CHILD DEVELOPMENT PERSPECTIVES

Considerations of Fairness in the Adolescent Brain

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ABSTRACT—***Adolescents experience a marked change in their evaluation of fairness, trust, and reciprocity that leads to more altruistic behavior and tendencies that are oriented toward others. In this article, I highlight advances in brain imaging research to focus on how adolescents make social decisions. Using the Ultimatum Game and the Trust Game as examples, I show that adolescents are relatively focused on the self in early adolescence, with impulse control and perspective taking increasing in later adolescence and early adulthood. These changes are accompanied by a shift in the relative contribution of the dorsomedial prefrontal cortex, a region important for self-referential processing, to the dorsolateral prefrontal cortex and temporal-parietal junction, regions important for controlling selfish impulses and perspective taking. This shift in balance may tip adolescents toward more self-oriented choices in early adolescence and allow them to consider consequences for others in later adolescence.***

KEYWORDS—*adolescence; fairness; trust; social development*

Imagine splitting $10 with a stranger you will never see again. How much would you give the other person? What do you think is a fair distribution of the money? These types of social decision-making interactions have been widely studied using economic exchange games. Originally developed in social and economic psychology, the games feature interactions between two or more individuals that involve a transaction of goods (e.g., money or candy) and a conflict in which one party gains and the other loses. The games tap into two processes: concern for one's own benefit and concern for others (Van Dijk & Vermunt, 2000).

Even young children value a fair distribution of goods (Benenson, Pascoe, & Radmore, 2007; Blake & McAuliffe, 2011). In the Dictator Game, a player divides coins with another person and the other person has to accept any division the player makes. Most individuals (adults, adolescents, and children) give away part of their money out of fairness considerations. This type of sharing also occurs in chimpanzees, suggesting that fairness has strong roots in our biology (Horner, Carter, Suchak, & de Waal, 2011).

Yet when social exchange requires some level of perspective taking, defined as the ability to understand *and* act on the thoughts and intentions of others, in adolescence, strategic social interaction increases. In other words, although the ability to take another's perspective (also referred to as theory of mind) is traditionally said to develop by 4–5 years (Wellman, Cross, & Watson, 2001), in more complex tasks or when different perspectives need to be combined, perspective-taking skill continues to develop throughout childhood and adolescence (Dumontheil, Apperly, & Blakemore, 2010).

In this article, I explain how the development of considerations of fairness and reciprocity is associated with changes in perspective taking in social interaction tasks during adolescence. I also focus on how changes in considerations of fairness have been approached from a developmental cognitive neuroscience perspective (Blakemore, 2008). This research provides opportunities for studying the developmental trajectories for different subcomponents of social decision-making processes (e.g., selfish impulses or taking others' perspective) by showing that different brain regions follow differential patterns of interactive specialization (Johnson, Grossmann, & Cohen Kadosh, 2009).

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The research described in this article was funded by an NWO-VIDI grant. I thank my coworkers, Berna Güroğlu, Wouter van den Bos, and Geert-Jan Will, for the inspiring collaborations and comments on a prior version of this manuscript.

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DOI: 10.1111/cdep.12022

Child Development Perspectives

THE DEVELOPMENT OF INTENTIONALITY UNDERSTANDING

Two paradigms—the Ultimatum Game and the Trust Game—are particularly valuable in studying the role of perspective taking in considerations of fairness.

The Ultimatum Game

The Ultimatum Game is a simple, but elegant game that examines relative gain for self and others. Two players divide a sum of money, with the first player deciding how the money is distributed and the second player deciding whether to accept the proposed split. When the second player accepts the split, both players receive money according to the proposed split. When the second player rejects the split, neither of the players receives anything. The games typically involve single interactions with anonymous others to reduce reputation effects (Güth, Schmittberger, & Schwarze, 1982). Among adults, unfair offers are often rejected, indicating that individuals would rather receive nothing than accept an unequal distribution of money (Van Dijk & Vermunt, 2000). Equal splits by first players in the game therefore can be interpreted as a concern for fairness, but also can reflect a strategic motivation because the first player needs to think about the second player's behavior when making an offer.

