Neural correlates of individual differences in generous preferences

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Task

You get to choose. Either you get $1 or a stranger gets $5. What do you choose?

In this revealed prosocial preference task (RPP) we used real money and no deception. All interactions were anonymous, and there was no oppotunity for reciprocity. Any subjects who self-reported disbelief were excluded.

Estimation Technique

Step 1: Participant makes a choice.

We gave subjects 200 forced choice monetary decisions between money for themselves ($0-$10) and money for a stranger ($0-$10). To precisely quantify the amount of money an individual was willing to sacrifice to give a dollar to a stranger (i.e. their indifference point or "IP"), we adaptively altered the ratio of the two offers.

Step 2: Estimate an indifference point (IP).

$$\mathbf{C}_{[1:t]} = \frac{1}{1+e^{(\alpha+\beta\times(\ln(OR_{[1:t]})))}}$$

$C_{[1:t]}$ is a vector of indicator variables {0,1} for each choice from the first trial through the current trial (t), where ones indicate choices for self. OR is the offer ratio for trial t. Using this model, we estimate α & β. α is the parameter estimate to a constant. β is the parameter estimate of interest, and represents the weight applied to the offer ratio. Using these parameters, we estimate indifference points from ln(-3) to ln(3).

$$\hat{\mathbf{IP}} = \frac{-\alpha}{\beta}$$

Step 3: Pick a ratio based on a normal distribution centered around the participant's indifference point (IP).

$$\mathbf{OR}_{\mathbf{t+1}} \sim \mathcal{N}(\mu = \hat{IP}, \sigma^2 = .25)$$

$$= P(\mathbf{OR}_{\mathbf{t+1}}) = \frac{1}{.25\sqrt{2\pi}} e^{-(x-\hat{IP})^2/2\times.25^2}$$

In order to discourage gaming of the system, we also draw from a normal distribution centered around 0 ~50% of the time.

$$\mathbf{OR}_{\mathbf{t+1}} \sim \mathcal{N}(\mu = 0, \sigma^2 = .25)$$

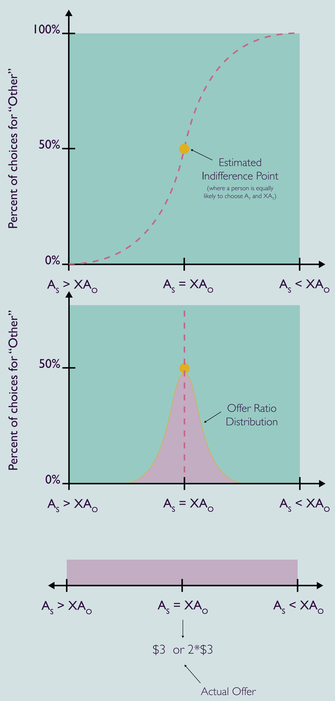
$$= P(\mathbf{OR}_{\mathbf{t+1}}) = \frac{1}{.25\sqrt{2\pi}} e^{-(x)^2/2\times.25^2}$$

Step 4: Randomly pick amounts to offer based on this ratio to present to the participant.

$$\mathbf{A}_{\mathbf{Self,t+1}} \sim \mathcal{U}\left(\frac{.01}{min(1, OR_{t+1})}, \frac{10}{max(1, OR_{t+1})}\right)$$

$$\mathbf{A}_{\mathbf{Other,t+1}} = A_S \times OR_{t+1}$$

Repeat this process with the next offer, $A_{Self,t+1}$ or $A_{Other,t+1}$.



