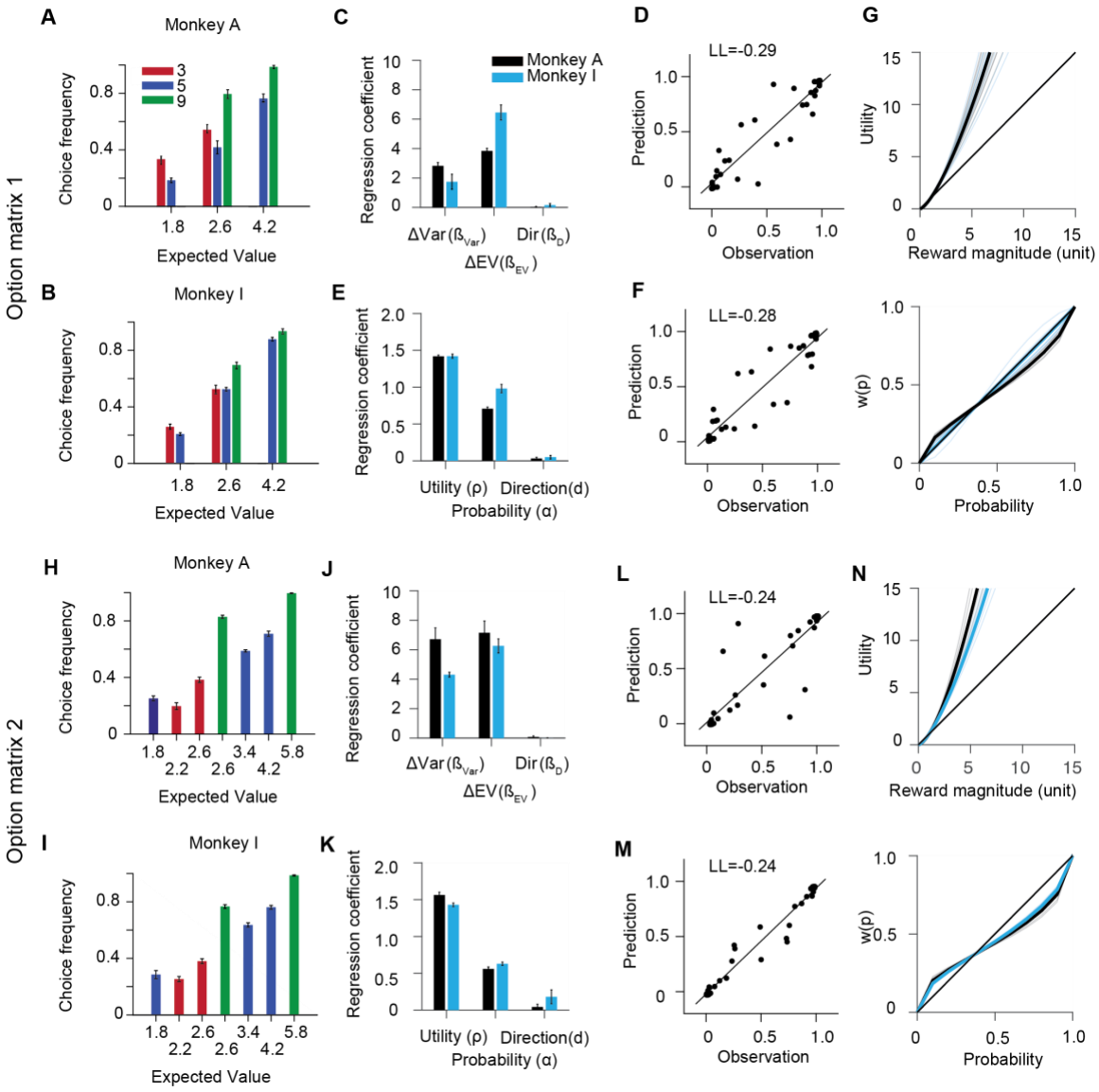

Figure S1. Choice patterns with both option matrices. Related to Figure 2. Quantitatively similar behavioral results were observed using both option matrix 1 and option matrix 2, when behavior was modeled using the risk-value and the prospect theory models. Across both option matrices, the monkeys behaved risk-seeking. (A-F) Option matrix 1. (A, B) The overall frequency of choosing a particular gamble option, when paired against all other options, for option matrix 1 for monkey A (A) and monkey I (B). The colors of the bars indicate the maximum reward amount of the gamble options (same as Figure 1B). (C) Regression coefficients of the risk-value model indicate preference for options with higher risk (ΔVar, β_{Var}) and higher expected value (ΔEV, β_{EV}) (Monkey A, black; Monkey I, blue). (D) Prediction accuracy of choice frequencies across the gamble options for the risk-value model. (E) Regression coefficients of the prospect theory model indicate a convex utility function (ρ) and an inverted S-shaped probability

weighting function (α) (Monkey A, black; Monkey I, blue). (F) Prediction accuracy of choice frequencies across the gamble options for the prospect theory model. (G) The top panel shows the utility functions across all sessions (thick line) and for individual sessions (thin lines). The bottom panel shows the probability weighting functions across all sessions (thick line) and for individual sessions (thin lines). (Monkey A, thick black and thin grey lines; Monkey I, thick dark blue and thin light blue lines) (H-M) Option matrix 2: Same schema as for option matrix 1. Error bars denote s.e.m.