Fairness behavior in the Ultimatum Game increases with age across childhood and adolescence (Blake & McAuliffe, 2011; Gummerum, Keller, Takezawa, & Mata, 2008), and better performance on a theory of mind task is associated with more strategic fairness behavior in young children (Takagishi, Kameshima, Schug, Koizumi, & Yamagishi, 2010). Thus, despite the finding that young children show fairness in the Dictator Game (Benenson et al., 2007; Blake & McAuliffe, 2011), strategic motives increasingly play a role when the second player can influence the outcome of the distribution (Steinbeis, Bernhardt, & Singer, 2012). These findings lead to the hypothesis that developmental changes in perspective taking drive fairness considerations.

This hypothesis was tested in detail in a behavioral study including participants from four age groups (9, 12, 15, and 18) that looked at fairness and perspective taking using the mini-Ultimatum Game (Guroglu, van den Bos, & Crone, 2009). In this game, the first player can choose between two options to divide 10 coins, for example, a fair split (e.g., 5 for the first player and 5 for the other player) or an unfair split (e.g., 8 for the first player and 2 for the other; see Figure 1). Both players are aware of the two options available to the first player. In a no-alternative condition, the first player can choose between 2 *same* unfair options (e.g., 8 for the first player and two for the other); in this case, the first player can only propose an unfair split (Falk, Fehr, & Fischbacher, 2003).