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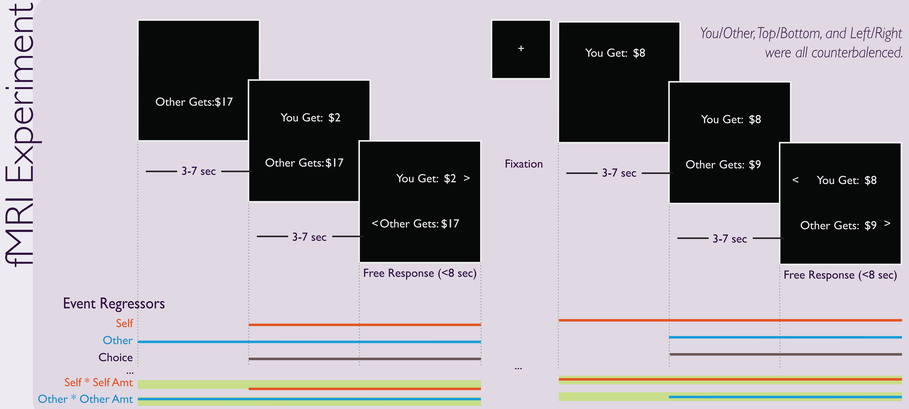
fMRI Experiment



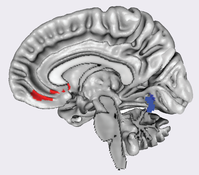
You/Other, Top/Bottom, and Left/Right were all counterbalanced.

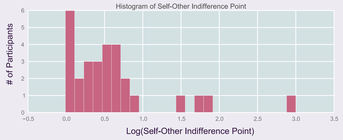
1) Subjects arrive and consent
2) 100 Trials of Self-Other in MRI
3) 200 trails of web-based IP estimation

In the fMRI task, 35 participants made 100 choices between some amount of money for themselves and some amount of money for another person. After the fMRI task, subjects made 200 choices on the web-based behavioral version of the task, seen to the left. Six subjects reported some amount of skepticism that the other participants were real, these subjects were excluded from all analyses, leaving 29 subjects. The amounts were determined based on our previous behavioral data collection, to present participants with the same offers, but maintain the ability to examine choices on each side of their indifference point. BOLD fMRI scans were acquired sagittally every 2.35 seconds (inplane: 1.72x1.72, 2mm slab skip 1mm). BOLD time-series images were motion corrected using FSL's mcflirt and smoothed using a 6mm gassian kernel. Eye-tracking data were acquired using Avotec goggles. Offers were presented as seen in the paradigm picture above. Self and other offer events were modeled when the offer was on the screen. Regressors were convolved with a canonical HRF and entered into a GLM. Within subject GLMs were performed using fMRIstat, using a design matrix adjusted to account for slice-time acquisitions. For each participant, parameter estimates for parametrically modulated self-amount and other-amount regressors, as well as their difference, were computed. Parameter estimates were rigid-body aligned to the structural T1-weighted anatomical. Structural scans were manually brain extracted and transformed to a standard space using ANTS, and transformations were applied to the parameter estimate maps. Outside of the scanner, each participant performed our RPP task online. Voxelwise across-subject analyses between individual participant parameter estimates and RPP self-other indifference points were performed in matlab using fMRIStat. Multiple comparison correction was performed using an intensity threshold of p<.005, two-tailed, and p<.05 cluster-size correction using non-isotropic random field theory. Because selfish subjects were outlying, and potentially using a different strategy, all individual difference correlations presented here are excluding participants with IP>2.

Self * Self Amt - Other * Other Amt = Greater Amount Tracking in Self
Other * Other Amt - Self * Self Amt = Greater Amount Tracking in Other

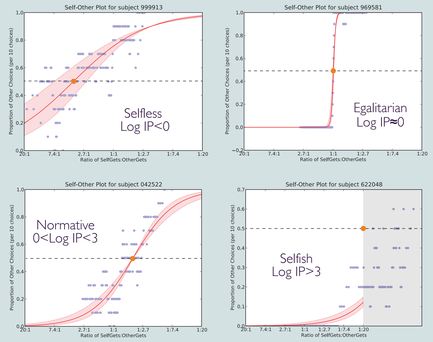
The vmPFC tracked self-amount more than other amount, on average.

