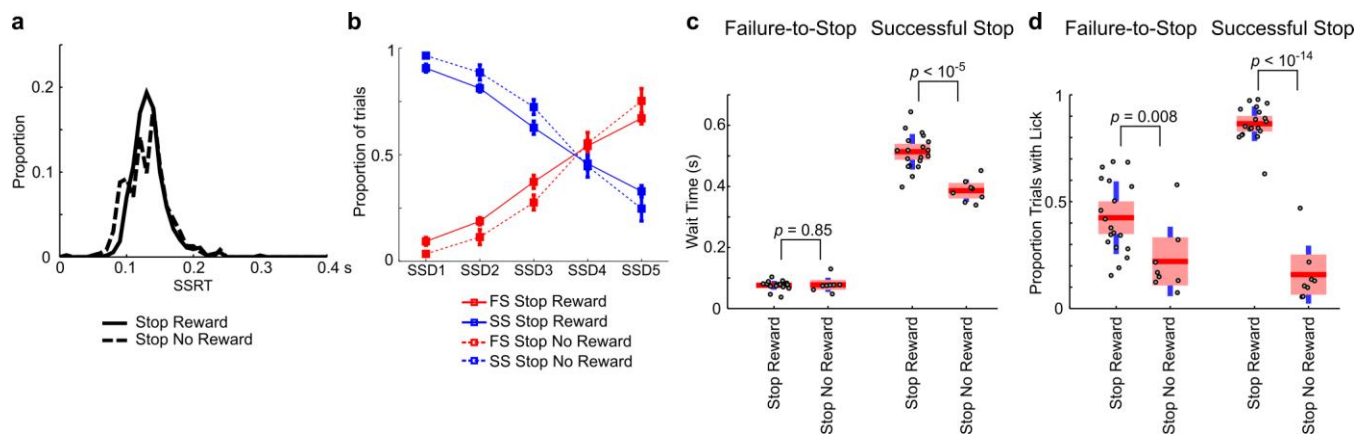


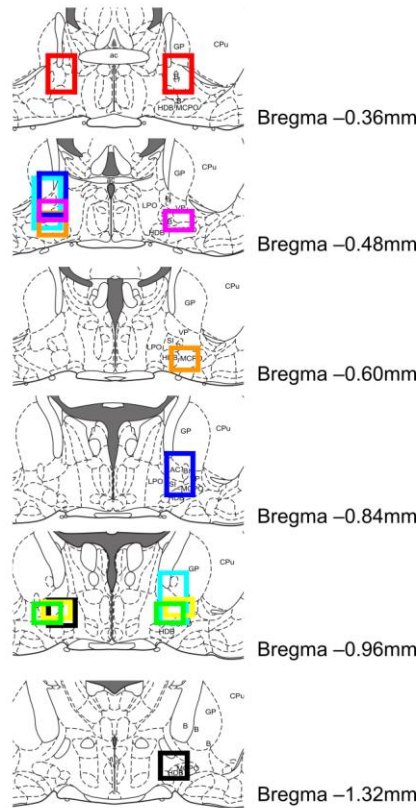


Supplementary Figure 1

Comparison of behavioral performance in two variants of SST

(a) Distributions of SSRT estimates in the two SST variants (Stop Reward: $n = 19$ rats, 543 sessions; Stop No Reward: $n = 8$ rats, 466 sessions). While rats were not required to stop in the Stop No Reward Task, they nonetheless showed rapid behavioral stopping to the stop signal, with similar SSRTs as in the Stop Reward Task. **(b)** The proportion (mean $\pm$ s.e.m.) of failure-to-stop (FS) and successful stop (SS) trials in the two SST variants at each of the five SSDs. SSD1 is always 0ms such that the tone and light were presented simultaneously. The remaining four SSDs were evenly spaced in 40ms steps and adjusted by experimenters between sessions. Rats failed to stop more often at longer SSDs in both variants of the SST. The similarity of SSRTs in both SST variants suggests that the rapid behavioral stopping in the SST does not depend on the knowledge that successful stopping is rewarded. **(c)** Wait time, the latency between stop signal onset and fixation port exit, was significantly longer in successful stop trials when stopping was rewarded (independent samples t-test). Individual animals (points) are plotted along with group mean (red), ± 1.96 s.e.m. (red shaded area) and ± 1 s.d. (blue) ($n=19, 8$; number of animals in the two SST variants) **(d)** The proportion of stop trials in which rats approached the reward port and licked at least three times was significantly higher in the Stop Reward Task than in the Stop No Reward Task. Conventions as in panel (c).

