

But is helping you worth the risk? Defining Prosocial Risk Taking in adolescence



Kathy T. Do^{a,1}, João F. Guassi Moreira^{b,1}, Eva H. Telzer^{a,*,1}

^a Department of Psychology and Neuroscience, University of North Carolina, Chapel Hill, United States

^b Department of Psychology, University of California, Los Angeles, United States

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ABSTRACT

Recent work has shown that the same neural circuitry that typically underlies risky behaviors also contributes to prosocial behaviors. Despite the striking overlap between two seemingly distinct behavioral patterns, little is known about how risk taking and prosociality interact and inform adolescent decision making. We review literature on adolescent brain development as it pertains to risk taking and prosociality and propose a new area of study, Prosocial Risk Taking, which suggests that adolescents can make risky decisions with the intention of helping other individuals. Given key socialization processes and ongoing neurodevelopmental changes during this time, adolescence may represent a sensitive period for the emergence of Prosocial Risk Taking, especially within a wide variety of social contexts when youth's increased sensitivity to social evaluation and belonging impacts their behaviors. Prosocial Risk Taking in adolescence is an area of study that has been overlooked in the literature, but could help explain how ontogenetic changes in the adolescent brain may create not only vulnerabilities, but also opportunities for healthy prosocial development.

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* Corresponding author.

E-mail addresses: kathydo@unc.edu (K.T. Do), jguassimoreira@ucla.edu (J.F. Guassi Moreira), ehotelzer@unc.edu (E.H. Telzer).

¹ Equal author contribution.

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1. Introduction

For decades, adolescence has been characterized as a time of “storm and stress” that is often associated with a heightened risk of engaging in negative, health-compromising behaviors (Arnett, 1999; Hall, 1904). However, researchers have recently shifted their attention towards investigating the positive aspects of adolescent development in order to better understand the factors promoting well-being (Lerner et al., 2005; Telzer et al., 2014). This latter focus underscores adolescence as not only a period of vulnerability for negative behaviors, but also a period of opportunity for healthy development (Dahl, 2004). Recent work combining theoretical and methodological approaches from developmental science, cognitive neuroscience, and social psychology illustrate that negative, risk-taking behaviors and positive, prosocial behaviors rely on overlapping neural circuitry (Telzer, 2016) and that these behaviors increase in adolescence, in part, due to changes in neural circuitry around the time of puberty. In fact, while theory and research on risk taking and prosocial behavior have been extensively discussed and well defined in the literature, the intersection of these two constructs has not been introduced to the field. This gap in the literature highlights the complexity of studying brain and behavior relationships during adolescence, whereby simpler models of adolescent brain development may fail to capture important interactions between affective, cognitive, and social processes that affect developmental outcomes (Crone and Dahl, 2012; Pfeifer and Allen, 2012).

To contribute to this increasingly interdisciplinary research on adolescent neurodevelopment, the current review proposes a new area of study called Prosocial Risk Taking, which emerges at the intersection of risk taking and prosociality. Prosocial Risk Taking considers how these two well-defined adolescent behaviors overlap to address an intriguing possibility: do adolescents *take risks to benefit others*? By moving beyond traditional methods examining risk taking and prosociality separately and focusing instead on how these behaviors interact and vary across social contexts, we may gain a more nuanced understanding of the complex psychosocial and neurobiological factors that influence adolescent decision-making. Prosocial Risk Taking challenges the widely-supported model of adolescence as a period of heightened vulnerability by suggesting that traditionally negative behaviors, like risk taking, could foster positive social development if those risks are taken to benefit others. Indeed, exciting advances in the field of developmental cognitive neuroscience often emerge from studying the cognitive, social, and neurodevelopmental processes by which they occur, highlighting the need to integrate multiple behavioral constructs to gain a more comprehensive understanding of adolescent development.

Before expanding on our definition of Prosocial Risk Taking, it is important to review the existing adolescent literature guiding the development and framework of the proposed area of study. First, we discuss prominent neurodevelopmental and social changes in adolescence, rendering it a sensitive period for cognitive, social, and affective processing. Second, we review the literature on adolescent risk taking and prosocial behavior, highlighting similarities in their developmental trajectories, underlying neural systems, and socialization processes. While prior reviews have summarized the risk taking literature (e.g., Crone et al., 2016), our review on proso-

cial development will be the first to synthesize behavioral and neuroimaging evidence in support of the emerging model of adolescence as a period of opportunity for positive, healthy behaviors. Third, we integrate these literatures to describe our proposed area of study, with a particular emphasis on its possible neural underpinnings. Finally, we discuss prospective methods of measuring Prosocial Risk Taking and its implications on developmental outcomes during adolescence.

2. Neurodevelopment and social sensitivity during adolescence

Adolescence is marked by complex biological and psychological transformations that underlie a wide range of behaviors (Nelson et al., 2005, 2016; Spear 2011). Specifically, adolescent neurodevelopment is characterized by a rapid maturation and hyperreactivity of the ventral affective system, which includes the ventral striatum (VS) and amygdala (Hare et al., 2008; Monk et al., 2003; Galván et al., 2006). Activation in the VS is implicated in motivation and reward processing (Somerville et al., 2010; Casey, 2015), shows developmental peaks in activation during adolescence (Galván et al., 2006), and is thought to underlie adolescent-specific increases in novelty seeking and approach behaviors (Telzer, 2016; Silverman et al., 2015). The amygdala plays a role in the detection of meaningful and salient stimuli, especially socioemotional ones (e.g., Guyer et al., 2008a,b; van Bavel et al., 2008), and shows adolescent-specific peaks in response to negatively-valenced stimuli (Hare et al., 2008) but hypoactivation in response to the omission of rewarding stimuli (Ernst et al., 2005).