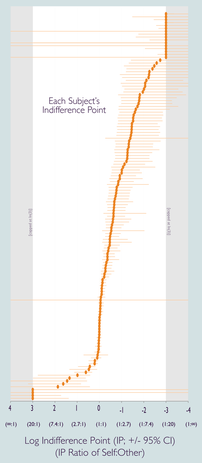




Behavioral Experiment

We tested 132 young adults using our adaptive online revealed prosocial preference task (RPP), in which participants made 200 choices between some amount of money for themselves and some amount of money for another person. There were substantial individual differences in self-other indifference point (IP) across participants (μ=.85, σ2=1.31). These data emphasize that different individuals have different pro-social preferences.

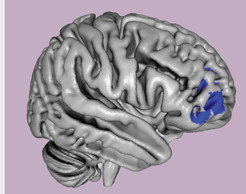




We examined the reliability of self-other IP as a measure of individual differences by testing 28 adults in the RPP two times, with 2 to 14 weeks between assessments. We observed significant correlations between IPs across time (r=.61, p=.0006; ICC=.61). These data suggest that individual differences in self-other IP are reliable over time and reflective of a trait-like tendency to value money to others.

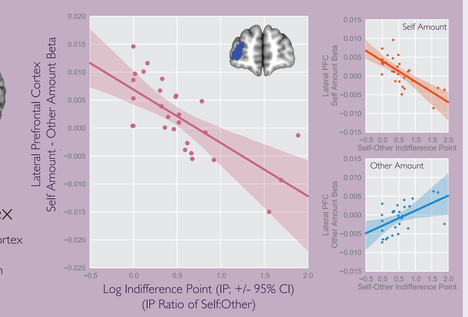
Neural valuation coding of self amount vs. other amount predicts generosity

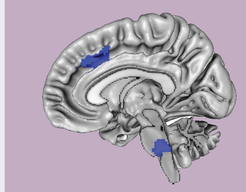
Self*Self Amt - Other*Other Amt = β_0*Constant + β_1*(Self-Other IP) + β_2*Age



Lateral Prefrontal Cortex

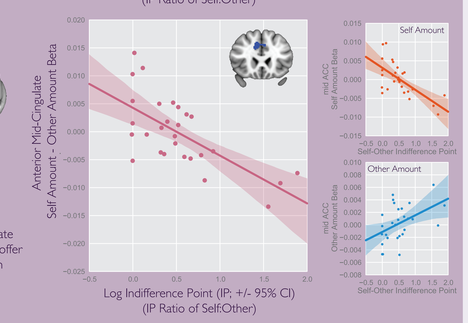
The degree to which lateral prefrontal cortex tracks the value of self and other offer amounts, predicts individual differences in self-other indifference point.

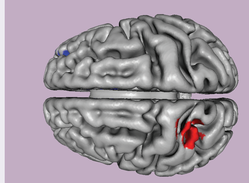




Anterior Mid-Cingulate

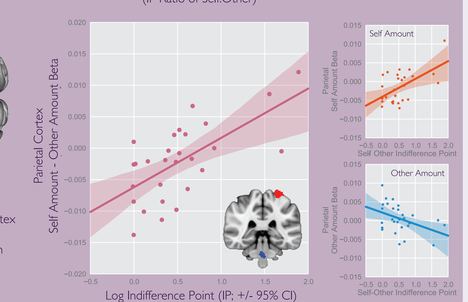
The degree to which anterior mid-cingulate cortex tracks the value of self and other offer amounts, predicts individual differences in self-other indifference point.





Parietal Cortex

The degree to which somatosensory cortex tracks the value of self and other offer amounts, predicts individual differences in self-other indifference point.



p<.005, FWE Corrected p<.05
p<.005, FWE Corrected p<.05

We developed a reliable way to measure generosity using our RPP task, and demonstrated that individual differences in neural valuation signals are associated with variation in other-oriented preferences.

Try it yourself!
http://webtasks.keck.waisman.wisc.edu/self_other_demo