**Supplementary Figure 1**

**Striatal recordings and cerebellar stimulation.**

(a) Single-unit recordings were made in the dorsolateral striatum by using a drivable 8 wire microarray. The left photograph is a Nissl stained section of the striatum and shows the initial implant site in the dorsal edge of the dorsolateral striatum (DLS). Wires were advanced through the DLS after the initial implant in ≈75 µm increments as needed. The right photograph shows the final location of microwires at the end of the series of experiments done in this mouse. To identify the final location of the recording sites at the end of the experiment, current was passed through each electrode to produce lesions, and the animal was killed and the brain fixed soon after. Red arrows indicate the position of two such lesions.

(b) To electrically stimulate the dentate nucleus, a bipolar stimulating electrode was stereotaxically implanted into the contralateral cerebellum during the same surgery when the recording microarray was implanted in the striatum. The stimulating electrode tract is indicated by the red arrows.

(c) To stimulate the dentate nucleus optogenetically, ChR2 was expressed in the dentate nucleus by stereotaxic
injection of an AAV. A fiber optic implant was stereotaxically placed immediately above the injection site, contralateral to the recording site. The specificity of expression of ChR2 was examined by examination of ChR2-YFP expression (indicated in green; DAPI staining in blue). The location of the fiber optic was also ascertained at the end of each experiment histologically. In the case shown, the fiber optic tract is indicated by red arrows.

(d) In separate experiments to confirm that optogenetic stimulation reliably increased firing rate of neurons in the DN, single-unit recordings were made from ChR2-expressing neurons in the DN in awake, head-restrained mice using an optrode. The optrode, made by fixing a fiber optic to a recording electrode, allowed for simultaneous optogenetic stimulation and recording of DN neurons. An example neuron is shown. Stimulus was delivered at time zero.

Abbreviations: 4V: 4th ventricle; Int: interpositus nucleus; DN: dentate nucleus; LV: lateral ventricle; DLS: dorsolateral striatum; CC: corpus callosum.
Supplementary Figure 2

Striatal response characteristics to cerebellar stimulation.

(a) The average stimulus threshold for producing a response in striatal response with electrical stimulation of the dentate nucleus.

(b) The average striatal neuron response magnitudes (for both the excitatory and inhibitory periods) when the dentate nucleus was stimulated at the minimum threshold intensity that produced a detectable response.

(c) The fractional change in the response of striatal neurons to electrical stimulation of the dentate nucleus as the stimulus intensity was increased.
(d) The average laser power threshold emerging from the fiber optic for producing a detectable response in striatal neurons with optogenetic stimulation of the dentate nucleus.

(e) The average striatal neuron response magnitudes (for both the excitatory and inhibitory periods) when the dentate nucleus was optogenetically stimulated at the minimum threshold intensity that produced a detectable response.

All data shown are represented as mean ± S.E.M.
Supplementary Figure 3
Inactivation of the thalamus

Two approaches were used to inactivate the thalamus, primarily targeting the intralaminar nuclei.

(a) Response of a striatal neuron to cerebellar stimulation before, during, and 1 hour post infusion of QX-314 into the thalamus. The infusion cannula was stereotaxically placed to target CL although it is likely that the adjoining intralaminar nuclei might have also been affected. Note partial recovery during the washout period.

(b) To test whether specifically inactivating the thalamic neurons would attenuate striatal responses to cerebellar stimulation, the inhibitory light sensitive opsin ArchT was expressed by stereotaxically injecting an AAV targeting the centrolateral nucleus of the thalamus. As can be seen from Arch-GFP expression in green (DAPI staining in blue) Arch was expressed to large extent in the CL and the adjoining regions. The fiber optic was also stereotaxically implanted to target CL, further narrowing the area which was optogenetically manipulated. The fiber optic injury tract is indicated by red arrows and shows that CL was accurately targeted.

Abbreviations: LHb, lateral habenula; LDDM, laterodorsal thalamic nucleus, dorsomedial part; HP, hippocampus; CL, centrolateral thalamus; MDL, mediodorsal thalamic nucleus, lateral part; PC, paracentral nucleus of the thalamus; CM, centromedial thalamus;

(c) To examine the firing rates elicited by ArchT inactivation, we performed single-unit optrode recordings from thalamic neurons in awake, head-restrained animals (n=7, N=3). Activation of ArchT significantly decreased the firing rate of the thalamic neurons by approximately 80% (****=p<0.0001, one-tailed student’s t-test) for the duration of the 1 second pulse. Data shown in the left panel are normalized to the mean firing rate. S.E.M. is indicated in the dotted-red lines. Mean ± S.E.M. shown in the right panel.
Supplementary Figure 4

Striatal responses to cerebellar stimulations are blocked by isoflurane-induced anesthesia.

Previous work has demonstrated that striatal responses to cerebellar stimulation occur only with strong trains of cerebellar stimulation and at latencies between 50-350 ms. However, the recordings were made under anesthesia. To test whether anesthesia influences striatal responses to cerebellar stimulation, after obtaining reliable striatal responses to cerebellar stimulation in awake mice, the animals were anesthetized using isoflurane. In all cases examined (n=34, N=4) isoflurane-induced anesthesia reversibly abolished cerebellar-induced striatal responses. An example experiment is shown.
Supplementary Figure 5

Surgical removal of the motor cortex

To test whether the motor cortex is necessary for the short latency striatal responses to cerebellar stimulation, motor cortices were aspirated bilaterally.

(a) Photograph of brain of a mouse after surgical removal of the cortex. For presentation and comparison purposes, the cortex was removed only on one side in this mouse. In actual experiments the motor cortex was similarly aspirated on both hemispheres.

(b) Nissl stained coronal slice of brain of an animal actually used for the experiments described in the text. Note the complete removal of the motor cortex. The deformation of ventricles seen here was routinely seen when the cortex was removed.

Abbreviations: Cg: cingulate gyrus; M1: primary motor cortex; M2: secondary motor cortex; S1: somatosensory cortex; S2: secondary somatosensory cortex; Str: striatum; cc: corpus callosum.