Supplementary Material

Confidence in value-based choice

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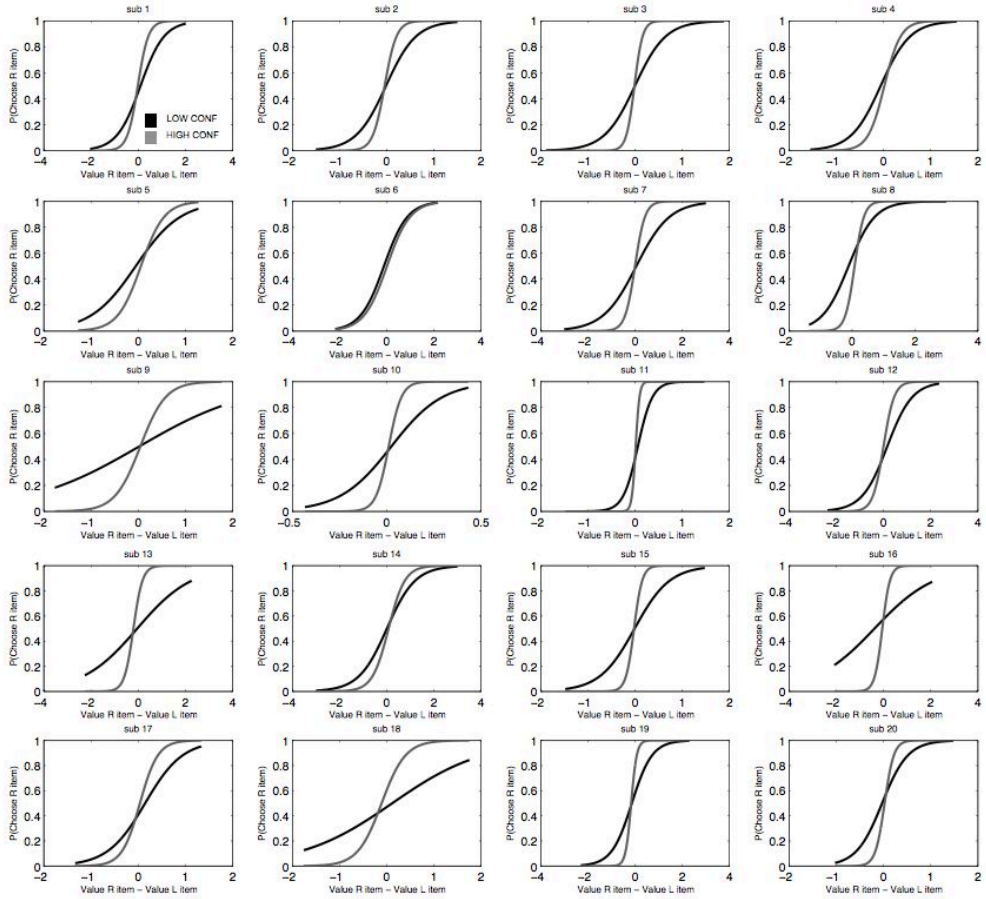
Supplementary Figures

Supplementary Figure 1 – *Choice plots for all participants*



Probability of choosing the item on the right as a function of the difference in value (i.e. bid price) between the 2 items (logistic fit; black line = low confidence choices; grey line = high confidence choices).