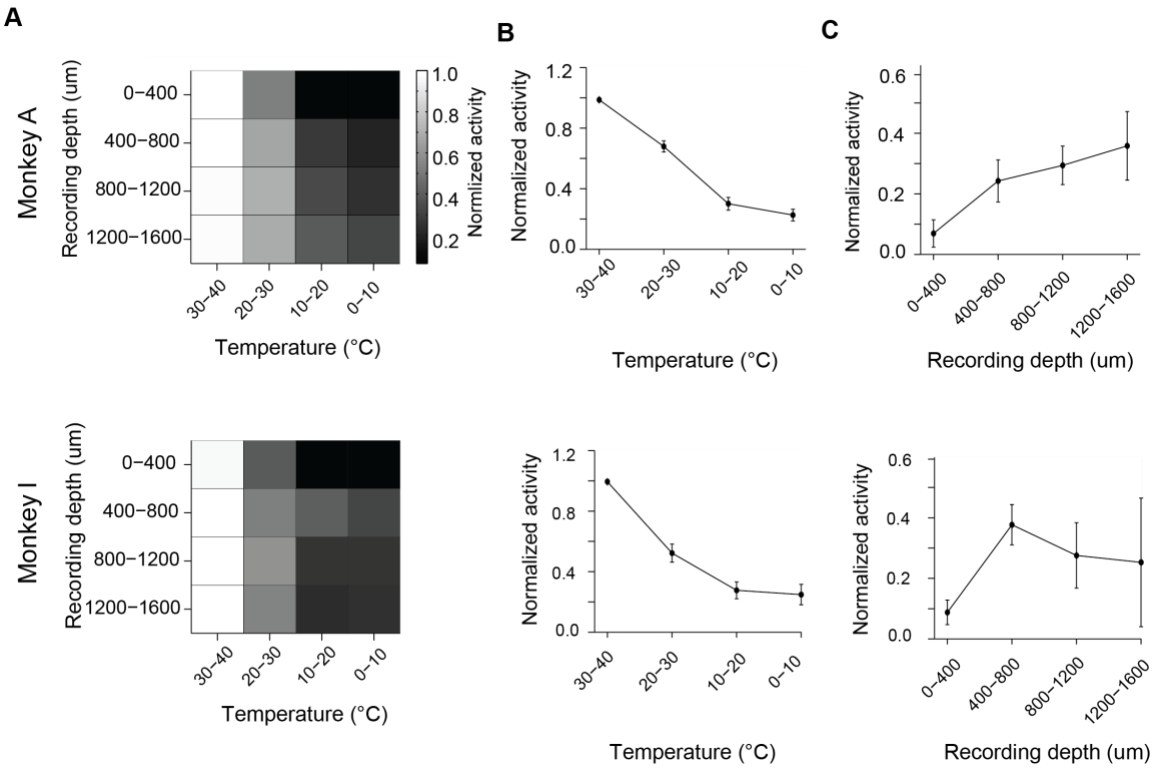

Figure S2. The effect of cooling inactivation on action potentials. Related to Figure 1 and STAR Methods. (A) The effect of cooling on SEF multi-unit spiking activity as a function of the temperature of the cooling probe and depth of recording for both Monkey A (top) and Monkey I (bottom). For each inactivation session, the average multi-unit firing rate during each trial was normalized to its maximum average firing rate across all trial conditions. The matrix shows the average normalized activity across all recordings for each monkey for a particular combination of temperature and recording depth. The brightness of the gray scale indicates activity levels. As the matrix indicates, maximum neuronal activity is seen during control temperature conditions in the absence of inactivation. The darkness of an element in the matrix therefore indicates the degree to which activity is reduced by inactivation. (B) The neuronal activity as a function of temperature averaged across all recording depths for both monkeys. (C) The neuronal activity as a function of recording depth averaged across all temperatures for both monkeys. b and c confirm the pattern seen in the matrix. The error bars represent s.e.m.. Lowering the temperature of the cooling probe leads to a reduction of neuronal activity. The activity reduction is more pronounced the closer the recording site is to the cooling probe above the cortical surface. Nevertheless, even at the deepest recording sites (1200-1600 μm), the neuronal activity was still reduced by around 70% if temperatures were less than 10°C. Altogether, the distance over which the cooling affected the cortex was restricted to ≤2.5 mm. Accordingly, neighboring areas in the medial wall, such as

pre-supplementary motor area and anterior cingulate cortex (ACC) should not be affected by the cooling.