In contrast to the ventral affective system, the prefrontal cortex (PFC), which is involved in cognitive control, shows protracted development into the second decade of life (Spear 2000, 2011; Lebel et al., 2008; Tamnes et al., 2010). As a result, relatively hypersensitive affective systems in conjunction with a still maturing cognitive control system may render adolescents susceptible to poor behavioral and emotional regulation (Steinberg, 2010; Strang et al., 2013; Silvers et al., 2012). Indeed, extant literature demonstrates that these neurodevelopmental processes in adolescence contribute to greater rates of health compromising behaviors in humans (Somerville et al., 2010; Casey et al., 2011), as well as non-human primates (Fairbanks, 1993) and rodents (Spear, 2000, 2011).

In addition to changes in affective and inhibitory control systems, adolescence is a sensitive developmental phase for social cognitive processing (Blakemore and Mills, 2014). Significant structural and functional changes occur in the social brain network during adolescence (Mills et al., 2014a; Blakemore and Mills, 2014), which is comprised of the temporoparietal junction (TPJ), posterior superior temporal sulcus (pSTS), dorsomedial and medial prefrontal cortices (dmPFC, mPFC), and other cortical midline structures such as the medial posterior parietal cortex (mPPC; see Pfeifer and Peake, 2012 for an expanded characterization of the social brain). Numerous studies have found that teenagers exhibit increased activation in social brain circuitry relative to adults or children when processing social cognitive information, which may differ across social contexts (e.g., peers, parents) (Blakemore and Mills, 2014; Somerville et al., 2013). For example, the mere thought of being watched by peers uniquely induces self-conscious emo-

tions, heightened physiological arousal, and activation in the mPFC, a region implicated in self-concept and socioemotional processing, during adolescence (Somerville et al., 2013). Adolescents' heightened concern with social status and evaluation evokes increased activity in mentalizing (mPFC, TPJ, STS), reward (vmPFC), and impulse control (vlPFC) regions, which has been shown to prompt shifts in attitudes and behaviors toward those of others, ranging from parents to unknown adults (Chein et al., 2011; Knoll et al., 2015; Welborn et al., 2016). Indeed, while interactions with peers may be a particularly salient social context during this developmental period, parents and unknown adults just as powerfully guide adolescents' choices and elicit mentalizing (mPFC), reward (VS), and regulatory-related (vlPFC, dlPFC) activity (Telzer et al., 2015; Engelmann et al., 2012). These findings underscore how neural sensitivity to social status goals can considerably impact decision-making and social interactions during adolescence.

While previous research has primarily focused on how the developing brain predisposes adolescents to health-compromising behaviors, there is an emerging literature exploring how adolescent brain development facilitates healthy outcomes. In particular, scholars suggest that hyperactive reward and affective processing, coupled with heightened social cognitive processing, also underlie adaptive and beneficial behaviors (see Telzer, 2016). For instance, the ventral affective system, which is often implicated in risk taking behaviors, is also responsive to healthy rewards, such as helping others (Telzer et al., 2015; Telzer et al., 2013a, 2014). Interactions between reward-related circuitry and prefrontal systems can even bolster inhibitory control (Teslovich et al., 2014; Pfeifer et al., 2011; Telzer et al., 2015). Overall, these findings highlight that normative changes in the adolescent brain are associated with both positive and negative outcomes. In subsequent sections, we will integrate these perspectives (i.e., that heightened reward sensitivity engenders negative risk taking and positive other-oriented behaviors) and propose that these neural systems may also facilitate behavior that is helpful towards others, even when there are inherent risks to oneself.

3. Risk-taking behaviors during adolescence

Risk taking, or engaging in a behavior with an uncertain outcome that may lead to detriments in a given domain (e.g. health, social, etc.), is one of the most widely studied topics in developmental science. This is due, in part, to its real-world impact: morbidity and mortality rates increase 200–300% from childhood to adolescence, with 70% of annual adolescent deaths in the United States stemming from risky behaviors such as reckless driving or unsafe sexual practices (Centers for Disease Control & Prevention, 2012; Victor and Hariri, 2016). In the following section, we briefly discuss the developmental trajectories of risk taking behaviors, the supporting brain systems involved, and how social factors influence risk-taking.

3.1. Developmental trajectories of risk taking

Evidence from self-reports and experimental tasks suggests that heightened risk taking is an adolescent-specific phenomenon (Casey, 2015) marked by an inverse U-shaped pattern that peaks around early-to-middle adolescence (Steinberg et al., 2008; Braams et al., 2015). Peaks in self-reported sensation seeking along with ineffective cognitive control may underlie increased risk taking during adolescence relative to childhood and adulthood (Steinberg et al., 2008). Importantly, longitudinal studies provide further support that risk taking and sensation seeking increase over time within individuals, an effect that is most pronounced during the adolescent years and is followed by decreases towards the end of

adolescence and start of adulthood (Steinberg et al., 2008; Kim-Spoon et al., 2016; Icenogle et al., in press; Duell et al., 2016).