Histological reconstruction of BF recording sites

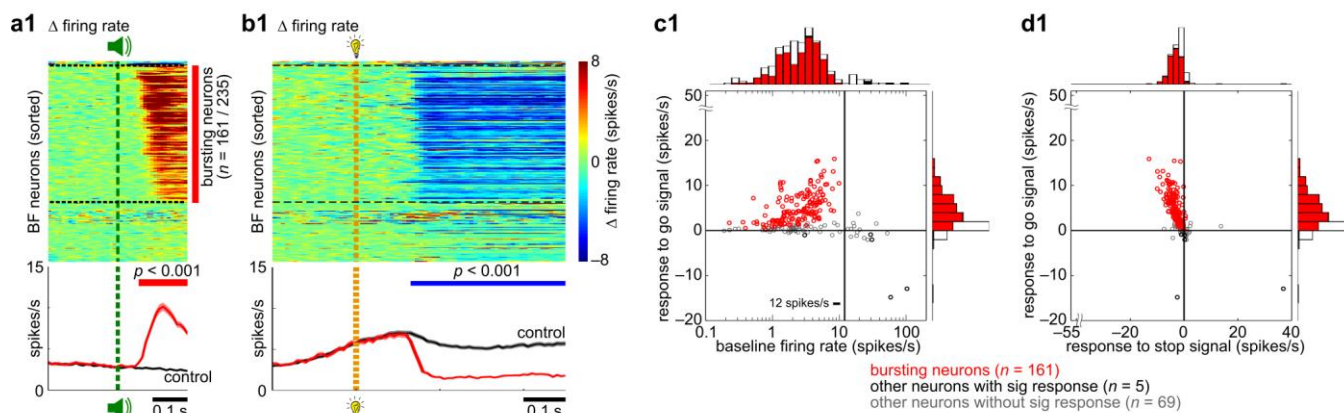


Supplementary Figure 2

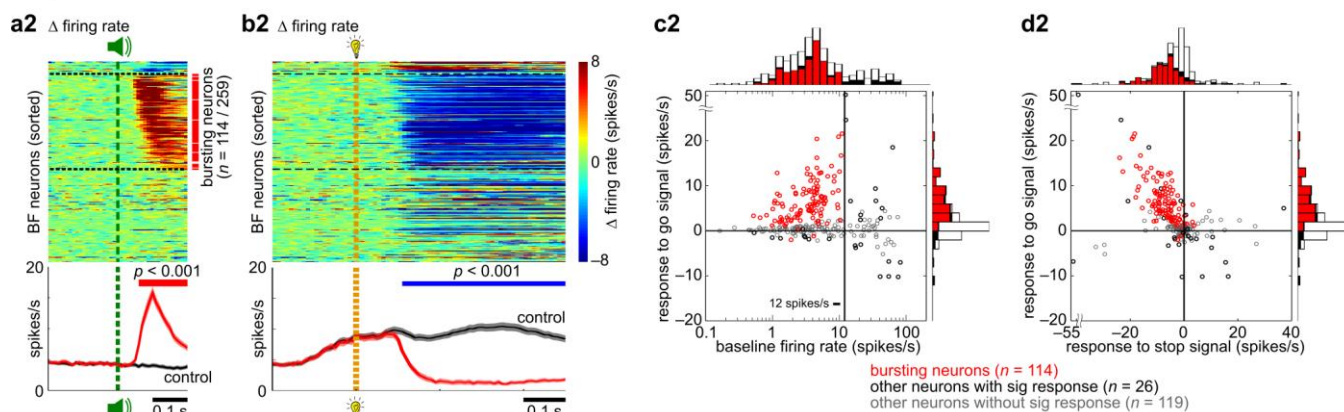
Histological reconstruction of BF recording electrode locations

Summary of the histological reconstruction in the current study, with each pair of colored boxes representing the locations of BF recording electrodes in one rat. Electrodes are located throughout multiple subregions including the ventral part of globus pallidus (GP), caudal ventral pallidum (VP), substantia innominata (SI), nucleus basalis of Meynert (NBM, or B), magnocellular preoptic nucleus (MCPO) and horizontal limb of the diagonal band (HDB), consistent with the widespread spatial distribution of cortically-projecting BF neurons²⁰.