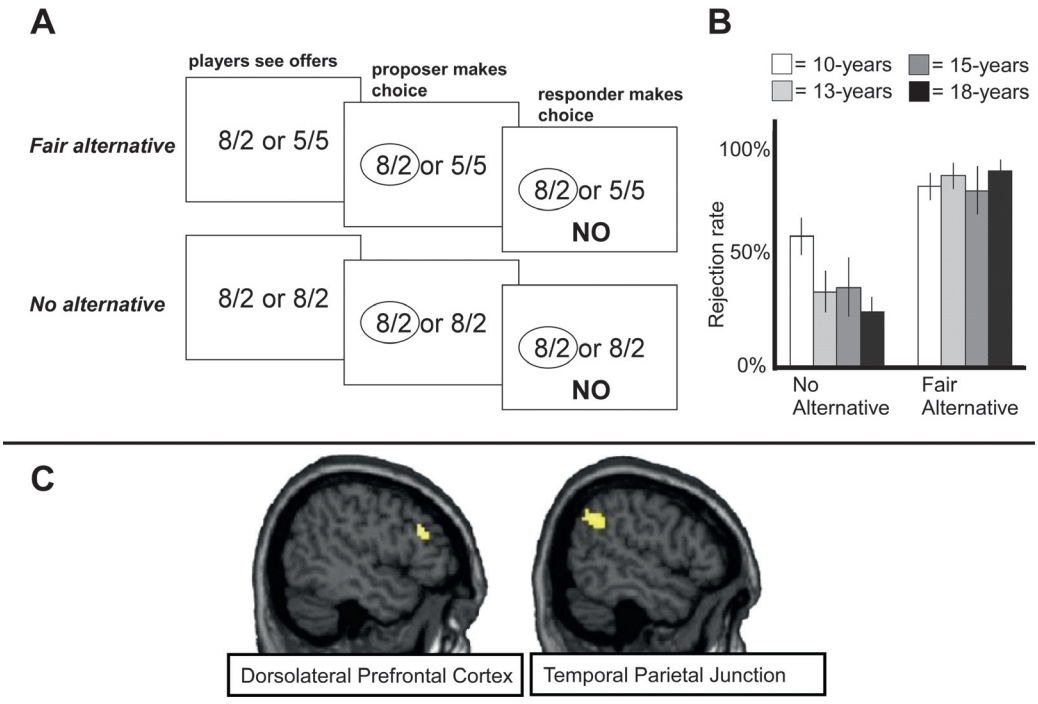

Figure 1. Example of the mini-Ultimatum Game with intentionality manipulations. (A) In the fair alternative condition, the proposer can choose from an unfair (8/2) or a fair (5/5) division of coins. In the no-alternative condition, the proposer can only choose from the same two unfair divisions (both 8/2). (B) Whereas unfair offers with a fair alternative are most of the time rejected by all participants, the unfair offers with no alternative are rejected less often with increasing age, suggesting a role of perspective taking. (C) Receiving an unfair offer with no alternative correlates with more activation in dorsolateral prefrontal cortex and temporal-parietal junction with increasing age. The images were based on a regression analysis in which age was added as a predictor for activation.

In the study, when the first player proposed an unfair offer (8/2) when the alternative was fair (5/5), players of all ages rejected these unfair offers most of the time. But when the first player had no alternative (8/2 vs. 8/2), the number of times participants accepted an unfair offer increased with age. Apparently, older adolescents understood that the first player had no choice but to propose an unfair distribution and were willing to act on this understanding.

A neuroimaging study used the same mini-Ultimatum Game design in which participants were second players. In prior studies with adults that did not manipulate perspective taking, presentation of an unfair offer was associated with increased activation in the anterior insula, a region associated with the experience of disgust and negative affect, and the anterior cingulate cortex (ACC) and the dorsolateral prefrontal cortex (DLPFC), regions associated with conflict and control (Sanfey, 2007; Van Overwalle, 2009). In a study with adults using the mini-Ultimatum Game, the DLPFC and the temporal-parietal junction (TPJ) were more active when participants received an 8/2 offer in the no-alternative condition (8/2 vs. 8/2) relative to a fair alternative offer (8/2 vs. 5/5; Guroglu, van den Bos, Rombouts, & Crone, 2010). These two brain regions have previously been associated with overriding selfish impulses and perspective taking (Rilling & Sanfey, 2011; Van Overwalle, 2009). When comparing participants of four age groups (10, 13, 15, and 20), the neuroimaging results revealed an age-related increase in activation in the DLPFC and TPJ in the no-alternative condition compared to the fair alternative condition. These results may indicate that inhibition of selfish impulses and perspective taking continue to develop gradually during adolescence (Guroglu, van den Bos, van Dijk, Rombouts, & Crone, 2011). This is further supported by the finding that the DLPFC and TPJ are increasingly more active during the processing of unfair offers across childhood and adolescence, and that these brain regions are important for inhibition and perspective taking (Rilling & Sanfey, 2011).

The Trust Game

The Trust Game is another way to measure perspective taking in reciprocity (Berg, Dickhaut, & McCabe, 1995). This game involves two players dividing a sum of money. The first player has two options: to split X amount between himself or herself and the second player, or to trust the second player to divide the money, in which case the amount at stake is tripled (3X). Now, the second player can decide how to divide 3X: he or she can reciprocate the trust by splitting 3X equally or can defect and keep most of the 3X. The second player has no economic incentive to share the money because it is a single transaction.

To examine the development of trust and reciprocity, participants of four age groups (9, 12, 16, and 20) acted as second players in the Trust Game with anonymous others (van den Bos, Westenberg, van Dijk, & Crone, 2010). The amounts in the game were manipulated by varying risk for the first player (see Figure 2 for a detailed example): In some trials, the first player took a high risk by trusting the second player, whereas in other trials, the first player took a low risk by trusting the second player. This allowed us to examine whether second players took the perspective of the first player when deciding whether to defect or to reciprocate (i.e., appreciating and acting on the risk the first player took by trusting them).

General reciprocity increased between ages 9 and 16, with a stable pattern between ages 16 and 20 years. More importantly, reciprocity increased with age when the risk for the first player was great. Thus, when the first player took a big risk by trusting the second player, older adolescents reciprocated this trust more often, showing appreciation of the risk that the first player took (van den Bos et al., 2010).

