Neural Correlates of Cooperation Priming across Social Value Orientations

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Specific Aims (What do you intend to do?)
The broad, long-term objective of this proposal is to understand the neural basis of cooperative behavior and its influences. We will look at the neural correlates of priming effects of cooperation and competition in the brain with respect to game theory and Social Value Orientations (SVO), a measure of allocation between self and other. We have two main specific objectives. First, we wish to explore the behavioral outcomes of morality, neutral, and might primes on pro-social (cooperative), and pro-self (individualistic or competitive) SVOs, hoping to replicate Smeesters et al 2003. Second, we wish to explore the difference in the neural activity of these two groups when primed to be in different Game Theory mindsets. Our hypotheses follow:

Pro-social, neutral prime: activation in the Temporal parietal junction and the Anterior Cingulate Cortex (ACC) as seen in trust games with pro-socials (van den Bos 2009), as well as Posterior Cingulate Cortex, related to expectation of future reward (Suzuki et al 2010). Behaviorally, cooperation is just above midline (2 dollars given).
Pro-self, neutral prime: activation in the orbito medial prefrontal cortex (OMPFC) and ventral striatum as is seen in unilateral defectors (Susuki et al 2010). Cooperation just below midline.
Pro-social, moral prime: activation in the rostral ACC, NAcc, caudate, VMPFC, and OFC, related to mutual cooperation in Prisoner's Dilemma games (Rilling 2002). Greatly increases cooperation relative to neutral.
Pro-self, moral prime: striatum activity might increase as well as the anterior medial prefrontal cortex (aMPFC), because they are accurately predicting the mental attitudes of their cooperative counterparts (Amodio and Frith, 2006; Smeesters et al 2003). Greatly reduces cooperation.
Pro-self and pro-social, might prime: we hypothesize a shared mechanism across SVO's engaging the anterior insular cortex, related to injustice processing, and the DLPFC, involved in cognitive control of perhaps cooperative behavior (though this might be lower for pro-self individuals) based on studies of unfair offers in the Ultimatum Game (Sanfey et al 2003).

Significance **(**Why is the work important?)
This work is significant primarily because it is a pioneer in its field, as no one has looked at the neural correlates of priming cooperation. We know about the neural circuitry of social preference and cooperation (Fehr 2007) but have not examined how framing or priming effects can modify it, and differentially so with respect to SVO. With respect to economics, our research has a wealth of implications for the study of empathy, which has recently become a topic of interest (Kirman and Teschl 2009). We hope to show the existence of "other-regarding" preferences, as Kirman calls them, and shed light on the underlying mechanisms of cooperation, which is conceptually linked to altruism and empathy, two very socially relevant ideas.

Our work will also contribute to understanding social dynamics, as we delve into the mechanisms behind people who systematically take advantage of those who want to cooperate,

or perhaps are perceived as weaker. Specifically with respect to priming in game theory situations, our work will shed light on the *biased perception principle*, which states that primes do not influence behavior in an automatic fashion but rather by influencing the appraisal of the situation (Smeesters et al 2003). If the data confirm our hypothesis, they would suggest that automatic, personality dependent cascades are activated in the brain with respect to different primes. However, the possibility still exists that primes are really a mediator of behavioral choice rather than a direct influence on automatic systems.

Innovation (In what ways is this work innovative?)

While some work has been done on neural correlates of reciprocity with respect to SVO (van den Bos 2009), it has never been looked at in conjunction with priming effects, thus our techniques are all novel and innovative. This work seeks to shift the priming research focus from behavioral studies which often lack mechanistic explanations to more domain general regions involved in cooperation and social competition, as well as the effects that a changing environment and priming have on these regions. Further, our commitment to using SVO in an initial study involving priming is innovative, as we believe it is too strong an effect to ignore.

It also opens up doors to study reciprocal altruism and to enlighten the indirect reciprocity paradigm which states that individuals do not need meet again to favor cooperative strategies, and favor those with good histories (Nowak and Sigmund 1998). By gaining insight into the minds of pro-self and pro-social actors, we can draw comparisons with who will be cooperated with and rejected and make mental maps of who would be a bad teammate. Also, we plan to use real money to increase the validity of our results, which is not always done.

Approach (How are you going to do the work?)

Participants and SVO We will use 18, healthy, right-handed volunteers who will be paid based on their give-some task performance. SVO questionnaires will be issued a week before the study to avoid priming effects from the questions asked within (regarding money allocation between self/other) and results will be used to select 9 pro-social and 9 pro-self participants for the final study (according to Van Lange 1999; van den Bos 2009). Consistency will be ignored, for now.

Task A 12-trial give-some game in which each participant receives four coins with a one-dollar value that are worth two dollars each to their partner outside the machine. The participant then decides how many to give away at each trial and receives an amount in return from a pre-programmed partner who they think is human to ensure differential brain activity is due to priming, not partner activity. The amount offered (0-4) is our proxy for cooperation at each step.

Priming Priming will take place before each game trial and will be announced as a "visual perception test." Participants will be told to rate the color contrast in a picture on a scale from 1-9. In a fixed order before trials (there is room for careful coordination of primes and fixed partner behavior), 4 neutral primes photos (a stack of cups, a water bottle, deodorant, and an electrical socket), 4 might prime photos (board room, suitcase, a dress suit, and an in/out box, per Kay et al 2004), and 4 morality prime photos (a soup kitchen, a hiking group, a supportive elementary school classroom, and a community service group) will appear before the subjects. A control group will receive no primes to control for normal reaction to the computer partner. It will close with a postexperimental questionnaire to determine possible suspicion of the priming effect.

Data processing We will borrow logistical fMRI data collection and analysis from Van Den Bos 2009 and focus mainly on our own regions of interest from our hypothesis. We will look at both behavioral results across subjects with respect to priming as well as within SVO groups.

Neurally, we will do a within subject analysis to see changes responding to various primes as well as compare the major regions of interest across SVOs.
Problems and Future Directions Strong reactions to the behavior of the partner might provide a stronger result than the primes. In the future, other primes such as a verbal prime (Smeesters et al 2003), friend or foe prime (Kay et al 2004), and competency prime (Utz et al 2004) can be examined as well. In the future, high- and low-consistency in SVO should also be examined for its relationship to priming effects.

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