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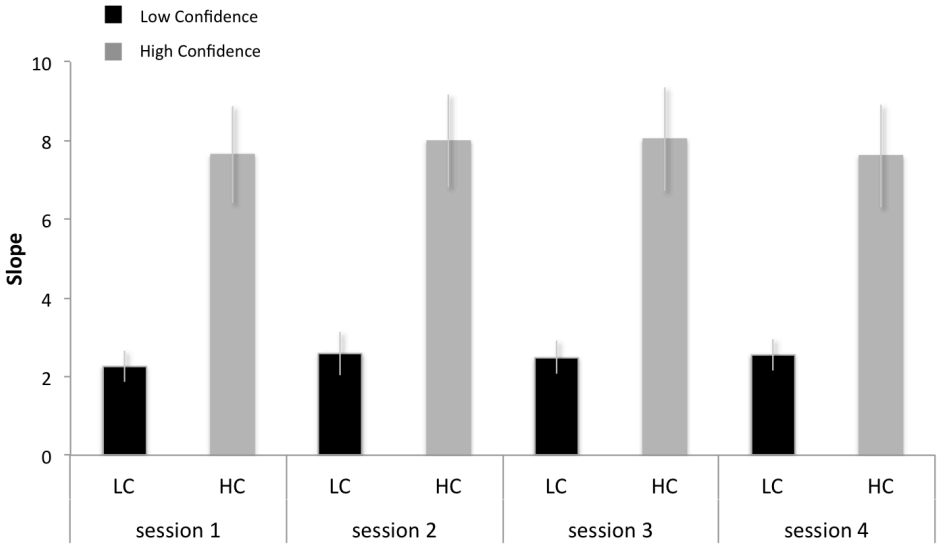
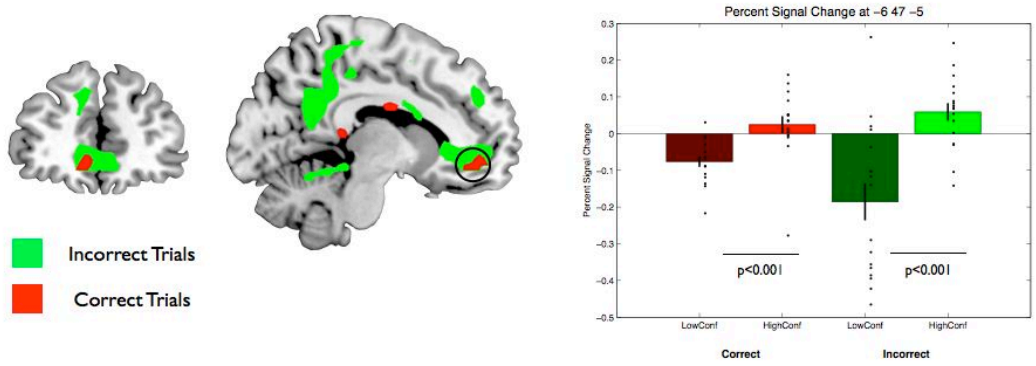
Supplementary Figure 2 – ***Stability of the behavioural effect over time***



Slope from a logistic regression model predicting choice from DV, separately for high and low confidence and split by session.

Supplementary Figure 3 – ***Effect of correct/incorrect choice on the confidence signal in vmPFC***



Here we ask whether the vmPFC response to confidence can be explained by a categorical difference between correct and error trials. We constructed another GLM similar to GLM 2 (see Methods) in which we split the categorical confidence regressor into two further regressors: one for correct trials (i.e. trials in which the participant chose the item with higher value – red in the figure) and one for incorrect trials (i.e. the participant chose the item with lower value – green in the figure). This analysis revealed a significant response in vmPFC to confidence in both conditions, confirming that the effect of confidence we identified was not driven by a categorical responses to errors.

