Neural and Affective Correlates of Decision Making in the Ultimatum Game

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Introduction:

Individuals rarely use economic rationality during the Ultimatum Game (UG). To explain this, previous studies explore the effects of fairness sensitivity and uncertainty on behavior and neural activity during UG. The uncertainty hypothesis argues that uncertainty about an opponents' cooperation promotes generosity. The fairness sensitivity hypothesis predicts that individuals will reject offers that they believe to be unfair. We explore the effect of affective priming on behavior and neural activity, while evaluating the uncertainty and fairness hypotheses.

Methods:

Six uncompensated volunteers (3 male, right handed, mean age 26.1) each participated in 120 UG rounds. Positive (pos), negative (neg), or neutral visual primes appeared before each round for 71ms masked between two consonant letter strings. UG is a two player game where players divide a reward. In each round, Player A makes an offer. B evaluates the offer. If B accepts, the reward is split based on A's offer. If B rejects, neither player is rewarded. Participants played against a computer, but were told they were playing against a new human each round. The task was designed using Psychopy (v.3.01) and administered in a 3T Seimens Trio scanner. BOLD slices were acquired with interleaved EPI (TR 2.5s, TE 30ms, 90 deg flip angle, 256mm FOV, 64x64 matrix, 3.2mm slice thickness) and realigned to correct for head movement before coregistering with an anatomical image (TR 1.9s, TE 2.52ms, 9 degree flip angle, 256mm FOV, 256x256 matrix, 1 mm^3 resolution) and transforming to MNI305 space using the Freesurfer template averaged across 30 subjects. Analysis was done with FSFAST, SPM and MATLAB. BOLD slices were smoothed with 5mm FHWM Gaussian kernel and high-pass filtered to correct for signal intensity drifts. A GLM model was defined by convolving block onset times and durations with the canonical SPM HRF. Contrast images were compared in a random-effects group analysis to create statistical parametric maps. Multiple comparisons were corrected for with a permutation test (voxel-wise threshold $p < 0.01$, cluster wise p value < 0.0167).

Results:

For player A, neg affect predicted less generous offers and pos affect predicted more generosity. Player B was more likely to reject low offers, but did not show a behavioral effect in response to prime valence. Though not directly compared, similar physiological results were seen in players A and B. Ungenerous offers following a neg prime recruited left (L) hippocampus (Hc), amygdala (Ag) and the insula (Ins) relative to baseline. Ungenerous offers with a neg affect more strongly activated bilateral striatum (Str), Ag, L Ins, Hc and mPFC relative to generous offers with primed neg. For pos affect, generous offers appeared with activation of right (R) cerebellum (Cb) and bilateral occipital (Occ) cortex. Generous offers with pos primes resulted in activation of L nuc. accumbens, Str, Hc and R Cb compared to ungenerous offers with a pos prime. Ungenerous offers with neg primes significantly activated L fusiform, Hc, Ag and Cb compared to generous offers after pos primes. Compared to neg primed ungenerous offers, generous offers with pos primes activated L Occ, R parietal cortex and Cb. The R caudate was found to represent affective valence independent of direction for ungenerous offers only. The R Cb and Occ represented absolute affective valence for generous offers.