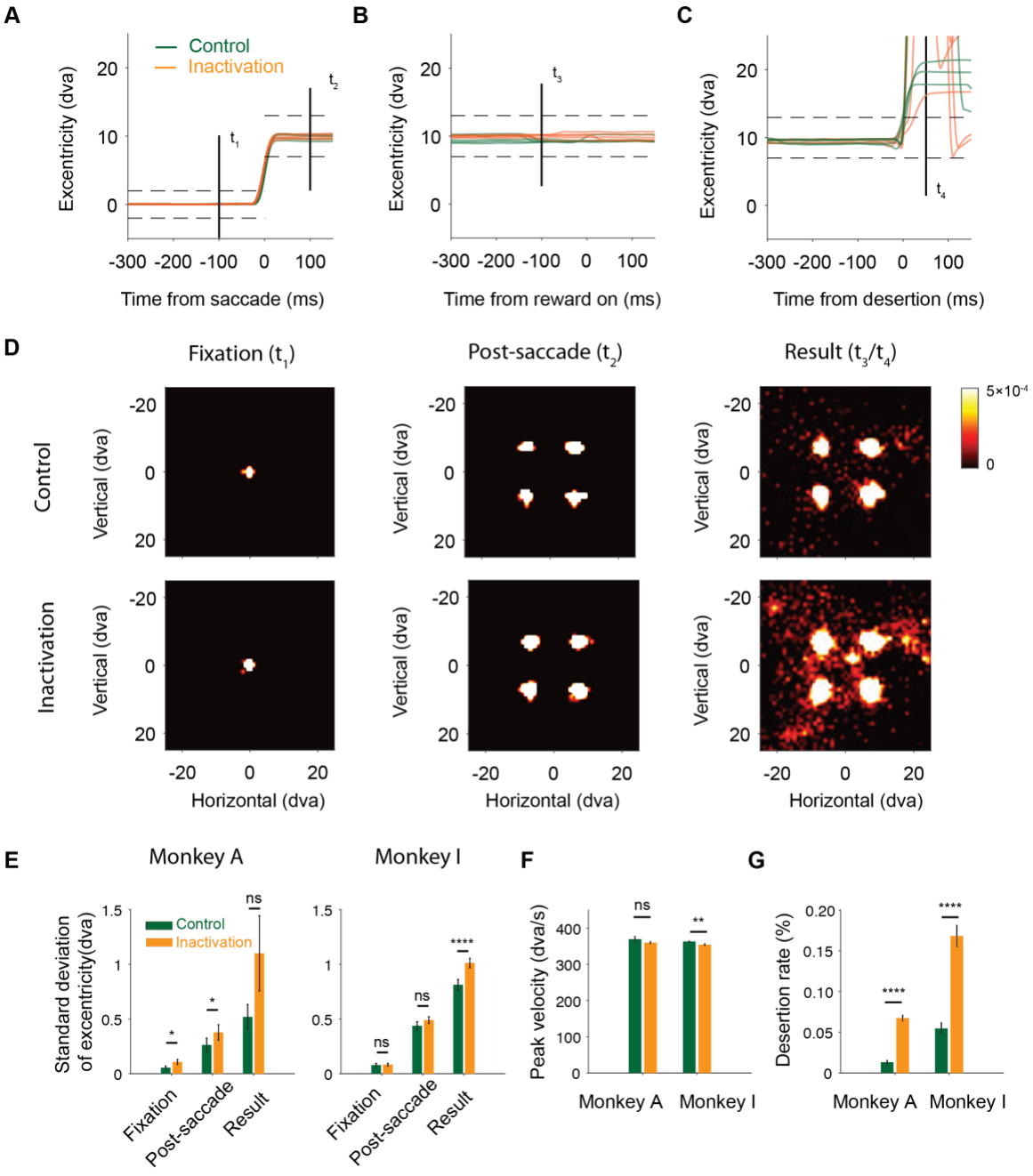

Figure S3. The effect of bilateral SEF inactivation on saccade and fixation metrics. Related to Figure 4. (A-C) Eye position traces during an example session in the control (n=5 trials, green) and inactivation (n=5 trials, orange) condition. The eye position traces were quantified by eccentricity (dva, degree of visual angle, radius from the center of the screen). The dashed lines indicate the positions of fixation or saccade windows. (A) The eye position traces during the choice period immediately before and after the saccades. The traces are

aligned on the onset of the saccade, with which the monkey chooses the desired gamble option. (B) The eye position traces aligned on reward onset during the success trials, in which the monkey successfully finished the trials. The reward onset time is the same as the result cue turn-off time, and it is the time when fixation is no longer required. (C) The eye position traces aligned on desertion onset in the desertion trials during result period. In these trials, the monkeys fail to hold fixation by making a saccade outside of the fixation window after the gamble results were revealed. (D) Eye position density estimates during the fixation (t1, left), post-saccade (t2, middle), and result (t3 and t4 combined, right) periods when fixation was required to finish the trial. The fixation period shows the eye position distribution during the fixation period (t1=100ms before saccade onset, see a). The distribution during post-saccade period shows the scatter of the fixations shortly after saccade to the choice option (t2=100ms after saccade onset, see a). The distribution