The Self and Its Reputation in Autism

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In this issue of *Neuron*, a study by Chiu et al. examines the brain responses of autistic volunteers in a trust game. The findings reveal an unusual lack of brain activity in mid cingulate cortex when they make their investments. We speculate that this may arise because autistic individuals are unaware that they will also gain or lose reputation in their partner's eyes.

A study in this issue of *Neuron* details how Chiu et al. (2008) have measured brain activity (using fMRI) while volunteers, who are classified as being at the high-functioning end of the autistic spectrum, were engaged in a simple social interaction. The task was an iterated trust game in which two subjects take turns as investor or trustee. The investor chooses how much to money to invest. This chosen amount is tripled on its way to the trustee, and the trustee then chooses how much to repay to the investor. Read Montague and his colleagues have studied this game extensively in large groups of volunteers and have observed a characteristic pattern of brain activity in the anterior cingulate cortex. When making an investment (*self* phase), transient increases in activity are seen in an area of mid cingulate cortex ($-7 < y < 14$ in Talairach coordinates). When learning what sum has been repaid (*other* phase), transient increases are seen in posterior cingulate ($-43 < y < -41$) and anterior cingulate ($25 < y < 42$). The high-functioning autistic volunteers in this study did not differ in their behavior in the trust game, but did show a significantly different pattern of brain activity. They did not show the characteristic activity increase in the mid cingulate cortex during the self phase.

There are a number of reasons why we consider this to be an important and exciting result. It is now widely agreed that autism is a biological disorder associated with specific brain abnormalities (Bock and Goode, 2003). However, the precise nature of these abnormalities remains obscure. A key, defining feature of the disorder is impairment in reciprocal social interactions stemming from a specific problem with mentalizing or "theory of mind" (Baron-Cohen et al., 2000). A number of previous studies have investigated patterns of brain activity associated with mentalizing in autism, but the tasks used have not directly involved two-way social interactions (Frith, 2001). Volunteers have observed social interactions or have answered questions about them, but have not been themselves engaged in social communication. In the study by Chiu and colleagues, however, the volunteers were directly engaged in a social interaction. Importantly, the results suggest that the abnormality associated with autism is restricted to only one phase of the interactive game: the point where the autistic volunteer makes an investment, not the point where the autistic volunteer is told about the repayment made by their partner. Additional results from Read Montague's group give further clues as to the implications of this result. First, the same pattern of activity in cingulate cortex is observed when volunteers are shown pictures of people engaged in athletic activities and asked to imagine themselves taking part. This is further evidence as to the nature of the cognitive process associated with this pattern of activity: it involves thinking about the *self* acting in a social context. Second, the characteristic patterns of activity in the cingulate cortex are only observed when the trust game is played with a human partner. No such distinct patterns emerge when the game is played in the absence of a responsive social partner.

Does this result show that autistic people play the game as if they were not interacting with a socially responsive partner? No. The result is more subtle than that. The pattern of brain activity in cingulate cortex is consistent with this idea for the self phase, but for the other phase, the autistic volunteers resemble controls when playing with a responsive social partner. This is an exciting result because it suggests that some mechanisms of social interaction are intact in these high-functioning cases. What is the critical difference between the self phase and the other phase? We believe that the simple distinction of self versus other is not adequate. In the pictures of athletic activity, in which volunteers were asked to imagine themselves taking part, there are many players. At least part of the imagining must involve thinking about how one would fit in with the group, and how other group members would evaluate one's performance. Actually, this is a question about the kind of reputation one might gain in the eyes of the others. Likewise, in the self phase of the trust game, the amount one invests can be seen as a measure of how much one trusts one's partner. It is not just giving an amount of money; it is giving a signal to the other person: "trust me" and "I trust you" (see Figure 1). In other words, at the point of investment we are predicting what the effect of our investments is going to be on the behavior of our partners. In the other phase of the game, we are also evaluating a signal. But there is a difference. The evaluation is after the fact. We know what the investment is. We are not at this point trying to build our reputation in the other player's eyes.