Neural correlates of trustworthiness in adolescents (ages 12–22 years) also were tested while they played the Trust Game as second players (van den Bos, van Dijk, Westenberg, Rombouts, & Crone, 2009, 2011). On each trial, the participant received either trust or no trust from the first players. Neuroimaging showed increased activation in the DLPFC and TPJ when receiving trust relative to not receiving trust. In both regions, this activation difference correlated positively with a behavioral index for risk-related reciprocity, strengthening the hypothesis that these regions are important for perspective taking. Again, activation in both regions for trust relative to no-trust offers increased with age, with the strongest change between ages 12–14 and 15–17 years. Because prior work implicates these areas in perspective taking (e.g., Rilling & Sanfey, 2011), this outcome provides further support for the hypothesis that perspective taking increases with age.

In two different exchange paradigms, activation in DLPFC and TPJ increased gradually with age during social interactions that require perspective taking (Guroglu et al., 2011; van den Bos et al., 2011). These results fit well with other developmental studies in which TPJ is more engaged when participants think about others' intentions in stories or theory of mind tasks (Saxe, Whitfield-Gabrieli, Scholz, & Pelphrey, 2009). The DLPFC activation in social decision-making studies has been associated with the inhibition of selfish impulses (Steinbeis et al., 2012), as well as with cognitive control in general (Bunge et al., 2005). Therefore, the age-related change in DLPFC activation during perspective taking may reflect a more general increase in cognitive capacities, such as the ability to inhibit selfish impulses (Steinbeis et al., 2012).

EARLY ADOLESCENTS' FOCUS ON SELF

Accompanying young adolescents' greater skill in perspective taking is an increased focus on the self (Harter, 1999). Self-referential processing can be studied in the social decision-making context by focusing on selfish choices, such as when individuals maximize gains at the expense of others.