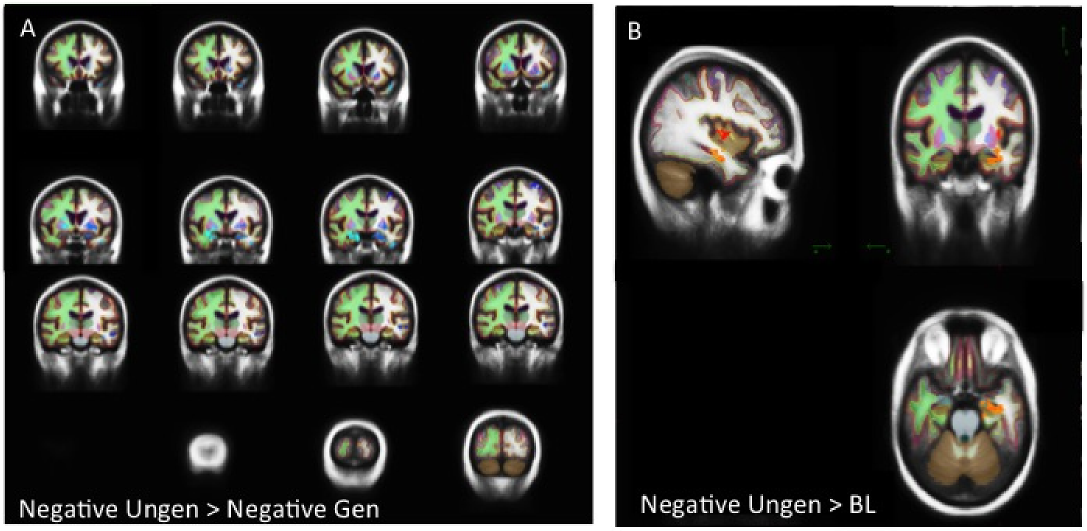

Figure 1. Effect of Negative Affect on Offer Making. What neural systems are activated during offer-making following presentation of a negative neural prime? A) Holding affect negative, ungenerous offers activated the limbic system and striatum bilaterally compared to generous offers. B) To isolate the effect of a negative prime from general decision making circuits, we compared a negative prime preceding an ungenerous offer to a baseline composed of neutral primes preceding generous and ungenerous offers. Cluster-wise p value threshold 0.067; FDR $p < 0.01$; Hc in yellow, Ag in blue, ER cortex in red, Cb in beige. Color of positive/negative activation is shown on a logarithmic scale from (dark red/blue) $p < 0.05$ - $p < 0.00001$ (light blue/yellow).

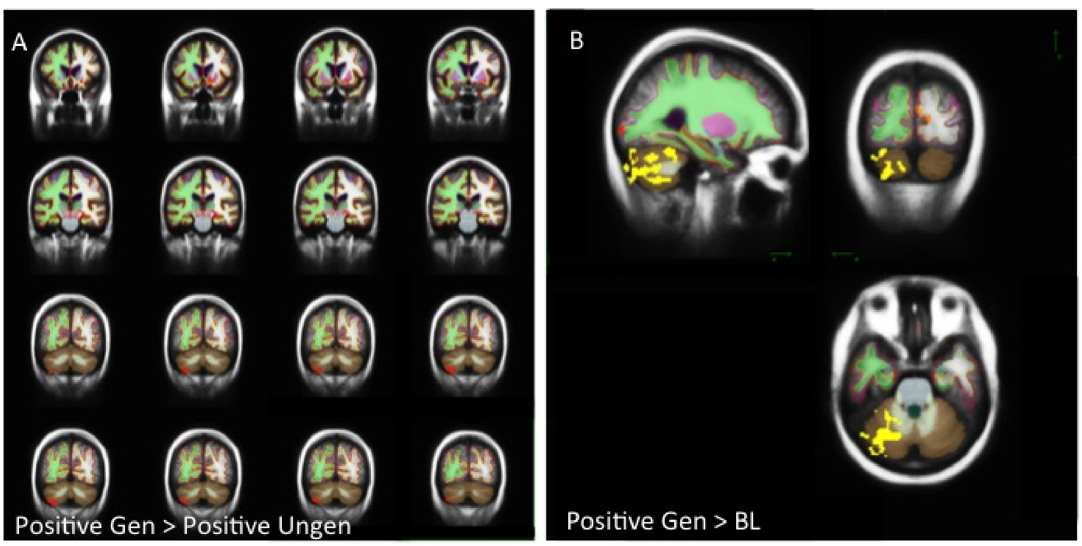

Figure 2. Effect of Positive Affect on Offer Making. What neural systems are activated during offer-making following presentation of a positive neural prime? A) Holding affect positive, generous offers activated cerebellum compared to ungenerous offers. B) To isolate the effect of a positive prime from general decision making circuits, we compared a positive prime preceding an generous offer to a baseline composed of neutral primes preceding generous and ungenerous offers. Cluster-wise p value threshold 0.067; FDR $p < 0.01$; Hc in yellow, Ag in blue, ER cortex in red, Cb in beige. Color of positive/negative activation is shown on a logarithmic scale from (dark red/blue) $p < 0.05$ - $p < 0.00001$ (light blue/yellow).