Where is the difference in the autistic brain? It is in the self phase, which we have now relabeled reputation management phase. It involves higher-order mentalizing: you care what another person thinks of you, and even further, you care that the other person trusts you. You would not do this when playing against a computer. In autism there is no difference. Given that autistic people have mentalizing difficulties, such higher-order representations in fast on-line interaction are probably too difficult. In a truly reciprocal interaction, other people's thoughts of us are the means to see the value of our own actions. This goes far beyond the value of the investment in money. This is where we find the real reward for our interactions.

However, if the autistic volunteer approaches the task with an impoverished analysis of the interaction, should we not expect to detect a difference in behavior? This is a perennial problem when brain imaging is used in the study of abnormal groups. On the one hand, experimenters will go to great trouble, as have Chiu and colleagues, to make sure that patients and controls are matched on behavior. Otherwise critics will rightly point out that the differences in brain activity might simply be a consequence of differences in behavior and therefore tell us nothing about critical differences in brain function between the groups. On the other hand, if the abnormal group is engaging a different brain system to perform the task, then it must be possible, by using the right task, to demonstrate differences in behavior.

What differences in behavior might we expect find in the behavior of autistic volunteers? One clue might come by identifying the changes that occur when normal volunteers play economic games against a computer rather than a responsive social partner. In the ultimatum game the rejection of low offers can be seen as a form of altruistic punishment, through which we try to change the behavior of the person making the low offer. There would be no point in such behavior if we were playing against a computer. Indeed it has been observed that lower offers are accepted if people believe the offer is made by a computer (Rilling et al., 2004) or on the basis of the spin of a roulette wheel (Blount, 1995). Do autistic volunteers make this distinction between playing against people versus computers? If so, then they must be thinking about the effect that their behavior has on the other player.

In the same way it would be possible to study whether people are thinking about their reputation in the eyes of others. In the dictator game there is no reason to make good offers except to bolster our reputation. Evidence for this comes from the observation that smaller offers are made in this game when the player has complete anonymity (Hoffman et al., 1996). When playing against a person, we will have some regard for what that person, as well as the experimenter or other observer, thinks about us. When playing against a computer, only the opinion of the experimenter would be relevant. If autistic players show such distinctions, then they must have some representation of their reputation in the minds of others. Investigation of variations in behavior and brain activity when playing against people or computers would enable us to pinpoint more precisely the missing processes in the autistic player.

Figure 1. Earning the Respect of Others

Finally we must consider what we can learn from the location of the deviant activity in the autistic brain. The authors adopt a very ingenious, but somewhat eccentric, method of analysis: looking at the pattern of activity across the whole of the cingulate cortex. This makes comparison with previous studies problematic. The pattern of activity associated with repayment is reminiscent of that seen in theory-of-mind tasks, with activity in both posterior and anterior cingulate. However, mentalizing is more typically associated with activity in paracingulate cortex. According to Tomlin et al. (2006), the pattern seen across anterior cingulate cortex is not replicated across the paracingulate cortex. However, critically, the deviant pattern of activity associated with autism was not observed in this theory-of-mind region, but in a region of mid cingulate cortex. This region roughly corresponds to the rostral cingulate zone of Picard and Strick (1996). The region has been associated with response selection or decision. Indeed a recent study of decision-making in a volatile environment (Behrens et al., 2007) suggests that the rostral cingulate zone is associated with decision making ($-8 < y < 20$), while a more anterior region is associated with monitoring ($32 < y < 36$). These coordinates are consistent with the results reported by Chiu et al., and fit well with the trust game: the self phase is the point where the subject decides what response to make, while the other phase is the point where the subject monitors what effect his investment has produced. The problem with equating the results of Chiu et al. with those of Behrens and colleagues is that the latter task (and those used in previous studies with similar results) did not involve interaction with a responsive social being, but with a complex one-armed bandit. It will be exciting to investigate whether decision-making tasks of a sufficient or certain kind of complexity can recreate the experience of interacting with another person.

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