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Buffering effect of positive parent–child relationships on adolescent risk taking: A longitudinal neuroimaging investigation

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ABSTRACT

Adolescence is marked by a steep increase in risk-taking behavior. The serious consequences of such heightened risk taking raise the importance of identifying protective factors. Despite its dynamic change during adolescence, family relationships remain a key source of influence for teenagers. Using a longitudinal fMRI approach, we scanned 23 adolescents twice across a 1.5-year period to examine how changes in parent–child relationships contribute to changes in adolescent risk taking over time via changes in adolescents' neural reactivity to rewards. Results indicate that although parent–child relationships are not associated with adolescent risk taking concurrently, increases in positive parent–child relationships contribute to declines in adolescent risk taking. This process is mediated by longitudinal decreases in ventral striatum activation to rewards during risk taking. Findings highlight the neural pathways through which improvements in positive parent–child relationships serve to buffer longitudinal increases in adolescent risk taking.

Adolescence is a time of dramatic changes in brain, behavioral, and psychological functioning. A key change during this phase of development is a steep rise in risk taking. Compared with younger children, adolescents tend to engage in a variety of risky behaviors, such as reckless driving, substance use, and unprotected sexual activity (Arnett, 1992; Karriker-Jaffe et al., 2008), resulting in significant increases in morbidity and mortality rates in an otherwise healthy developmental period (e.g., National Vital Statistics Report, 2011). It is therefore crucial to identify protective factors that can prevent these upward trajectories of risk-taking behavior. Given the important role of family relationships in adolescents' adjustment (Collins and Steinberg, 2006; Smetana et al., 2006), the current study aimed to examine how changes in family relationships during the teen years influence trajectories of adolescent risk taking through changes in neural reactivity.

During adolescence, youth tend to individuate from their family and become more oriented toward peers (Collins and Steinberg, 2006; Nelson et al., 2005). Indeed, dramatic changes in parent–child relationships are well-documented (Keijsers and Poulin, 2013; Laursen et al., 1998; Loeber et al., 2000; McGue et al., 2005). While normative patterns may characterize family relationships as increasing in negativity during adolescence (Laursen et al., 1998; Tsai et al., 2013), this is also a time during which some adolescents experience improvements in the quality of their family relationships, including more positive interactions, greater feelings of cohesion, and a heightened sense of family identity (e.g., Steinberg, 2001). The changing nature of parent–child relationships may serve an important protective role for adolescents' psychological well-being. Indeed, positive parent–child relationships are a key factor related to reduced adolescent risk taking. For example, greater parental support and child disclosure to parents are associated with adolescents' lower problem behavior, such as drinking, delinquency, and drug use (Jessor et al., 2003; Stattin and Kerr, 2000), and lower rates of parent–child conflict are associated with less externalizing symptoms, conduct problems, and antisocial behavior (Burt et al., 2006; Klahr et al., 2011a,b). Thus, higher quality family relationships serve to buffer adolescents from engaging in risk-taking behavior.

Theories and empirical studies on adolescent brain development suggest that increases in risk taking during adolescence may occur, in part, due to increased activation in reward-related regions. The development of the reward system, and the ventral

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striatum in particular, develops relatively early, peaking in neural reactivity around adolescence (Casey et al., 2008; Steinberg, 2008). Emerging evidence has shown that the social environment, such as parents and peers may play a role in adolescent brain function during risk taking. For example, prior research shows that negative environmental factors, such as in the presence of peers, amplify adolescents' ventral striatum activation, leading to greater risk-taking behavior (Chein et al., 2011). In contrast, the presence of mothers serves as a protective factor by reducing adolescents' ventral striatum activation during risk taking (Telzer et al., in press). However, little is known about how the *quality* of parent–child relationships or how *changes* in relationship quality contribute to longitudinal changes in adolescents' neural sensitivity to risk taking.

Several prior studies have demonstrated that early family relationships impact children's brain development. For example, early maternal deprivation and severe parental neglect or abuse in young children is associated with altered ventral striatum activity during adolescence (Goff et al., 2013; Hart and Rubia, 2012; Mehta et al., 2010). Thus, early parent–child relationships may influence adolescent brain development in the long run. However, no prior studies have carefully examined how changes in parent–child relationships during later development affect adolescents' neural reactivity. Given that family relationships change substantially during adolescence, a time when the brain is highly sensitive to sociocultural processing (Blakemore and Mills, 2014), it is key to understand how the changing nature of these relationships may affect adolescents' risk taking and neural sensitivity over time.

