Investigating Signal Integration with Canonical Correlation Analysis of fMRI Brain Activation Data

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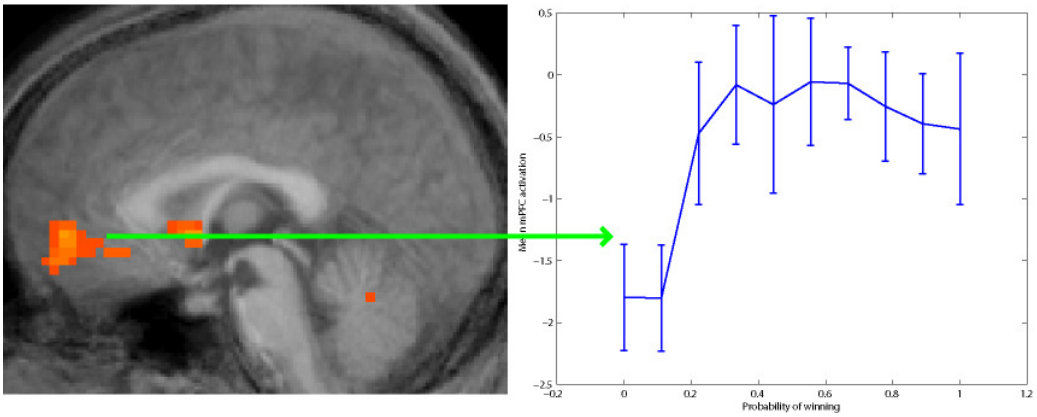
Supplementary Online Material

Figure S1

Activation of the downstream area for variable CCA weights



(a) We show here the activation of the downstream area to the gambling experiment described in the main text. Results are based on a random-effects GLM analysis with the combined signal of ER and risk as one of the predictors. The combined signal was obtained with CCA with fixed weights across all subjects. The area extends for 50 voxels ($3x3x3mm^3$) around the center (0, 46, -2) in Talairach coordinates (threshold at $q<0.025$, corrected for false discovery rate for the whole brain (Genovese et al., 2002)).

(b) Mean activation of the mPFC cluster against the probability of winning. Activation reflects the effect of both ER and risk; as such, mPFC encodes a signal of ER and Risk that is increasing in its two components. The inverted U shape shows that the area encodes risk positively. However, the activation is not symmetrical around p=0.5; it is higher for corresponding probabilities of reward above 0.5, reflecting the influence of ER on the activation.

Table S1

Subject #1:	9.64883 ER +	128.528 Risk	(p=1.13496e-007)
	36.8398 ER -	50.7502 Risk	(p=0.00663731)
Subject #2:	23.0167 ER -	118.01 Risk	(p=0.24606)
	30.2432 ER +	71.4444 Risk	(p=0.430946)
Subject #3:	37.4796 ER +	14.2743 Risk	(p=5.31106e-005)
	4.83338 ER -	136.457 Risk	(p=0.347261)
Subject #4:	17.1629 ER +	121.727 Risk	(p=0.00550291)
	33.6703 ER -	63.2059 Risk	(p=0.606536)
Subject #5:	10.5285 ER +	130.463 Risk	(p=0.0262662)
	36.0511 ER -	39.7772 Risk	(p=0.0587259)
Subject #6:	30.9063 ER +	71.453 Risk	(p=0.000131275)
	21.7995 ER -	117.237 Risk	(p=0.0392572)
Subject #7:	36.8018 ER +	14.8235 Risk	(p=0.000187338)
	10.4833 ER -	138.163 Risk	(p=0.84029)
Subject #8:	34.3306 ER -	51.2403 Risk	(p=0.398796)
	16.0396 ER +	127.469 Risk	(p=0.870918)
Subject #9:	29.212 ER +	68.3016 Risk	(p=0.00411023)
	25.1743 ER -	122.158 Risk	(p=0.527578)
Subject #10:	17.9495 ER +	120.223 Risk	(p=0.00151001)
	33.1722 ER -	65.5006 Risk	(p=0.136472)
Subject #11:	30.3345 ER +	82.8602 Risk	(p=0.230737)
	22.3165 ER -	108.725 Risk	(p=0.97784)
Subject #12:	25.0819 ER +	89.7165 Risk	(p=0.0210484)
	28.7212 ER -	105.428 Risk	(p=0.973022)
Subject #13:	33.7852 ER -	64.1337 Risk	(p=1.85357e-005)
	18.778 ER +	121.874 Risk	(p=0.00630116)
Subject #14:	36.9806 ER +	49.9829 Risk	(p=0.0831124)
	9.21998 ER -	128.921 Risk	(p=0.542606)
Subject #15:	36.5121 ER -	43.5183 Risk	(p=0.000494975)
	12.1574 ER +	130.347 Risk	(p=0.120537)
Subject #16:	13.767 ER +	123.949 Risk	(p=0.00427524)
	35.3256 ER -	59.7966 Risk	(p=0.82054)
Subject #17:	35.3855 ER +	31.7852 Risk	(p=0.00399616)
	14.2118 ER -	134.704 Risk	(p=0.386965)
Subject #18:	23.0758 ER +	105.158 Risk	(p=0.0773288)
	31.0818 ER -	89.2707 Risk	(p=0.253785)
Subject #19:	37.6783 ER -	28.6966 Risk	(p=6.37116e-005)
	3.93041 ER +	134.483 Risk	(p=0.017682)

Estimates of CCA weights and Wilk's lambda p-values for all rows (rows correspond to the two CCA solutions; only the first row is relevant for the post-CCA GLM analysis depicted in Figure S1) and all subjects. We observed that out of 19 subjects, 14 had weights with identical signs for both predictors on both rows (p(single comparison, all subjects)<0.032).

Table S2
Results of the CCA estimation with AR(1) correction

Overall p-value < 10^{-7}					
Weight	p-value	Predictor / adjusted time course	Talairach		
			x	y	z
$a_1 = 46$	$<10^{-7}$	ER			
$a_2 = 92$	<0.0002	Risk			
$b_1 = 0.36$	<0.0004	Putamen	-22	-8	8
$b_2 = 0.41$	$<10^{-6}$	Ventral Striatum	-12	5	-3
$b_3 = -0.28$	<0.0002	Insula	-31	21	9

CCA weights computed after removal of serial correlation from the adjusted fMRI data with an AR(1) model (autocorrelation estimate based on raw adjusted fRMI data for all 19 subjects). The overall significance, computed with Wilks' lambda, is $p<10^{-7}$; estimated weights on predictors and adjusted time courses are all significant (see Appendix B for the computation of p-values).

Reference

Genovese, C.R., Lazar, N.A., Nichols, T., 2002. Thresholding of statistical maps in functional neuroimaging using the false discovery rate. Neuroimage 15, 870-878.