Stop Reward Task



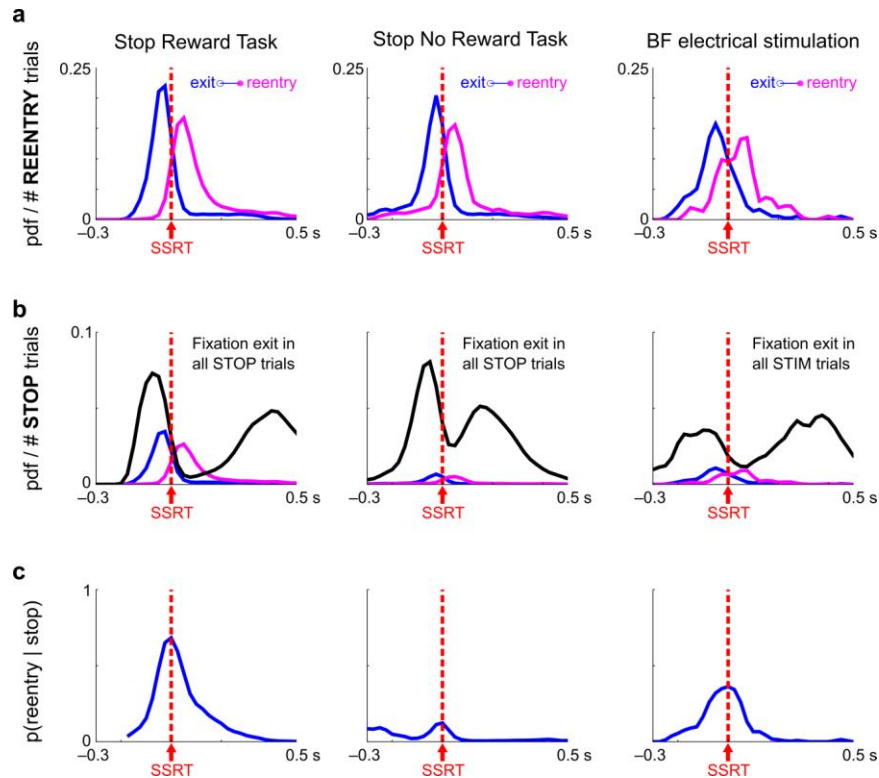
Stop No Reward Task



Supplementary Figure 3

BF bursting neurons were similarly inhibited by the stop signal in both variants of SST

The results in **Fig. 2** were plotted separately for the Stop Reward Task (top) and Stop No Reward Task (bottom). Conventions are the same as in **Fig. 2**. Inhibition to the stop signal was selective for BF bursting neurons in both SST variants.

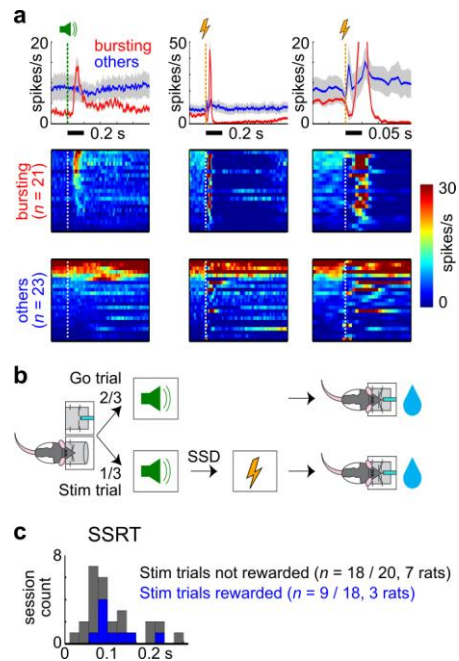


Supplementary Figure 4

Comparison of reentry behavior in the two SST variants and in the BF electrical stimulation experiment