We sought to examine how changes in positive parent–child relationships are associated with changes in adolescents' neural sensitivity to rewards and changes in their risk-taking behavior over time. To this end, we used a longitudinal design in which adolescents completed an fMRI scan twice, approximately 1.5 years apart. We focus on middle to late adolescence, because this is a time when adolescents are given more autonomy for decision making (Wray-Lake et al., 2010), and therefore have more opportunities to engage in risky behaviors. Moreover, their family relationships may also witness important changes. For example, prior studies have shown changes in the time adolescents spend with their parents, and adolescents' perceptions of relationships with parents continue to change during this phase of development (De Goede et al., 2009; Lam et al., 2012). In particular, adolescents report significant declines in their sense of family cohesion and family identity declines that tend to taper off at 12th grade (Tsai et al., 2013). Moreover, although many studies have demonstrated a rise in risk-taking behavior as children enter early adolescence, risk taking and reward seeking also show large changes from middle to late adolescence (Steinberg, 2010). Thus, it is important to examine individual differences in such changes and the neural correlates associated with such changes.

In the current study, we examined whether changes in parent–child relationships contribute to changes in adolescent risk taking. We hypothesized that greater increases in positive parent–child relationships from Time 1 (T1) to Time 2 (T2) would be associated with greater declines in adolescent risk-taking behavior during this same period. Second, we investigated how changes in positive parent–child relationships are associated with longitudinal changes in adolescents' neural reactivity to rewards during risk taking. Given the important role of the ventral striatum in reward processing, we hypothesized that greater increases in positive parent–child relationships from T1 to T2 would be associated with declines in ventral striatum activation during risk taking from T1 to T2. Finally, we conducted mediation analyses to test whether longitudinal changes in neural activation explain the link between changes in positive parent–child relationships and changes in adolescent risk taking. We hypothesized that greater increases in positive parent–child relationships would contribute to greater declines in adolescent risk-taking behavior through changes in neural reactivity to rewards over time.

1. Method

1.1. Participants

A community sample of 24 adolescents[1] completed two fMRI scans, approximately 1.5 years apart, a developmental window characterized by significant changes in brain function (Van den Bulk et al., 2013). One participant was excluded from analyses due to excessive head movement (i.e., >2.5 mm). All participants were recruited from one public high school and were in the 10th or 11th grade at T1 and in the 11th or 12th grade at T2. Our final sample comprised 23 adolescents (15 girls; M_{age} T1 = 15.78 years, range = 15.34–17.13 years, SD = .60; M_{age} T2 = 17.13 years, range = 16.43–18.42 years, SD = .70). Participants were not currently taking any medications and did not report being diagnosed with any mood disorders. Most participants were from low-SES families. A majority of fathers (87%) and mothers (91%) had high school diploma or less, with an average annual family income of $26,000 (range = $10,000–53,200). Participants completed written consent and assent in accordance with the University's Institutional Review Board.

1.2. Positive parent–child relationships

To obtain a full scope of family relationship quality, at both T1 and T2 adolescents reported on their sense of parental support, disclosure to parents, and conflict with parents, three key aspects that reflect parent–child relationships in daily life (Smetana et al., 2006; Steinberg, 2001). Adolescents' sense of parental support was assessed by 9 items of the Inventory of Parent and Peer Attachment (IPPA) (Armsden and Greenberg, 1987). Adolescents rated the degree to which each item (e.g., "My parents respected my feelings." and "My parents helped me to talk about my difficulties.") was true for them in the past month on a 5-point scale ranging from "almost never or never true" to "almost always or always true". α = .94 at T1 and .95 at T2. Adolescents reported on their spontaneous disclosure to parents in the past month using 5 items (Stattin and Kerr, 2000; e.g., "Did you spontaneously tell your parents about your friends?" and "Did you hide a lot from your parents about what you do during nights and weekends?") on a 5-point scale ranging from "almost never" to "almost always". α = .74 at T1 and .81 at T2. Parent–child conflict was assessed by 10 items (Ruiz et al., 1998; Telzer et al., 2014b; e.g., "You and your parents had a serious argument or fight." and "You and your parents yelled or raised your voices at each other."). Adolescents reported how true each item was for them in the past month on a 5-point scale ranging from "almost never" to "almost always". α = .91 at T1 and .85 at T2. The mean of parent–child conflict was taken, with higher scores indicating greater parent–child conflict.

The scores of parental support, child disclosure, and parent–child conflict were correlated: greater parental support was associated with greater child disclosure (T1: r = .44, p < .05; T2: r = .51, p = .01) and lower family conflict (T1: r = –.50,

[1] This sample is a subsample of a larger study of 48 adolescents who completed a scan at T1. Prior data from the full sample at T1 with the BART data have been published (e.g., Telzer et al., 2013a,b, 2014a,b, 2015). Based on factor analyses, the measures used in the present study are distinct from measures in prior reports. Published work from this longitudinal data using the BART task and the same sample only focuses on the main effect of longitudinal changes in neural reactivity during risk taking (Qu et al., in press).