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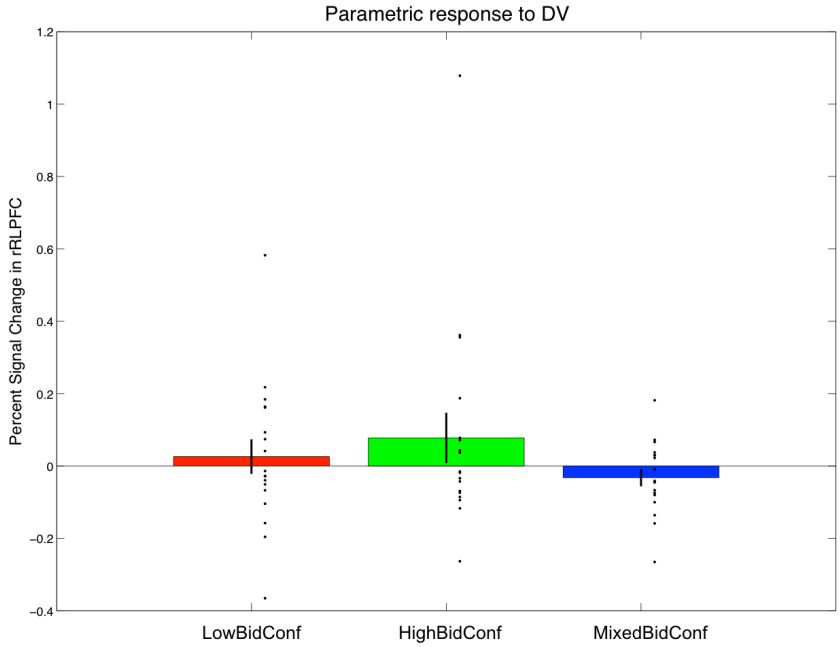
Supplementary Figure 4 – *Effect of bid confidence on the response of rRLPFC to |DV|*



In this analysis each item was categorized (using a median split) into high or low bid confidence (using the bid confidence measured at the end of the experiment). This allowed us to construct a new parametric GLM (see Methods) in which each regressor is split into three new regressors: low bid confidence pairs, high bid confidence pairs, and mixed bid confidence pairs. Each regressor was parametrically modulated by both choice confidence and |DV|. Note that 2 subjects had to be excluded from this analysis due to a reduced variability in the bid confidence that did not allow a median split. This new model established that the activity of rRLPFC is insensitive to |DV| across all levels of bid confidence (in each of the 3 conditions the parametric response to |DV| in rRLPFC is not significantly different from zero -- one sample t-test $p>0.1$). This analysis excludes the possibility that a |DV| signal in rRLPFC may have been masked by weak value signals in low bid confidence trials. The plot shows the parameter estimates for the LowBDMconf condition (green), the HighBDMconf condition (red) and the MixedBDMconf condition (blue).

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Supplementary Tables

Supplementary Table 1 – *Analysis of additional factors affecting confidence and value*

Factor	Analysis	Results
Item familiarity*	Linear regression of familiarity and |DV| on confidence	Mean familiarity was a significant predictor of choice confidence (t_{19}=3.09, P<0.01, individually significant in 13 out of 20 subjects); as established previously, |DV| also significantly predicted choice confidence in this model (t_{19}=8.55, P<0.001)
Actual retail price**	Pearson correlation between price and BDM bid	1 out of the 20 participants showed a significant positive correlation between the actual retail price of each item and the bids they submitted for these items (group mean r = 0.0064 ± 0.24).
Belief about retail price*	Pearson correlation between price and BDM bid	4 out of 20 subjects showed a significant correlation between their beliefs about retail prices and the bids they submitted for these items (group mean r = 0.23 ± 0.27).
Taste[†]	One-way repeated measures ANOVA of mean confidence by factor sweet/salty/mixed	Confidence ratings were not affected by item type ($F_{(1.273, 24.182)}$ = 1.001, P = 0.347).
Calorie content[‡]	One-way repeated measures ANOVA of mean confidence by factor high/low/mixed calorie	Confidence ratings were not affected by calorie level ($F_{(1.141, 21.671)}$ = 0.681, P =0.437).

*Item familiarity and belief about retail price were collected in post-experiment questionnaires. **Actual retail prices were taken from a UK supermarket website. [†]Taste was determined by categorising each item as sweet or salty, and dividing post-choice confidence ratings into 3 groups: sweet (where both items in the choice pair comprised items categorised as sweet); salty (where both items in the choice pair comprised items categorised as salty); mixed (where a choice pair consisted of one item categorised as sweet and one item categorised as salty). [‡]Calorie content was determined by categorising items as high or low calorie (median split), and dividing post-choice confidence ratings into 3 groups: high calorie (where both items in the choice pair comprised items categorised as high calorie); low calorie (where both items in the choice pair comprised items categorised as low calorie); mixed calorie (where a choice pair consisted of one item categorised as high calorie and one item categorised as low calorie).