(a) The distributions of fixation port exit and reentry events in all reentry trials in the three task conditions (Stop Reward, Stop No Reward, and BF electrical stimulation) relative to SSRT, reproducing **Fig. 6b** and **Fig. 8e**. In all cases, fixation port exit and reentry events were most common just before and after SSRT, respectively. These distributions were normalized by the number of reentry trials in each task, so the area under each distribution summed to one. **(b)** The distributions from **(a)** were normalized by the number of stop trials (or stimulated trials) in each task. The distributions of fixation port exit times in all stop trials were shown in black, and the areas under each black trace summed to one. **(c)** The distributions of fixation port exit in reentry trials (blue traces in **(b)**) were normalized by the distributions of fixation port exit in all stop trials (black traces in **(b)**) in each task at each 25ms bin. Fixation port exits at or around SSRT in stop trials were most likely to become reentry trials in all three task conditions.

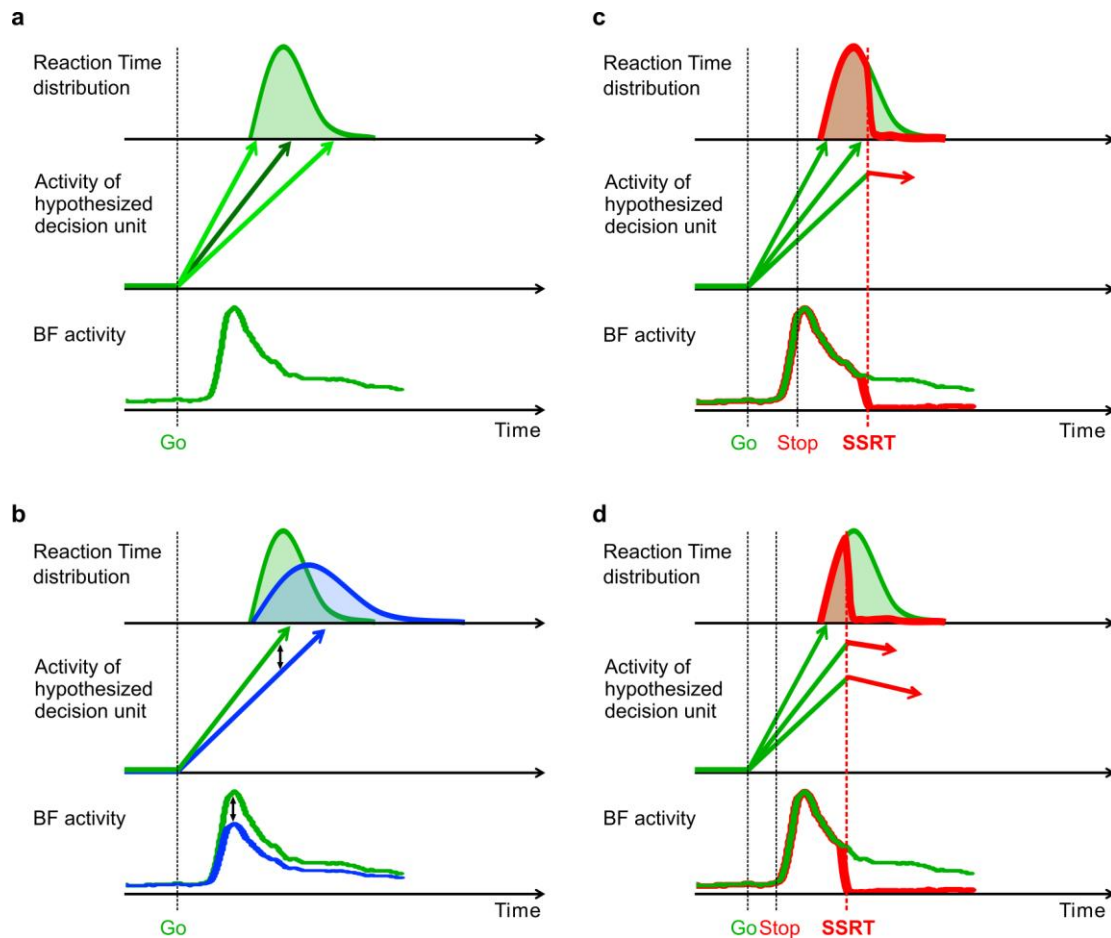
Results in **(b)** and **(c)** show that fixation port reentries were most frequent in the Stop Reward Task, followed by BF electrical stimulation, and least frequent in the Stop No Reward Task. The difference of reentry frequency between the two variants of SST likely reflected the modulation of task contingency, such that there was a stronger motivation to reenter when successful stopping leads to reward. Despite the lower frequency of reentry events in the Stop No Reward Task, the reversal of accelerometer signals at SSRT was similarly evident in most failure-to-stop trials in the Stop No Reward Task (**Fig. 6c, 6d**; 13/15 sessions from the Stop No Reward Task). The reentry behaviors and accelerometer signals together suggest that, in both SST variants, movement patterns in failure-to-stop trials began to differ from latency-matched go trials at SSRT. The difference between the two SST variants, however, was that the reversals of accelerometer signals at SSRT were converted at a lower rate to fixation port reentries in the Stop No Reward Task compared to the Stop Reward Task.



