Supplementary Online Materials

Empathic choice involves vmPFC value signals
that are modulated by social processing implemented in IPL

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CONTROL BEHAVIORAL EXPERIMENT

Twenty subjects (mean age: 21.85, SE: 0.76), with the same demographic characteristics required for the main fMRI experiment, participated in a control behavioral study. None of the subjects had previously participated in the fMRI experiment. The experiment was almost identical to the fMRI task, except for the following differences. First, half of the subjects completed the empathic choice task first and the self-oriented choice task second; the other half of the subjects completed the tasks in the opposite order. Second, the inter-trial interval was reduced to 1s, as was the interval between bids and feedback in empathic choice trials. Third, subjects completed both tasks on the same day.

For each individual we carried out a linear regression of bid-for-other on bid-for-self and other-bid, separately for self-oriented and empathic choice trials. This regression measures the extent to which the bids-for-other were driven by their own preferences or by the actual preferences of the other subject. As shown in Fig. S1, we found no significant differences across the two order conditions (min p=0.29, t-test).
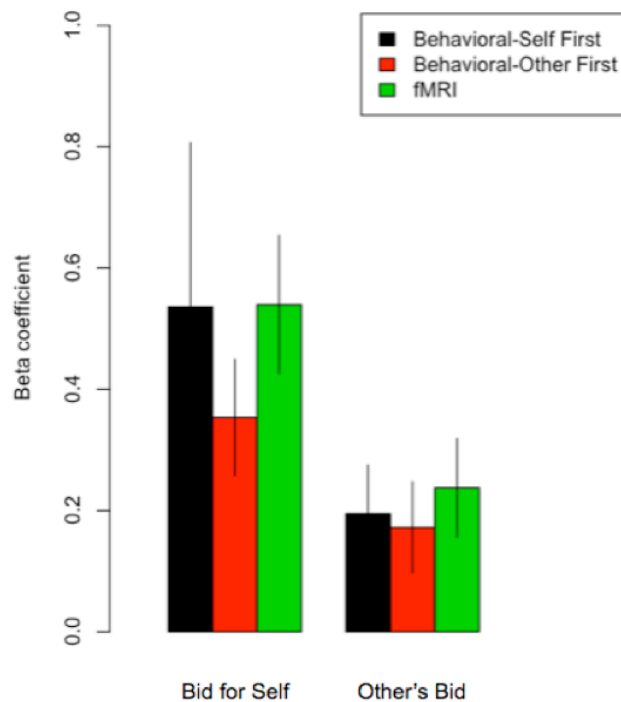

Fig. S1. Results of the companion behavioral experiment

TIME COURSE ANALYSIS FOR vmPFC

We carried out a post-hoc ROI analysis to estimate time courses of BOLD activity in the vmPFC valuation areas. This was done as follows. First, we extracted a time course of average BOLD activity at each TR within the region of vmPFC that was found to correlate with stimulus values in both self-oriented and empathic choice trials (Fig. 1C depicts the ROI). Second, we removed from this time course the variance associated with the six motion regressors estimated during the pre-processing process. Third, we resampled the time series into ten time bins per TR, and smoothed it using cubic spline interpolation. Fourth, we then estimated a finite impulse response model that included separate regressors for the following conditions: 1) empathic choice trials for which the bid-for-other was above average for those trials, 2) empathic choice trials for which the bid-for-other was below average, 3) self-oriented choice trials for which the bid-for-self was above average, 4) self-oriented choice trials for which the bid-for-self was below average. The model was estimated at each time bin within a 20 second window starting at the onset of the DVD cue. Finally, the parameter estimates for each condition were averaged across participants at each time point. Fig. S2 depicts the results of the analysis.
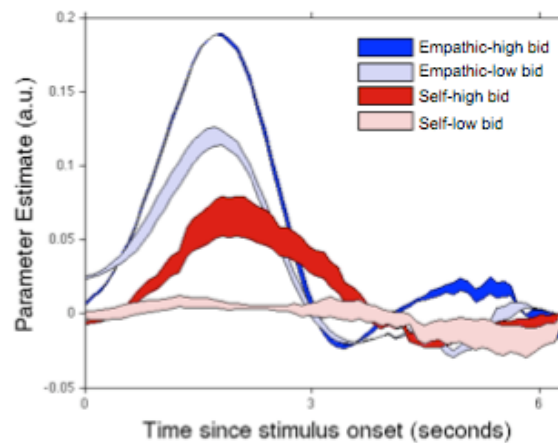

Fig. S2. Time course of BOLD responses in the vmPFC valuation area.