3.2. Neural mechanisms underlying risk taking

Adolescent-specific peaks in risk taking and sensation-seeking behaviors are subserved by still-maturing affective and cognitive circuits in the brain. Cross-sectional and longitudinal neuroimaging studies have revealed that adolescents show greater VS reactivity during experimental paradigms that measure reward receipt and risk taking compared to children or adults (Galván et al., 2006, 2007; Qu et al., 2015; Braams et al., 2015; Silverman et al., 2015). Importantly, several of these studies also report that VS reactivity is associated with greater real-life risk-taking behavior. By contrast, regulatory prefrontal regions mature steadily with age, but have only been linked to effective regulation of the VS and diminished risky tendencies as individuals begin to mature out of adolescence (Qu et al., 2015). Similar developmental imbalances between the PFC and other subcortical regions, such as the amygdala and nucleus accumbens, have also been shown to underlie adolescent risk taking (Mills et al., 2014b). Risk taking in adolescence is associated with blunted amygdala reactivity to threat, such that risky scenarios sometimes elicit less amygdala activation in adolescents relative to children or adults (Ernst et al., 2006). Given the amygdala's role in processing threat and risk-aversion (LeDoux, 2007; Sokol-Hessner et al., 2013), this neural signature, along with dysregulated cognitive control in prefrontal regions, is thought to render adolescents less risk averse and more susceptible to risk taking behaviors (Casey, 2015).

3.3. Contextual considerations for risk taking

Recent work addressing individual differences in adolescent risky behavior (Braams et al., 2015; van Duijvenvoorde et al., 2015) demonstrates that risk-taking tendencies are not ubiquitous across all social contexts. In non-socioemotional contexts, adolescents behave similarly to adults whereas in socioemotionally salient contexts, adolescents tend to make riskier decisions, perhaps due to a combination of heightened arousal and diminished impulse inhibition (Botdorf et al., 2016). One of the most emotionally salient social contexts for adolescents is the presence of peers, though the presence of other sources (e.g., parents) is also meaningful. Unsurprisingly, adolescents, but not children or adults, are more likely to make risky decisions when their peers are present compared to when alone, which occurs in tandem with a relatively hyperactive striatal signal (Chein et al., 2011; Gardner and Steinberg, 2005). Notably, this behavioral tendency is not unique to human adolescents, as it has also been documented in rodents (Macriè et al., 2002; Laviola et al., 2003; Logue et al., 2014). Conversely, other forms of social influence can actually attenuate adolescent risk-taking tendencies. The presence of older adults (strangers and parents) reduces adolescents' risky decisions (Silva et al., 2016; Telzer et al., 2015), and the presence of adolescents' mothers alters reward sensitivity in the adolescent brain, such that it appears to be more neurobiologically rewarding to make safe decisions instead of risky ones (Telzer et al., 2015). These findings parallel recent evidence implicating the additional role of the social brain network (e.g., mPFC, TPJ) when adolescents make social decisions in which the outcomes are uncertain (Telzer et al., 2015; Braams et al., 2014), suggesting that teenagers may require more mentalizing capacities when considering the social implications of their risky decisions. Interestingly, increased approach motivation in adolescence (Luciana et al., 2012), especially in social contexts, may lend itself to a greater propensity for committing behaviors where others stand to benefit, which raises an intriguing possibility that,

although adolescents may be more likely to take risks, they could be doing so in order to help others.

4. Prosocial behaviors during adolescence

The ability to become less self-oriented and more helpful to others has been considered one of the hallmarks of adulthood (Arnett, 2003). Yet, surprisingly less attention has been devoted to understanding the development of prosocial behaviors relative to risk taking behaviors. Prosociality describes voluntary actions intended to benefit another, which range from cooperating with others to making donations. Longitudinal work in humans has shown that children and adolescents who exhibit greater prosocial behaviors have better relationships with peers (Eisenberg et al., 2006), less internalizing and externalizing problems (Bandura, 1999), and better academic performance (Caprara et al., 2000; Wentzel et al., 2004). Prosocial youth are also more likely to have better cognitive and emotion regulation abilities (Rothbart and Rueda, 2005; Eisenberg et al., 2006), which may enable them to adapt to environmental stressors better than their less prosocial counterparts. Together, these findings underscore the adaptive benefits of prosocial behaviors.

4.1. Developmental trajectories of prosociality

Although there is a general increase in prosocial behaviors from childhood through adulthood (Eisenberg and Fabes, 1998), the literature is mixed during the adolescent years, with reports of increases, no change, or even declines in prosocial responding. For example, a six-year longitudinal study using self-report assessments characterized the development of prosocial behaviors from adolescence to adulthood as a cubic trend, whereby helping behaviors increased from ages 15–18, dropped off in the early 20s, and increased again from ages 25–26 (Eisenberg et al., 2005). Another longitudinal study of over 500 adolescents reported declines in prosocial behaviors from ages 13–17 before increasing again until age 21 (Luengo Kanacri et al., 2013). Moreover, cross-sectional studies report greater prosocial behaviors in younger adolescents compared to older adolescents, with peaks between ages 12–13 years (Burnett Heyes et al., 2015; Güroğlu et al., 2014; Meuwese et al., 2015; van Hoorn et al., 2016). As a result, there is less known about prosocial development within the adolescent years, marking it an interesting and important area for future research.