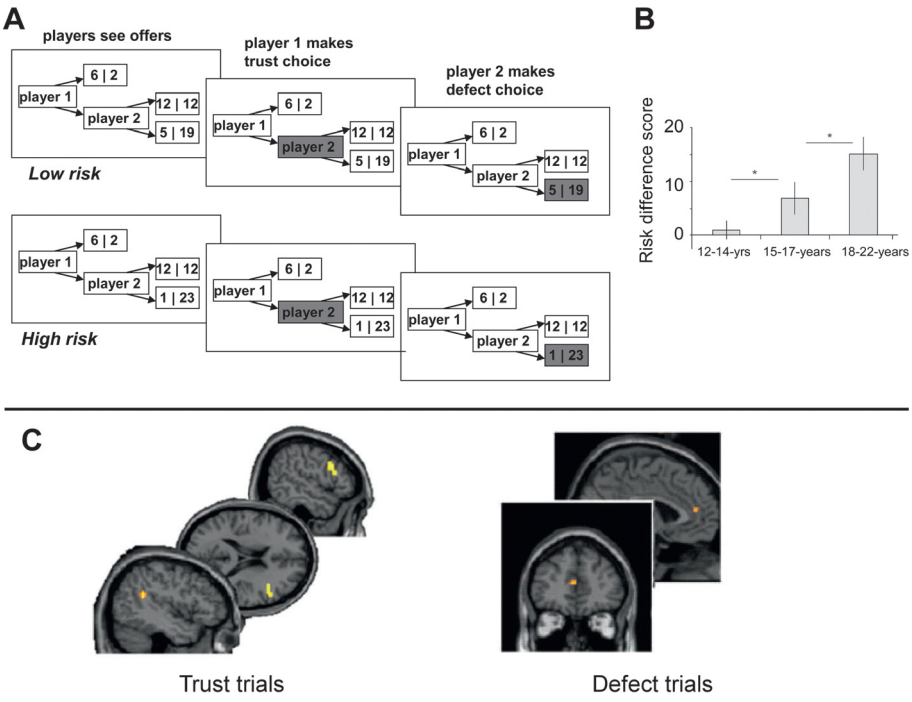

Figure 2. Example of the Trust Game with risk manipulations. (A) In the low-risk condition, Player 1 loses only one coin in case Player 2 defects (6 vs. 5) In the high-risk condition, Player 1 loses five coins in case Player 2 defects (6 vs. 1). (B) With increasing age, participants reciprocate more as second players in the high-risk condition, thereby showing understanding of the risk that Player 1 took. (C) Receiving trust correlates with more activation in dorsolateral prefrontal cortex and temporal-parietal junction with increasing age. Reciprocating results in a negative correlation with age in MPFC. The images were based on a regression analysis in which age was added as a predictor for activation.

In the Trust Game described earlier, adolescents' brain activation was examined when they defected relative to when they reciprocated. Defection was associated with increased activation in the dorsal-medial prefrontal cortex (DMPFC) in older adolescents (ages 15–17 years) and in adults, a region previously associated with strategic bargaining and maximizing one's own gains (Rilling & Sanfey, 2011; Van Overwalle, 2009). However, the young adolescents (ages 12–14 years) showed activation in the DMPFC not only when defecting but also when reciprocating (van den Bos et al., 2011). The DMPFC is more active in young adolescents when they think about themselves (Pfeifer, Lieberman, & Dapretto, 2007) or about socially embarrassing situations (Burnett, Bird, Moll, Frith, & Blakemore, 2009), and this area is important for self-referential processing (Denny, Kober, Wager, & Ochsner, 2012). Reciprocity choices may ask for more emphasis on the self-other differentiation in early adolescence compared to older adolescents and adults, which may indicate that adolescents engage more in self-oriented strategizing in social dilemmas.

THE IMPORTANCE OF PRIOR INTERACTIONS FOR FAIRNESS

Social context profoundly affects considerations of fairness (Tomasello & Vaish, 2012). Given the strong need for belonging in adolescence, I hypothesized that prior interactions with peers would also influence considerations of fairness.

Being rejected is stressful for individuals of all ages (Williams & Jarvis, 2006). The experience of social rejection is associated with increased activation in the ACC and the insula (Lieberman & Eisenberger, 2009). Adolescents show this activation to an extent that is similar to adults (Masten et al., 2009), but adolescents also show activation in the subgenual cingulate cortex (Gunther Moor et al., 2012; Masten et al., 2009), a region previously associated with negative affect (Masten, Eisenberger, Pfeifer, & Dapretto, 2010).

If adolescents are more sensitive to social rejection, then experiences that involve social rejection may also influence the exchange of goods in a social game with the individuals who excluded them. Indeed, when adolescents played the Dictator Game with players who had previously excluded them, they allocated less money to the excluders, and this "punishing" behavior was stronger for 10- to 12-year-olds than that for older players. This interaction with the excluders was associated with increased activation in the ventrolateral prefrontal cortex (VLPFC), TPJ, ACC, and insula (Gunther Moor et al., 2011), showing that even young adolescents activate the VLPFC and TPJ, regions linked to inhibiting impulses and perspective taking, in situations in which perspective taking is highly salient.