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Supplementary Table 2 – *Race model fits*

Subject	σ_{stim}	σ_{conf}
1	1.33	0.22
2	1.33	0.35
3	1.13	0.11
4	2.15	0.27
5	1.54	0.14
6	2.15	0.80
7	1.33	0.11
8	1.74	0.27
9	2.36	0.27
10	1.13	0.22
11	1.13	0.11
12	1.33	0.19
13	1.74	0.16
14	1.13	0.19
15	0.72	0.16
16	N/A	N/A
17	1.54	0.32
18	1.74	0.47
19	1.33	0.19
20	1.33	0.24
Mean	**1.50**	**0.27**

Our race model simulations provide qualitative insight into the inter-relationship between confidence, DV and RT that we observe in the behavioural data (Fig. 1). Here we explore individual fits of model predictions to subject data. We held threshold constant, leaving two free parameters, $\boldsymbol{\sigma}_{stim}$ and $\boldsymbol{\sigma}_{conf}$. For each subject, we fit 3 data features – the average psychometric function, the difference between psychometric functions under high and low confidence [P(right_hi) – P(right_lo)] and the RT-confidence relationship. Choice probabilities were binned into 5 quantiles; RT was z-scored and binned into 7 quantiles. The normalised discrepancy function between model and data was calculated as follows:

$$E = \sum_{i,j} \frac{|e_{i,j} - m_{i,j}|}{n_i N_i}$$

where E is the total discrepancy for a particular parameter setting, e and m are experimental and model values, respectively, i indexes each function, and j indexes each point on the ith function. n_i is the number of points in the ith curve, and N_i is its range of values. This denominator ensures the contribution of each curve to the total discrepancy is expressed as a fraction between 0 and 1. Fits were carried out using exhaustive gridsearch across a 2-dimensional parameter surface. Error surfaces were inspected to avoid local minima. Best-fitting parameters from each individual subject are included in the Table below. We observed

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that *E* was less sensitive to changes in σ_{conf} than $\sigma_{stim.}$ The fit for one subject did not result in a clearly-defined global minimum, and is thus excluded.

Supplementary Table 3 – *BOLD activation*

Contrast	Region	MNI [x, y, z]	K_E	P - value
Difference in value (increase)	**vmPFC**	[12, 56, 4]	190	$p < 0.005^{*}$
	Precuneus	[– 6, – 52, 16]	444	$p < 0.0001^{*}$
	Left STS	[– 45, – 67, – 25]	136	$p < 0.05^{*}$
Difference in value (decrease)	**ACC**	[9, 20, 49]	184	$p < 0.005^{*}$
Confidence (increase)	**vmPFC**	[12, 47, -11]	190	$p < 0.005^{*}$
	Precuneus	[– 3, – 46, 34]	113	$p < 0.05^{*}$
Confidence (decrease)	**ACC**	[9, 17, 40]	198	$p < 0.0001^{*}$
	Left anterior Insula	[– 48, 11, -2]	233	$p < 0.0001^{*}$
	Right anterior Insula	[51, 8, 4]	135	$p< 0.0001^{*}$
	Left subthalamic nucleus (STN)	[– 6, – 10, 7]	34	$p< 0.005^{*}$
	Right RLPFC	[27, 47, 28]	42	$p < 0.005^{\S}$

K_E = cluster size ; * = FWE cluster corrected ; **§** = small volume corrected (SVC) within 8-mm sphere centred on the coordinates [36, 44, 28] taken from [Fleming et al 2012]

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Supplementary Table 4 – *List of items*

Item name
Kettle Chips (Sweet Chilli)
Wotsits Crisps
Twix Bar
M&Ms
Lion Bar
Bounty
Walkers Cheese & Onion Crisps
Milky Way Bar
Brunch Bar
Cadburys Twirl
Monster Munch Crisps
Skittles
Nestle Milky Bar
Nestle Kit Kat
Mars Bar
Dairy Milk Turkish Delight
Cadbury Crunchie
KP Salted Peanuts
Doritos Cool Original Crisps

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