Altogether, these studies fail to find consistent increases in prosocial behavior across adolescence, a perplexing result given that adolescence is a time when social cognitive abilities, like perspective taking and sensitivity to others, are increasing. Based on previous work, one possibility is that developmental increases in perspective-taking and group belonging, which are supported by social brain development (Blakemore and Mills, 2014; Blakemore, 2008), are a precursor for actuating prosocial behavior during adolescence. These empirical inconsistencies suggest that there may be several social, cognitive, and neurobiological processes that meaningfully shape adolescents' prosocial responding in a way that current methodological approaches are unable to capture.

4.2. Neural mechanisms underlying prosociality

The act of helping others, or even just watching others experience positive outcomes, engages the mesolimbic reward system (Harbaugh et al., 2007; Morelli et al., 2014; Telzer et al., 2014). Specifically, the VS and ventromedial prefrontal cortex (vmPFC), which have been implicated in tracking the salience and receipt of rewards, show increased activation when individuals donate to others (Telzer et al., 2014; Zaki and Mitchell, 2011). This occurs even when donations are forced (e.g., taxation for the public good)

instead of voluntary (Harbaugh et al., 2007), suggesting that just the act of giving is rewarding and satisfying. In fact, helping others may be more intrinsically rewarding than gaining a reward for oneself. Behavioral and neural evidence reveal that teenagers and adults place a greater subjective value on prosociality insofar as they are willing to incur a personal cost (earning less money themselves) to donate more money to others, and exhibit greater VS and vmPFC activity when making these costly donations than when gaining a reward for oneself (Telzer et al., 2014; Zaki and Mitchell, 2011). These findings suggest that individuals may be intrinsically motivated toward prosocial actions because the reward associated with helping others is more valuable than purely selfish gains.

Prosocial behaviors are also supported by brain regions implicated in perspective-taking (Burkart and Rueth, 2013; Eisenberg, 1986; Greene and Haidt, 2002; Lukas and Clutton-Brock, 2012), an ability that improves considerably from childhood to adulthood. Within the adolescent years alone, early adolescents think and act more selfishly but by late adolescence engage more impulse control and other-oriented thoughts (Eisenberg et al., 1995; Elkind, 1985; Steinberg, 2009). Greater perspective-taking abilities and cognitive regulation may reduce self-oriented considerations and promote other-oriented actions, with cognitive regulation, more specifically, associated with age-related increases in prosocial behaviors during adolescence (Güroğlu et al., 2014; Luengo Kanacri et al., 2013). Brain regions implicated in self-control (dorsolateral PFC (dlPFC)) and social cognition (TPJ, pSTS, mPFC) are activated during costly prosociality, or helping another at a cost to oneself, suggesting that prosocial decisions involve greater regulatory and mentalizing processes (Telzer et al., 2015; Telzer et al., 2011). Moreover, TPJ activity increases when individuals learn they are trusted (a process that involves an attentional shift from oneself to the other person) and correlates with more advanced perspective-taking abilities (van den Bos et al., 2011), self-reported altruism, and charity donations (Hare et al., 2010; Tankersley et al., 2007). Though no study to our knowledge has characterized the neural contributions of prosocial behavior from childhood to adulthood, cross-sectional research on prosocial decision making has found increases in reward and social cognition circuitry during adolescence (Telzer et al., 2013a, 2014), with exaggerated effects among early adolescents (12–14 years old) compared to late adolescents (15–17 years old) (van Hoorn et al., 2016). Thus, neural processes involved in self-control and mentalizing, which are still undergoing significant maturation, may be important for facilitating other-oriented concerns and prosocial responding.

4.3. Contextual considerations for prosociality

Social processes considerably shape adolescent prosocial behaviors and healthy outcomes. For example, implicit ingroup biases (Telzer et al., 2015), stronger family obligation values (Telzer, Masten, Berkman, Lieberman, & Fuligni, 2010; Telzer et al., 2011), and greater popularity among peer groups (Cillessen and Rose, 2005; Sandstrom and Cillessen, 2006) all increase prosocial decision-making. Recent work has found that adolescents exhibit greater prosocial behavior after receiving positive feedback from peers (van Hoorn, van Dijk, Meuwese, Rieffe, & Crone, 2014). Although the mere presence of peers has been associated with increased prosociality (Izuma, Saito, & Sadato, 2010; van Hoorn et al., 2016), the direction of this effect changes depending on the type of feedback given by peers, such that adolescents become more prosocial when peers approve of their actions and less when they disapprove (van Hoorn et al., 2014, 2016). These findings resonate with past work examining how adolescents integrate social information into their decision making process and suggest that social status goals (e.g., belonging to social groups) may drive adolescents to conform to others' behaviors. Perhaps adolescents' heightened

susceptibility to social feedback can be redirected toward healthier outcomes, especially because positive feedback, paralleled by increases in affective and regulatory activation, has been shown to have a greater impact on social decision making compared to negative feedback (Guyer et al., 2012; Jones et al., 2014).

Not only can prosocial behaviors enhance social connection with others, but they can also have a lasting impact at the neural level and improve adolescent adjustment. Greater prosocial behavior in family and peer contexts elicits greater neurobiological responses in reward (VS) and social brain (mPFC, TPJ, STS) circuitry (Hare et al., 2010; Telzer et al., 2011, 2014; van Hoorn et al., 2016). For example, heightened VS reactivity, coupled with a greater socialization of family and cultural values (Telzer et al., 2010, 2011), results in more positive real-world outcomes during adolescence, such as declines in risk-taking and depression (Telzer et al., 2013b, 2014). Thus, while susceptibility to social influence (e.g., from peers) is traditionally associated with maladaptive behaviors, greater sensitivity to social inputs may actually confer opportunities for healthy and positive adolescent development in more favorable contexts.