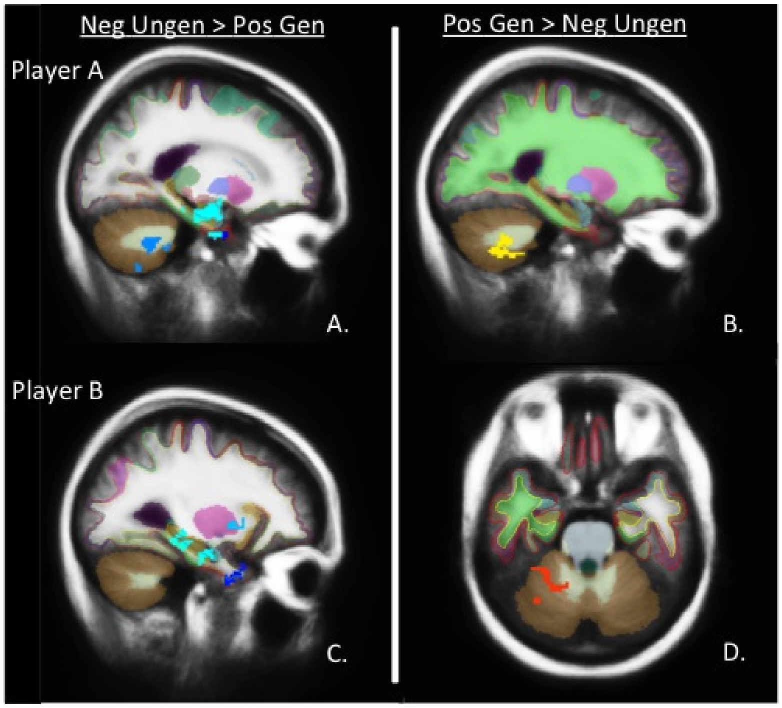

Figure 3. **Negative Affect vs Positive Affect with Respect to Fairness/ Generosity.** What neural systems characterize evaluation of an ungenerous (generous) offer with a neg (pos) affect? A) Player A neg ungenerous vs pos generous offers recruited right Cb, Ag, Hc and ER cortex. B) Player A pos generous vs neg ungenerous activated right Cb. C) Similar regions were activated for Player B during neg unfair offers. Striatum activation was also observed, reflecting reward prediction error of an unfair offer. D) Right cerebellum also activated for Player B when comparing pos unfair offers to neg unfair offers. Cluster-wise p value threshold 0.167; FDR p < 0.01.

Table 1

Regression results from Models 1 through 6. Models 1-3 use Player A responses, Models 4-6 use Player B responses. Models 2, 3, 5, and 6 regress reaction time. Models 1 and 2 regress generosity and acceptance, respectively. Subject controls not shown.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Prime Valence	.024, (.012)**	.065, (.123)	-.297, (.231)	.013, (.026)	.020, (.099)	-.230, (.198)
Offer Received (Player B)				.061, (.007)****	-.050, (.028)*	-.049, (.028)*
Round Time	-0.000, (0.0001)	-0.001, (.0002)***	-.001, (.0002)**	0.000, (0.000)	-.0002, (.0002)	-.0001, (.0002)
Reaction Time	-.069, (.025)***			.014, (.014)		
Offer Made (Player A)		-.311, (.113)***	-.305, (.112)***			
Offer Accepted (Player B)					.214, (.207)	.230, (.207)
df	355	355	355	343	343	343
adjusted R^2	0.672	0.369	0.371	0.286	0.574	0.576

*p<=.1, **p<=.05, ***p<=.01, ****p<=.001

·This table shows an affect of affective priming on Player A during offer making. No effect of prime was found for Player B. Player B was more likely to reject unfair offers.

Conclusions:

1) We discredit the uncertainty hypothesis because pos primes invoked greater generosity than uninformative neutral primes. 2) The same

regions implicated in response to unfairness also activate in response to affective stimuli, casting doubt that fairness sensitivity is represented independently of emotion. 3) We observe a neural dissociation of emotional contributions to decision making. Neg affect activated limbic circuitry and higher cortical association areas such as the In, cingulate and Pfc whereas pos affect correlated with Cb activation.

Emotion and Motivation:

Emotion and Motivation Other [2]

Higher Cognitive Functions:

Decision Making

Imaging Methods:

BOLD fMRI

Social Neuroscience:

Social Cognition [1]

Keywords:

Emotions

Limbic Systems
MRI
Social Interactions

[1|2] Indicates the priority used for review

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Corradi-Dell'Acqua, C. (2013). Disentangling self-and fairness-related neural mechanisms involved in the ultimatum game: an fMRI study. Social Cognitive and Affective Neuroscience, vol. 8, no. 4, pp. 424–431.

Gabay, A.S. (2014). The Ultimatum Game and the brain: A meta-analysis of neuroimaging studies. Neuroscience & Biobehavioral Reviews. Neuroscience & Biobehavioral Reviews, vol. 47, pp. 549-558.

Peirce, J.W. (2007). PsychoPy—psychophysics software in Python. Journal of Neuroscience Methods, vol. 162, no. 1, pp. 8–13.

Rand, D.G. (2013). Evolution of fairness in the one-shot anonymous Ultimatum Game. Proceedings of the National Academy of Sciences, vol. 110, no. 7, pp. 2581–2586.

Sanfey, A.G. (2003). The neural basis of economic decision-making in the ultimatum game. Science, vol. 300, no. 5626, pp. 1755-1758.

White, S.F. (2014). Punishing unfairness: Rewarding or the organization of a reactively aggressive response? Human Brain Mapping, vol. 35, no. 5, pp. 2137–2147.

Warriner, A.B. (2013). Norms of valence, arousal, and dominance for 13,915 English lemmas. Behavior Research Methods, vol. 45, no. 4, pp. 1191–1207.