during result period (t3=100ms before the reward was delivered or 50ms after the trials were deserted, see b and c) shows the eye positions of the monkeys during the time period after the gamble results were revealed. During this period, fixations were required for the reward delivery. (E) Standard deviations of eccentricities of fixations during fixation (t1), post-saccade (t2), and result periods in the success trials (t3) in control (green) and inactivation (orange) conditions. Inactivation significantly increase of fixation scatters during fixation and post-saccade periods for Monkey A, and during result periods for Monkey I. Importantly, the significant increased variances in eye position during the different periods were less than 0.2 dva. For comparison, the size of the fixation window was 4 dva, and the size of the saccade target window was 6 dva. (F) Peak velocities of saccades during choice period show no significant differences between control and inactivation condition for monkey A. They are slightly slower ($\overline{\Delta V} = -8.38$ dva/s, paired t-test, p=0.01) for Monkey I. (G) Desertion rates during the result period. The desertion trials are defined as the trials in which the monkeys made active saccades outside of the fixation window after the gamble results were revealed. The desertion rates are significantly higher for both monkeys (Monkey A: $\overline{\Delta rate} = 5.41$, paired t-test, $p = 1.00 \times 10^{-8}$; Monkey I: $\overline{\Delta rate} = 11.35$, paired t-test, $p = 1.24 \times 10^{-7}$). The error bars represent s.e.m; paired t-test; ns, non-significant; *, p <0.05; **, p <10^{-2}; ***, p <10^{-3}; ****, p <10^{-4}.