5. Prosocial Risk Taking

Given key socialization processes and a rapid reorganization of motivational, social, and cognitive neural circuitry during adolescence (summarized in Table 1), we propose a new area of study, Prosocial Risk Taking (PSRT), to explore the possibility that adolescents engage in risk-taking behaviors to benefit others. In this section, we discuss the proposed behavioral and neural mechanisms of PSRT and describe four behavioral types that may emerge when considering how prosocial and risk-taking tendencies interact. We discuss evidence that suggests adolescence could be a sensitive period for PSRT, with a focus on how individual differences in several psychosocial factors contribute to PSRT. Finally, we consider the best methodological practices for investigating this phenomenon and discuss its implications on adolescent adjustment and neurodevelopment.

5.1. Defining Prosocial Risk Taking

We define PSRT as the act of engaging in a risky decision with the intention of helping other individuals. We propose that PSRT has two necessary components:

- a The action is completed with the intention of primarily benefiting another individual and not oneself.
- b The action requires that oneself incurs a cost in the form of a risk, which is typically social (though it can be physical, emotional, etc.).

First, the primary beneficiary of the helpful act (e.g., emotional relief, monetary assistance, etc.) must be another individual. The action should not be completed with any intention to directly benefit oneself, though it is possible for an intrinsic reward to be indirectly experienced by the act of helping (e.g., warm glow). Thus, this component would not be met if the action was intended to benefit both another individual and oneself simultaneously, or benefit oneself more than the other individual. Second, there must be an unknown risk, or cost, to oneself (and not the other individual) when providing the prosocial act, which could arise from social, physical, or emotional factors. This component would not be met if there is no risk incurred to oneself or the risk is instead incurred by another individual.

To better illustrate PSRT, consider the following example: Imagine you are a teenager at school and witness a bully embarrassing another person. Do you intervene and defend the victim? Or do

you say and do nothing because you are worried about the consequences? What will your friends think if you do or do not intervene? What if the bully begins to target you? In social situations like these, adolescents often weigh the costs and benefits of their involvement when deciding how to act. In this example, the PSRT response would be to help the victim out of harm's way by standing up to the bully's offenses (prosocial action), despite the unknown risk of the bully possibly redirecting his/her physical and verbal attacks at them (physical risk and/or risk to social status). Notably, both of these risks are unknown as one may or may not incur either consequence when helping the other individual and the only benefit to oneself is the satisfaction indirectly associated with helping the other individual out of harm's way (See Table 3 for additional examples of PSRT).

Importantly, the two necessary components described above distinguish PSRT from simple risk taking or prosociality, particularly as PSRT integrates components of both constructs to describe a possibly unique phenomenon that has garnered less attention in the literature. For risk taking behaviors, there is no required benefit to another individual, only a risk to oneself and potentially to the other individuals involved. For prosocial behaviors, the intention to directly benefit another individual is present, but there is no risk incurred to oneself. Although there may be a personal cost associated with some forms of prosociality (e.g., donating time or money to a charity), such costs are known whereas PSRT requires an unknown cost associated with the risk. Thus, the time or effort that an individual typically acknowledges when making a purely prosocial decision is different from the type of unknown costs inherent in making a decision to engage in PSRT behaviors. See Table 2 for a direct comparison of PSRT, risk taking, and prosociality.

Because adolescent behavior and neurodevelopment are characterized by heightened social sensitivity, we propose that the cost of helping when performing PSRT actions will most often involve a social risk compared to other risk types (e.g., physical, emotional). Thus, we will focus our remaining discussion of PSRT on risks primarily incurred in a social context, though we acknowledge that the role of risk taking in our proposed area of study goes beyond these considerations. Perhaps the most salient of social consequences is how teenagers' actions influence the way others think about them, which can range from a loss of social standing within a group of peers to damaging a relationship with a parent or teacher. In fact, adolescents' increased social status considerations may impede their ability to engage in simple risk-taking or prosocial behaviors, especially in social situations that involve opportunities to engage in both types of behaviors. These more complex social situations require increased forethought to balance one's proclivities to engage in risk-taking and prosocial behaviors with emerging social standing goals. For example, adolescents who particularly value their social standing with others might adjust their response—whether oriented toward more prosocial or risk-taking behaviors—from what they want to do to what they think others might approve of. One interesting possibility may be that the intrinsic reward associated with helping someone, even when it involves a personal cost, is more important than its potentially negative consequences on adolescents' social status goals, though more evidence is warranted.

5.2. Four behavioral types may emerge at the intersection of prosociality and risk taking

The extent to which individuals engage in both prosocial and risk-taking behaviors may predict how they respond in a social dilemma. We propose that there are four types of individuals that emerge at the intersection of their prosocial and risk-taking tendencies: prosocial risk takers (PSRT), antisocial risk takers (ASRT), empathetic bystanders (EB), and indifferent bystanders (IB) (Fig. 1;

Table 1
Key findings from risk taking and prosocial literature reviews.