Supplementary Figure 5

Additional information related to the BF electrical stimulation experiments

(a) Response of bursting ($n=21$) and other ($n=23$) BF neurons to the go sound (left panel) and brief BF electrical stimulation (middle and right panels show different time scales, 11 sessions from 4 rats). Responses of individual neurons are color-coded in the middle and lower rows for bursting and other neurons, respectively. BF bursting neurons, but not other neurons, demonstrated near complete inhibition in response to BF electrical stimulation after a brief rebound excitation. **(b)** Schematic of a variant of the electrical stimulation experiment, which was the same as the version shown in **Fig.8a** except that the stimulated trials were rewarded as the non-stimulated trials, so that the presence of BF stimulation did not change reward contingency. In this task configuration, even if rats can perceive BF stimulation as a sensory cue, there was no reason to use perceived BF stimulation to modify behavior. **(c)** Distribution of estimated SSRT in two variants of the stimulation experiment. Stimulation slowed down fixation port exits in 18/20 sessions (7 rats) when stimulated trials were not rewarded (gray), and in 9/18 sessions (3 rats) when stimulated trials were rewarded (blue). SSRT estimates in the two variants of the stimulation experiment were not different (mean SSRT 111ms vs. 108ms, $F(1,25)=0.01$, $p=0.91$).



Supplementary Figure 6

A model for bidirectional control of the speed of response generation and inhibition by BF neurons

(a) Simple decision-making processes, such as those measured by RT, are commonly modeled by an activity accumulation process of a hypothesized decision unit that is likely located in the fronto-basal-ganglia circuit. In response to the go signal, a behavioral response is initiated once the activity of the decision unit reaches a threshold. Given the same go signal, the activity accumulation slope is variable from trial to trial (middle panel), resulting in variable RTs (top panel). This activity accumulation process likely depends on BF bursting activity (bottom panel) because successful detection in a near-threshold auditory detection task is coupled with the presence of BF bursting, while failed detection is coupled with the absence of BF bursting²⁵. **(b)** Blue and green traces depict neuronal and behavioral responses to two go signals that differ only in the associated amount of reward. A stronger BF bursting responses to the go signal is coupled with a faster and more precise RT distribution, suggesting that the strength of BF bursting modulates the slope of activity accumulation in the decision unit²³. **(c)** In the SST, the stop signal elicits near complete BF neuronal inhibition (red trace, bottom panel), which is coupled with and slightly precedes rapid behavioral stopping and SSRT (top panel). We hypothesize that BF neuronal inhibition leads to rapid behavioral stopping by preventing further activity accumulation in trials that have not reached threshold (middle panel). The short delay (~10ms) between the onset of BF neuronal inhibition and SSRT requires that BF can modulate cortical activity within the same delay. Consistent with such a requirement, BF bursting neurons can rapidly modulate cortical activity within 5-10ms to generate an event-related potential²⁶. **(d)** When the stop signal is presented earlier (compared to panel (c)), BF neuronal inhibition also occurs earlier and prevents more trials from reaching the threshold, resulting in more successful stop trials. Our results also suggest that the BF bursting response and BF neuronal inhibition can be independently controlled by the go signal and the stop signal, respectively, such that SSRT is not affected by the delay between go and stop signals. Together, these results support the unified hypothesis that BF bursting neurons serve as a bidirectional gain modulation signal for the decision-making process.