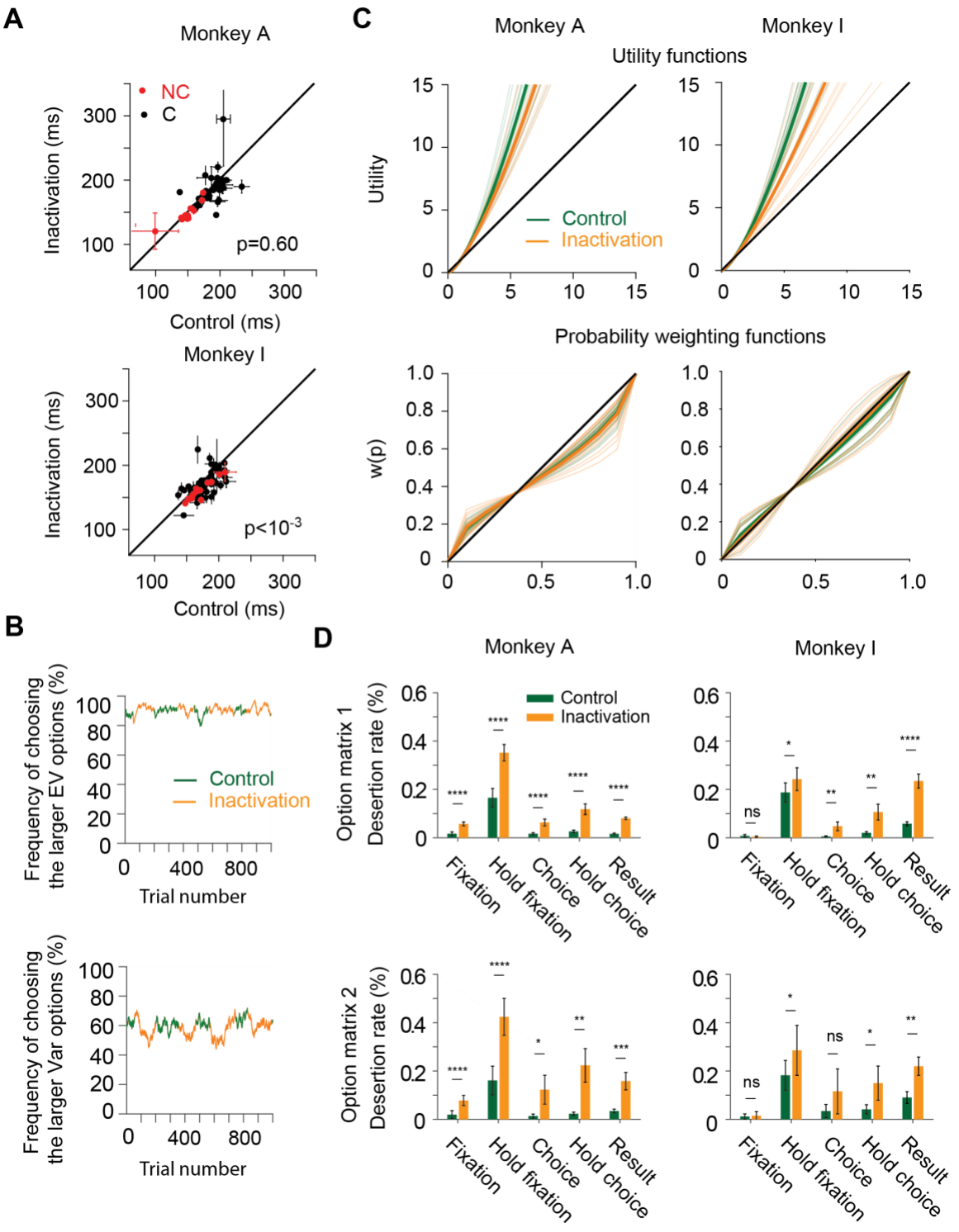

Figure S4. The effect of bilateral SEF inactivation on reaction time, risk preference and trial dissertation rate. Related to Figure 3 and 4. (A) The effect of bilateral SEF inactivation on reaction times for no-choice trials (14 trial types) and choice trials (42 trial types) for monkey A (top) and monkey I (bottom). There is no significant change of reaction times for monkey A in both no-choice

($p = 0.23$) and choice condition ($p = 0.78$). There is a small but significant reduction of reaction times for monkey I in both no-choice ($p = 1.08 \times 10^{-4}$) and choice condition ($p = 5.30 \times 10^{-3}$) (see also table S3). (B) An example session shows the trial-by-trial change of choice frequency for higher EV options (top) and higher Var options (bottom) during control (green) and inactivation (orange). (C) Reduction of risk-seeking estimated by the prospect theory model. The corresponding utility functions (top) and probability weighing functions (bottom) are shown during the control (green) and inactivation (orange) condition for both monkey A (left) and I (right). (D) Bilateral SEF inactivation increased the trial quitting rate of trial in almost all epochs of the task. The panels compare dissertation rates during 5 different trial periods in both monkeys across both option matrices in the control (green) and inactivation (orange) condition. Specifically, trial dissertation in each epoch is defined as: 1) Fixation: failing to saccade into the fixation window within a 1s time window following the onset of the fixation cue. 2) Hold fixation: breaking fixation during the 500-1000ms period when only the fixation spot was on the screen, before the targets appear. 