	Risk Taking	Prosociality
Definition	<ul style="list-style-type: none"> • Actions with the greatest outcome variability 	<ul style="list-style-type: none"> • Voluntary actions intended to benefit another individual
Developmental Trajectories in Behavior	<p><i>Inverse U-shape pattern</i></p> <ul style="list-style-type: none"> • Increases in childhood • Peaks in adolescence • Decreases in adulthood 	<p><i>Inconsistent patterns</i></p> <ul style="list-style-type: none"> • Increases in childhood • Inconsistent findings during adolescence (either increases, no changes, decreases) • Increases in adulthood
Brain Regions Implicated		
Reward regions VS, vmPFC	✓	✓
Threat Detection regions Amygdala	✓	
Cognitive Control regions dACC, dlPFC, vlPFC	✓	✓
Social Brain regions TPJ, mPFC, dmPFC	✓	✓
Developmental Trajectories in Brain		
Reward regions VS, vmPFC	<p><i>Inverse U-shape pattern</i></p> <ul style="list-style-type: none"> • Increases in childhood • Peaks in adolescence • Decreases in adulthood 	
Threat Detection regions Amygdala	<p><i>U-shape pattern</i></p> <ul style="list-style-type: none"> • Blunted threat response during adolescence relative to childhood and adulthood 	
Cognitive Control regions dACC, dlPFC, vlPFC	<p><i>Linear increase</i></p> <ul style="list-style-type: none"> • Steady improvements from childhood to adulthood 	
Social Brain regions TPJ, mPFC, dmPFC	<p><i>Inverse U-shape pattern</i></p> <ul style="list-style-type: none"> • Potential peaks for risky decisions in social settings 	<ul style="list-style-type: none"> • Greater activation in early adolescents (12–14 years old) relative to late adolescents (15–17 years old)
How Adolescence is Characterized	<ul style="list-style-type: none"> • Vulnerability • Orientation toward negative rewards • Sensitivity to social threat 	<ul style="list-style-type: none"> • Opportunity • Orientation toward positive rewards • Sensitivity to social connection

Note. Although here we briefly describe the developmental trajectories of various brain regions, it is worth mentioning that supporting evidence is more robust for certain regions compared to others. Namely, the reward and cognitive control regions have received more supporting evidence compared to the social brain and threat detection regions.

Table 2
Conditions by which Prosocial Risk Taking must occur.

Conditions	Prosocial Risk Taking	Risk Taking	Prosociality
Does it help another?	✓	X	✓
Is there an unknown risk (e.g., social, emotional, physical) for oneself?	✓	✓	X

Note: Checkmarks denote that the specified condition may be a necessary qualifier for this behavior to emerge and are not meant to be definitive of any one behavior.

Table 3). We will refer again to our bullying example to delineate differences in how these individual types might respond. PSRTs may be individuals who endorse high levels of prosocial and risk-taking behaviors, which means they may be high on other-oriented tendencies so they are inclined to help others, but they are also inclined to engage in risk taking. When witnessing a bully harass someone, PSRTs would risk being harassed by the bully or judged by their peers to intervene and help the victim. ASRTs may be individuals who are frequent risk takers, but have low prosocial inclinations; these individuals are more likely to engage in high levels of risk taking, but have fewer other-oriented orientations and thus may be less likely to help others. In this situation, ASRTs would have little concern for defending the victim and may instead

be more motivated to join the bully in his/her aggression, perhaps with the goal of enhancing their own reputation. EBs may engage in high levels of prosocial behavior but low levels of risk taking. Although they might want to defend the victim against the bully because they may be very other-oriented, they may be too scared of the consequences to intervene, particularly because they may be highly risk averse and would not be willing to take the risks necessary to do so. Finally, the IBs may be low in both prosocial and risk-taking inclinations, which mean these individuals are neither other-oriented so they do not want to help, nor risk-oriented so they rarely take risks. Thus, IBs may feel too indifferent about the situation to intervene on either person's behalf, choosing to remain uninvolved in the situation. See **Table 3** for additional examples of

Table 3
Example scenarios and responses from four proposed prosocial and risk-taking behavioral types.

Scenario	Prosocial Risk Takers	Antisocial Risk Takers	Empathetic Bystanders	Indifferent Bystanders
<i>You've been invited to a party by some popular classmates. When your friend asks if she can come too, the classmates say she can't come. Your close friends start spreading rumors about another classmate that you don't know very well.</i>	You don't want your friend to feel left out so you bring her to the party anyway, even though your classmates might be mad. Even though your friends might judge you, you tell them to stop talking about the classmate behind his/her back.	You go to the party without your friend anyway, even though it'll hurt her feelings. You add more gossip about the classmate to your friends' conversation, despite the risk of getting caught doing so by the classmate.	You feel bad that your friend can't go, but are too scared to say anything to your classmates. You can imagine how sad your classmate would be if he/she found out others were spreading rumors, but don't say anything because you're scared what they might say about you.	You don't care about going to the party or hanging out with your friend, so you don't say anything to either of them and stay home instead. You don't know the classmate well enough to say anything in the conversation, so you keep quiet.
<i>Your friend's strict parents catch the two of you with cigarettes.</i>	You take the blame instead so that your friend doesn't get in trouble, even though that means you might get punished more harshly.	You tell your friend's parents that the cigarettes are not yours so you don't get in trouble with your own parents, even though your friend might be mad at you for not also taking blame.	You don't say anything when your friend's parents start lecturing your friend, even though you feel bad when you see how upset your friend is for taking all the blame.	You don't say anything to your friend or his/her parents in hopes that the situation just blows over.
<i>Your brother/sister broke curfew and your parents, who are very upset, start disciplining him/her.</i>	You speak up and defend your brother/sister, even though you might get in trouble with your parents.	You start scolding your brother/sister with your parents, despite how mad he/she might get at you for not coming to his/her defense.	You can see how sad your brother/sister is becoming, but you don't want to get trouble so you don't say anything.	You don't think this is a big deal, but don't say anything and observe in the background.
<i>While in class, other students start talking and making jokes while the teacher is lecturing.</i>	You stand up for the teacher by telling your classmates to stop, even though they might start making fun of you.	Even though you might get in trouble (e.g., detention), you join in with your classmates and talk over the teacher.	Even though you understand how upsetting this could be for your teacher, you don't say anything because you're worried about what your classmates might think.	You're not interested in getting involved so you ignore both your teacher and classmates and stay quiet.