Fig. S3. Additional regions exhibiting a positive correlation with stimulus values in both empathic and self-oriented choice trials (GLM 1).
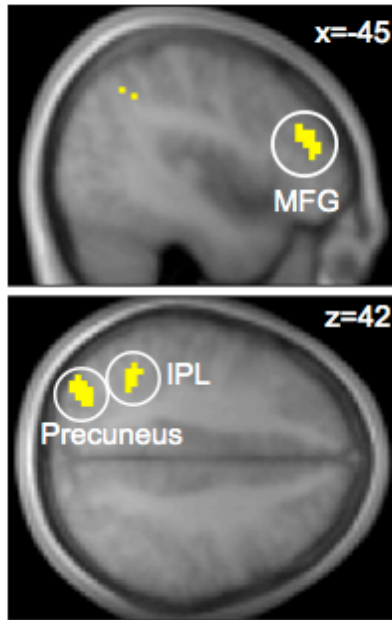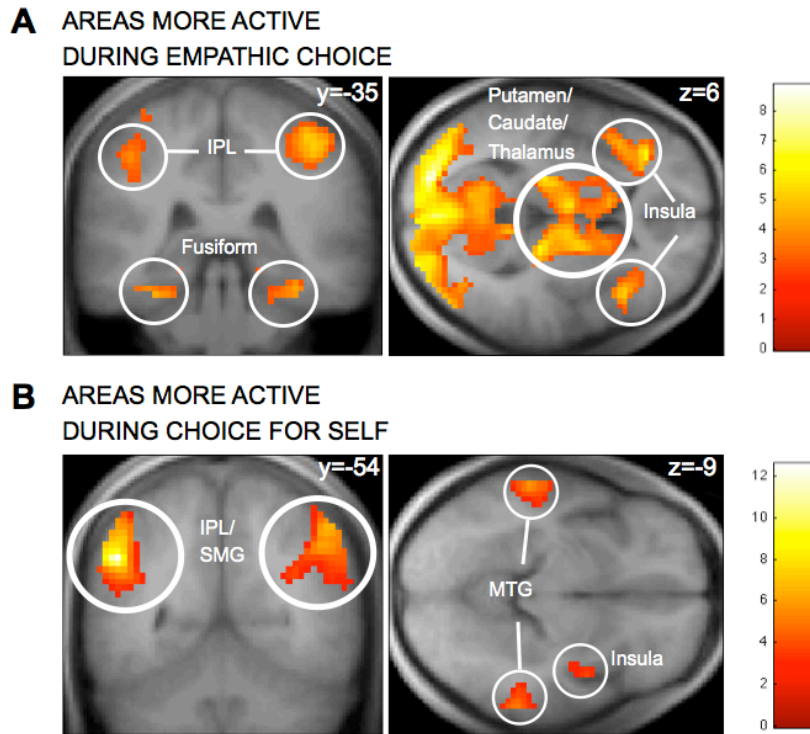
Fig. S4. A) Areas exhibiting higher average (unmodulated) activity during empathic choices. B) Areas exhibiting higher average activity during self-oriented choices. (GLM 1).

EXPERIMENTAL INSTRUCTIONS FOR SELF-ORIENTED CHOICE TASK

In this experiment you will be bidding on a number of DVDs. To enable this, please note that $10 has been placed on the table in front of you. This money is yours to use for this experiment. Whatever money you do not use will be yours to keep at the conclusion of the experiment.

In each round of the experiment, you will see the cover of a DVD displayed on the screen. Please look carefully at the DVD and decide how much you would be willing to pay for the DVD on a scale from $0 to $10, in increments of $2. So the possible bids are $0, $2, $4, $6, $8, and $10. If you already own the DVD, bid as if you do not own it. When you are ready, enter your bid for that item using the relevant key on the keypad. If you take longer than 6 seconds to enter a bid, one will randomly be selected for you. **You should bid in the following way: press "z" for $0, "2" for $2, "4" for $4, "6" for $6, "8" for $8, and "0" for $10.**

After you enter your bid, you will see a blank screen for several seconds, after which the next DVD will appear. You will bid in this way for 100 DVDs. After you have completed all rounds of the experiment, ONE of the rounds will be selected at random. The computer will generate a random number from 0 to 10. If this number is larger than or equal to your bid for the DVD in the selected round, you do not purchase the DVD and keep the entire $10. If the number is less than your bid, you pay the amount of the random number for the DVD, obtain the DVD, and keep the rest of the $10. Note that if a DVD you already own is selected, you will simply keep the $10 and will not have to buy the DVD.

For example, let's say trial number 22 was selected, and that in this trial you were shown a picture of the DVD "The Godfather" and entered a bid of $6. Let's say the random number drawn was 8. In this case, you would not be able to buy the DVD and would keep the entire $10. However, if the number drawn were 4, you would purchase the DVD for $4 and keep the remaining $6.

