}$	*a*b*	0.47	0.70	0.67	0.51
4c	Conserv. Priming Neuronal	Y=criterion$_{after}$ a=criterion$_{before}$ b=d'$_{difference}$	*a*b*	-0.18	0.07	-2.61	0.01
4g	Liberal Priming Behavior	Y=criterion$_{after}$ a=criterion$_{before}$ b=d'$_{difference}$	*a*b*	-0.26	0.37	-0.69	0.49
4g	Liberal Priming Neuronal	Y=criterion$_{after}$ a=criterion$_{before}$ b=d'$_{difference}$	*a*b*	0.15	0.12	1.22	0.22
7e	Conserv. NonStim	Y=criterion$_{non\text{-}stim}$ a=criterion$_{pre\text{-}stim}$ b=d'$_{difference}$	*a*b*	2.13	2.03	1.05	0.32
7e	Liberal NonStim	Y=criterion$_{non\text{-}stim}$ a=criterion$_{pre\text{-}stim}$ b=d'$_{difference}$	*a*b*	0.09	1.04	0.08	0.93

Table S2. Related to Figures 2, 4, and 7. Linear regression analyses of criterion (alpha) and d' (beta)