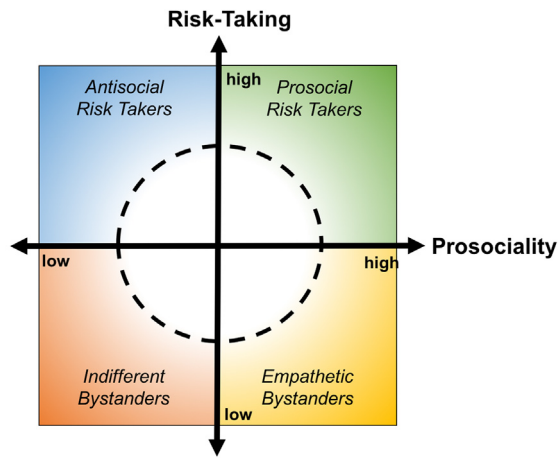


Fig. 1. A theoretical model characterizing the proposed intersection between prosociality and risk taking during adolescence. Each quadrant represents the four different groups that may emerge: (1) *Antisocial Risk Takers* may be likely to engage in high levels of risk taking but are low on prosocial inclinations, (2) *Prosocial Risk Takers* may be likely to engage in high levels of both risk taking and prosociality, (3) *Indifferent Bystanders* may show low levels of both risk-taking and prosocial proclivities, and (4) *Empathetic Bystanders* may be less likely to engage in risk taking but show high prosocial intentions. While individuals that fall within the center circle may be particularly sensitive to social and neural inputs for determining which group they most identify with, individuals located in the darker-colored areas of each quadrant might more strongly exhibit those behaviors.

PSRT, ASRT, EI, and IB responses to various social scenarios. The theoretical model proposed above using objective, non-social criteria may be helpful for quantifying how varying levels of prosocial and risk-taking engagement within an individual interact to influence decision-making.

5.2.1. Flexibility among the four subtypes

The proposed behavioral typologies that may emerge at the intersection of risk taking and prosocial behaviors (Fig. 1) serve primarily as a way to portray an undoubtedly complex decision-making process that likely varies along a continuum on each of the four dimensions. In other words, individuals may exhibit a general trend of behaviors that loosely follow one of the four categories, but are not confined to exclusively engage in one particular type over another. There may also be flexibility in one's tendency to engage in the four subtypes. In Fig. 1, the darker-colored areas of each quadrant suggest that some individuals might endorse the highest characteristics that predict PSRT, ASRT, EB, or IB. However, individuals with less extreme prosocial and risk-taking tendencies, who fall somewhere in the middle of the white-colored area within the center circle (Fig. 1), may be more sensitive to social inputs and may be pushed into different quadrants accordingly.

For example, consider a teenager who falls right in the middle of the prosocial and risk-taking scales, placing her at the origin (center) point of Fig. 1 where she may be most susceptible to social influence when faced with the bullying scenario discussed earlier. If the victim of the bullying was a close friend, the adolescent may be more likely to become more other-oriented, thus compelling her to go out of her way and risk getting hurt by the bully to stand up for her friend (PSRT), perhaps because she cares about maintaining her social standing with this friend. However, if instead the bully was a close friend, the teenager may want to align her actions with that of the bully's because she cares about "fitting in," choosing to act more on her risk-taking tendencies and harass the victim alongside the bully (instead of helping the victim), even though she risks getting in trouble (ASRT). Perhaps the adolescent responds to the situation with heightened activity in mentalizing and affective regions, allowing her to emotionally connect with the

victim by reflecting on how distressed the victim must be and thus, becoming implicitly biased to act more prosocial than usual; however, that same perspective-taking ability may also trigger concerns about what others might think if she helps the lesser-known victim, which may make her more risk averse and less likely to act on those empathic desires to help (EB). Finally, if the adolescent knows the bully well enough to realize that she would not get hurt if she tried to intervene but recruited low reward and social brain reactivity in response to the scenario, she may be less likely to consider how hurt the victim is or go out of her way to get involved in the situation, despite there being little physical or social risk in confronting the bully (IB). That is, the adolescent is not very concerned with her social status with the peer or victim to act on her usually average prosocial and risk-taking inclinations. Overall, these examples underscore how tendencies towards the four types of behavior are not immutable and can vary as a function of the environmental context and individual, trait-level differences.