3) Choice: failing to choose a target by making a saccade into one of the target windows within a 1 s time window following target onset (i.e., the decision-period). 4) Hold Choice: breaking fixation during the 500-600 ms period following the choice, before the gamble results were revealed. 5) Result: breaking fixation during the 300-600 ms period after the result was revealed and before the reward is delivered. Error bars denote s.e.m.; paired t-test, ns, non-significant; *, p <0.05; **, p <10^{-2}; ***, p <10^{-3}; ****, p <10^{-4}.

Table S1. Gamble options used in both option matrices. Related to Figure 1B.

	Options	1	2	3	4	5	6	7
Option Matrix 1	Maximum reward	3	3	5	5	5	7	7
	Probability of winning	40%	80%	20%	40%	80%	20%	40%
	Minimum reward	1	1	1	1	1	1	1
	Probability of losing	60%	20%	80%	60%	20%	80%	60%
	Expected value	1.8	2.6	1.8	2.6	4.2	2.6	4.2
	Variance	0.98	0.80	1.60	1.96	1.60	3.20	3.92
	Coefficient of variance	0.54	0.31	0.89	0.75	0.38	1.23	0.93
Option Matrix 2	Maximum reward	3	3	5	5	5	7	7
	Probability of winning	60%	80%	20%	60%	80%	20%	60%
	Minimum reward	1	1	1	1	1	1	1
	Probability of losing	40%	20%	80%	40%	20%	80%	40%
	Expected value	2.2	2.6	1.8	3.4	4.2	2.6	5.8
	Variance	0.98	0.80	1.60	1.96	1.60	3.20	3.92
	Coefficient of variance	0.45	0.31	0.89	0.58	0.38	1.23	0.68

Table S2. Bayesian information criterion (BIC) and log-likelihood (LL) for different risk models. Related to Figure 2.