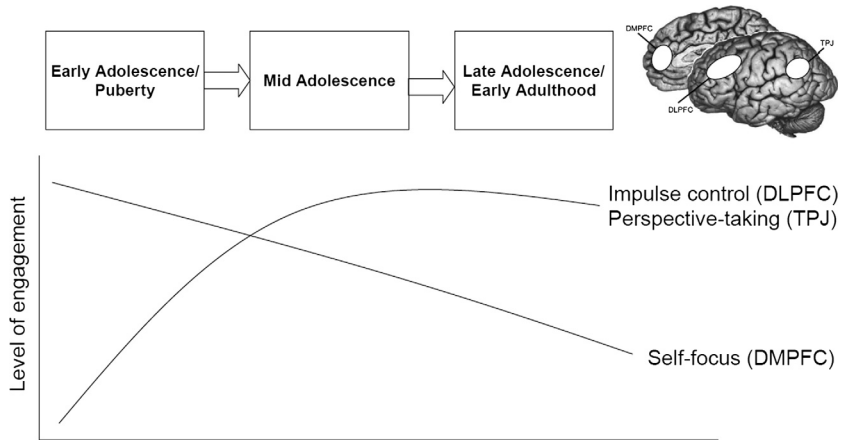

Figure 3. **Model for elevated self-oriented thinking in early adolescence and slowly emerging impulse control and perspective taking when considering consequences for others in social dilemmas. In early adolescence or puberty (10–14-years), rising gonadal hormone levels trigger a cascade of physical and social-emotional changes. Puberty is followed by mid-adolescence (15–18 years), during which adolescents gradually attain mature social goals. In late adolescence or early adulthood (19–25 years) adolescents reach the legal age for adult responsibilities. Adolescent development comes with increasing activation in dorsolateral prefrontal cortex (important for impulse control) and temporal-parietal junction (important for perspective taking) and reduced activation in MPFC (important for self-oriented thinking) in social dilemmas.**

CONCLUSIONS AND A WORKING MODEL

Economic exchange games involving social dilemmas shed light on the development of selfish impulses (i.e., maximizing one's own gain) and other-oriented behavior (i.e., taking others' perspectives). Behavioral and neuroimaging data indicate that activation in the DLPFC and TPJ when thinking about others' intentions increases with age (Gunther Moor, van Leijenhorst, Rombouts, Crone, & Van der Molen, 2010; Guroglu et al., 2009; van den Bos et al., 2011). This neural pattern is associated with greater understanding of others' intentions and more strategic fairness considerations.

The DMPFC is relatively overactive in early adolescence. This region was more active in young adolescents when they thought about how to split money in the Trust Game (van den Bos et al., 2011), but was also elevated in young adolescents in other studies involving self-oriented thinking (Burnett et al., 2009; Pfeifer et al., 2007). Self-oriented behavior that is observed in early adolescents (i.e., more self-oriented offers in the Ultimatum Game and Trust Game, more pronounced punishment of individuals who have previously excluded them) may be the result of elevated activation in the DMPFC, a region known to be involved in self-concept (Pfeifer et al., 2007), strategic bargaining (Rilling & Sanfey, 2011), and maximizing one's own gains (van den Bos et al., 2011).

Dorsolateral prefrontal cortex activation has been linked previously to the inhibition of selfish impulses (Steinbeis et al., 2012), suggesting a strong interplay between activation in the DMPFC and activation in the DLPFC and TPJ, with negative connectivity in adolescence (see Burnett & Blakemore, 2009, for preliminary evidence for this assumption). Figure 3 displays a model of how these brain regions may work together in situations in which concern for self conflicts with concern for others. These brain regions are likely to interact with several other areas that are part of the social brain network and that emerge during adolescence (for a review, see Burnett, Sebastian, Cohen Kadosh, & Blakemore, 2011). Research should distinguish between brain regions that are driving direct affective feelings (such as in social disgust, exclusion, or rejection) and those that cognitively regulate social emotions (such as perspective taking and the inhibition of selfish impulses). The DMPFC may be sensitive to affective components of social information processing (Sebastian et al., 2012).

Collectively, the findings I have reviewed indicate that decision making in adolescence shifts from self-oriented processing to other-oriented processing. The working model proposed earlier may also be a starting point to examine how social decision making is affected in various clinical populations, such as juvenile delinquents (van den Bos et al., 2012) and adolescents who behave aggressively (Sharp, Burton, & Ha, 2011). The goal of these studies is to unravel the mechanisms related to positive and negative peer interactions and to help improve adolescents' lives.

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