Note that only ONE of the rounds will be executed in this way. Note also that you have every incentive to be truthful in your bid for each DVD, since any single one of the bidding rounds can be implemented at the conclusion of the experiment. You must therefore treat every bid as if it will be implemented, though in the end only one of the bids will count. You should also note, then, that you do not have to divide your budget of $10 over all the rounds – only one of the rounds will actually be implemented, and hence you can treat each round as if you have all $10 available for that item. Thus bidding truthfully is the best strategy you can use in this experiment.

You will now go through five practice rounds to ensure you have understood the instructions. These practice rounds will not have any consequences for the actual experiment and they will not be used in selecting a random round at the end. **Please observe the DVD carefully and enter a bid when you are ready, but within 6 seconds of the DVD appearing.**

EXPERIMENTAL INSTRUCTIONS FOR EMPATHIC CHOICE TASK

In this experiment you will be asked to think about the preferences of another person (whom you will learn about shortly) and how much that person would be willing to pay for a number of DVD titles that will be shown to you.

On the next page, you will learn about the person whose preferences and choices you will be trying to guess. This person is a former Caltech student. Please read this carefully, as it will contain information that may be valuable to you during the experiment.

Meet Todd. He's from Omaha, NE and studied neuroeconomics at Caltech. He enjoys rock climbing, hiking, and yoga. He also enjoys watching movies, and his favorite film is Braveheart. He likes sports, pizza, and has a fondness for whisky, but dislikes traffic and having to wait for anything.

Todd came to our lab last year and went through 100 rounds of the following experiment. In each round, he was shown a DVD cover and was asked how much he would be willing to pay for that DVD from $0 to $10 in increments of $2 (e.g., either $0, $2, $4, $6, $8, or $10). We used a type of auction which ensured that Todd was telling the truth.

This experiment will also consist of 100 rounds. In each round of the experiment, you will see the cover of a DVD displayed on the screen for 6 seconds. This DVD cover is EXACTLY the same one seen by Todd. So for each DVD that you will see, we know how much Todd was willing to pay for it.

Your task in this experiment will be to try to guess the amount that Todd was willing to pay for each DVD shown.

In each round of this experiment, you are to look carefully at the DVD cover shown, and decide how much you think *Todd* was willing to pay for the DVD. This value should be between $0 and $10 and in increments of $2. Once you have decided on a value, you will indicate your bid of $0, $2, and so on by entering the number corresponding to your bid on the keypad. You have a maximum of 6 seconds to enter a value, after which a value will be entered for you randomly. **You should bid in the following way: press "z" for $0, "2" for $2, "4" for $4, "6" for $6, "8" for $8, and "0" for $10.**

After you have entered your choice, you will see a fixation screen with a "+" sign for 1 second. After this fixation screen, in order to help you to get to know Todd better, you will be told how far off your guess was from Todd's actual bid. For example, if your guess was $6 while Todd's guess was $4, you will be told that the error in your guess was 2. If your guess was $6 while Todd's guess was $10, you will be told that the error in your guess was -4. Your goal is to minimize the absolute value of the error – you want to obtain errors as close to 0 as possible for your guesses.

Following the feedback, after several seconds you will be shown another DVD cover, and you will complete the same task again for each round of the experiment.

Remember, this experiment is not about your own preferences, but what you think Todd's preferences are based on what you know about him. To ensure you are trying your best to guess his preferences, $10 has been placed next to you. This $10 is Todd's money, and you will use it to bid on each DVD.

After you have completed all rounds of the experiment, ONE of the rounds will be selected at random. The computer will generate a random number from 0 to 10. If this number is larger than your bid for the DVD in the selected round, you do not purchase the DVD with Todd's money, and we give the entire $10 to Todd. If the number is less than or equal to your bid, you pay out from Todd's money the amount of the random number for the DVD, and Todd obtains the DVD and keeps the rest of the $10.

For example, let's say trial number 22 was selected, and that in this trial you were shown a picture of the DVD "The Godfather" and thought that Todd would be willing to pay $6 for the DVD. Let's say the random number drawn was 8. In this case, Todd would not be able to buy the DVD and would keep the entire $10. However, if the number drawn were 4, Todd would have to purchase the DVD for $4 and keep the remaining $6.

Note that only ONE of the rounds will be executed in this way. So you do not have to divide Todd's budget of $10 over all the rounds - only one of the rounds will actually be implemented,

and hence you can treat each round as if Todd has all $10 available for that DVD. So you want to bid what you really think Todd would be willing to pay for the DVD shown in each round.

You will now do five practice rounds to ensure you have understood the instructions. These rounds are not based on real data from Todd's decisions; the 'feedback' at the end of each round is randomly generated for the practice rounds. These rounds will not have any consequences for the experiment; they are simply for you to become familiar with the task and to give you an opportunity to ask any questions you may have. Remember to first observe the DVD and then enter your decision of what you think Todd was willing to pay by entering the corresponding number on the keypad. **Remember: press "z" for $0, "2" for $2, "4" for $4, "6" for $6, "8" for $8, and "0" for $10.**