			Risk-value model					Prospect theory model		
			EV	Var	EV+CV	EV+Var	EV+Var +Repeat	U	P	U+P
Option Matrix 1	Control	BIC	330.59	481.50	287.98	275.61	293.37	293.64	378.51	**279.19**
		LL	-0.38	-0.51	-0.30	-0.29	-0.29	-0.30	-0.38	**-0.28**
	Inactivatio	BIC	198.70	389.82	186.51	**181.63**	193.76	194.39	232.15	190.03
		LL	-0.35	-0.54	-0.32	**-0.32**	-0.32	-0.33	-0.39	-0.31
Option Matrix 2	Control	BIC	337.28	322.09	220.73	208.64	227.68	290.29	314.58	**206.12**
		LL	-0.39	-0.38	-0.25	-0.24	-0.24	-0.34	-0.36	**-0.24**
	Inactivatio	BIC	176.76	279.23	141.41	**138.17**	152.22	178.58	171.39	144.89
		LL	-0.42	-0.43	-0.33	**-0.32**	-0.33	-0.42	-0.40	-0.33

BIC values are computed averaging across session across two monkeys. LL values are computed using cross validation for monkeys (see STAR Methods). The prospect theory models with both nonlinear utility function and probability weighting function are the best models (blue) with lowest BIC values for all control conditions.

Table S3. SEF inactivation does not have significant/consistent effect on saccade reaction times in both visual guided saccade task and gamble task. Related to Figure 3.

			Saccade reaction times (ms)				ANOVAs		
			Top-right	Top-left	Bottom-left	Bottom-right	Dir	Inact	Interact
Visual guided	**Monkey A**	Control	170.07 ±3.16	163.42 ±2.56	176.27 ±4.28	188.39 ±3.10	F (3,24) =18.65 p<0.001	F (1,24) =0.19, p=0.67	F (3,24) =0.59, p=0.63
		Inact	162.94 ±3.08	161.46 ±3.13	178.90 ±4.69	184.66 ±2.54			
	Monkey I	Control	155.67 ±2.87	152.30 ±3.19	178.45 ±6.82	178.41 ±11.50	F (3,16) =9.41 p<0.001	F (1,16) =0.53, p=0.48	F (3,16) =0.17, p=0.91
		Inact	150.67 ±0.52	142.97 ±0.79	176.31 ±5.41	179.45 ±8.36			
No-choice	**Monkey A**	Control	158.23 ±3.11	149.30 ±4.87	156.82 ±9.97	165.29 ±3.79	F (3,120) =2.79 p =0.04	F (1,120) =0.24 p=0.62	F (3,120) =1.11, p=0.34
		Inact	151.66 ±8.49	146.77 ±5.74	175.37 ±15.24	166.20 ±17.64			
	Monkey I	Control	166.28 ± 7.22	167.18 ±9.99	181.90 ±11.80	181.59 ±14.55	F (3,112) =35.01 p <10^{-4}	F (1,112) =28.63, p<10^{-4}	F (3,112) =2.77, p=0.04
		Inact	156.47 ±1.92	149.80 ±2.67	171.71 ±3.15	179.33 ±3.89			
Choice	**Monkey A**	Control	169.83 ±6.68	169.17 ±7.08	174.47 ±9.07	184.21 ±8.69	F (3,120) =0.47 p =0.70	F (1,120) =0.92, p=0.37	F (3,120) =0.17, p=0.91
		Inact	159.25 ±13.28	171.38 ±5.74	166.76 ±15.24	171.47 ±17.64			
	Monkey I	Control	169.09 ± 1.35	165.96 ±1.48	191.89 ±1.86	193.41 ±1.84	F (3,112) =203.6 p <10^{-4}	F (1,112) =17.03 p =10^{-4}	F (3,16) =4.54 P<0.01
		Inact	161.24 ±1.69	156.82 ±1.63	187.34 ±1.54	195.50 ±1.82			

Saccade reaction times columns represent the monkeys' saccade reaction time ± s.e.m. for each direction during inactivation (Inact) and control (Control) conditions. ANOVAs test columns represent the p value in ANOVAs test for a direction effect (Dir), an inactivation effect (Inact), and an interaction effect (Interact) between direction and inactivation on reaction time during the visual guided saccade task. The results show that both monkeys showed a directional bias in their reaction time, but no consistent inactivation effect.