5.2.2. Contextual influences

Given extensive research demonstrating how risky and prosocial decision making are modulated by social context during adolescence (e.g., Chein et al., 2011; Cascio et al., 2014; van Hoorn et al., 2014, 2016), PSRT is likely receptive to influences from the social environment. For instance, given adolescents' sensitivity to social evaluation (Somerville et al., 2013; Welborn et al., 2016; van Hoorn et al., 2014), adolescents may be less inclined to engage in PSRT behaviors in a large crowd of people and may instead respond like an empathic bystander; the composition of the large crowd may change the magnitude of this relationship too, as being in the presence of peers from different social statuses might elicit different behavior than being in the presence of authority figures (e.g., parents; e.g., Telzer et al., 2015; Guassi Moreira and Telzer, in press). Conversely, if the social ecology in a given scenario values prosociality, teenagers may be more inclined to commit PSRT (e.g., van Hoorn et al., 2016). Moreover, adolescents may be especially motivated to engage in PSRT when peers (other than the beneficiary) are present (Gardner and Steinberg, 2005; Chein et al., 2011), as peer contexts can be emotionally arousing and reduce adolescents' capacity for cognitive control (Botdorf et al., 2016). Or perhaps individuals who usually respond like an empathic bystander can become motivated to overcome their risk aversion if a close other, relative to an acquaintance, is the primary beneficiary. While more empirical evidence is needed to delineate how social context impacts these proposed behavioral typologies, an individual's tendency to engage in PSRT will likely be shaped by contextual influences.

5.3. Examining the role of individual differences on Prosocial Risk Taking

Given previous work on individual differences in risk taking and prosocial behavior, some adolescents may be more inclined than others to engage in PSRT. For instance, adolescents vary more than adults or children in their propensity to take risks (van Duijvenvoorde et al., 2015), and show greater exploratory learning behavior when making risky choices (McCormick and Telzer, in press). Likewise, teenagers display variability in their likelihood to behave prosocially, with social influence factors predicting prosocial behaviors more than individual trait factors (Lai et al., 2015). Given the variability found in the subcomponents of PSRT, one's likelihood of engaging in PSRT may depend on individual differences that affect their willingness to be prosocial, take risks, or both. In the following section, we discuss two relevant individual difference variables and their implications on PSRT: empathy and sensation seeking. These individual difference variables are not

meant to be exhaustive and we acknowledge that other factors are likely to influence the extent to which individuals engage in PSRT.

5.3.1. Empathy

Empathy is a key component implicated in prosocial motivations. The link between empathy and prosocial behaviors has long been established (Eisenberg and Fabes, 1990; Eisenberg and Miller, 1987), with recent work extending this to animal models (Ben-Ami Bartal et al., 2011; Decety et al., 2016; but see Vasconcelos et al., 2012). Developmentally, the association between empathy and prosociality emerges as early as 3 years in the human lifespan (Knafo et al., 2011) and persists past late adolescence (Carlson et al., 2015). Evidence from neuroimaging studies also converge on the importance of empathic, other-oriented concerns in predicting prosociality (e.g., FeldmanHall et al., 2015; Zaki and Mitchell, 2011). Accordingly, we expect empathy to be positively correlated with the tendency to engage in PSRT. Presumably, if empathic concern for the beneficiary of PSRT is low, it may be less likely for an adolescent to engage in PSRT.

5.3.2. Sensation seeking

Numerous studies have established the link between sensation-seeking and risk-taking behaviors (Lauriola et al., 2014). Although somewhat modest in adults (Lauriola et al., 2014), the link between the two is stronger during adolescence, as some scholars have pegged increased rates of risk taking in adolescence as the result of developmentally heightened sensation seeking (Steinberg et al., 2008; Steinberg, 2010). We speculate that high sensation-seeking adolescents may be more likely to engage in PSRT by virtue of their propensity to engage in general risk taking. Risk taking often elicits feelings of heightened somatic arousal (Sokol-Hessner et al., 2009, 2013), which sensation seekers appear to enjoy (Joseph et al., 2009). Accordingly, we suggest that PSRT behaviors are similar to other forms of risk taking such that it evokes a similar profile of physiological arousal, one which sensation seekers will be less averse to, or may even actively seek out. Importantly, within adolescence, there is still a notable amount of variation in sensation seeking (Steinberg et al., 2008; Braams et al., 2015). Thus, similar to empathic processes, we do not suggest that heightened sensation seeking is sufficient to precipitate PSRT. Likewise, while high sensation seeking individuals may be inclined to engage in greater rates of PSRT, they may also be more likely to engage in antisocial risk taking as well.

5.4. Exploring adolescence as a sensitive period for Prosocial Risk Taking

Given that risk-taking behaviors and prosocial inclinations generally increase with age, we hypothesize that the opportunity to engage in PSRT behaviors also increases from childhood to adulthood—perhaps with adolescence as a uniquely sensitive period—and is supported by ongoing changes in the developing brain and social environment. During childhood, shifts from self- to other-oriented considerations and gradual increases in risk-taking proclivities may encourage early signs of PSRT behaviors. Yet, while PSRT behaviors may begin to emerge during childhood, adolescents may encounter even more opportunities to engage in PSRT as a result of their increasingly salient and changing social environments. Recent research has underscored the dynamic nature of adolescent decision making across social contexts (e.g., sensitivity to others' opinions) (Schriber and Goyer, 2016), which has wide implications for the facilitation of PSRT behaviors during this developmental window. Furthermore, individual differences in youth's neurobiological susceptibility to social context may influence the importance of risk-taking, prosocial, and/or social status considerations when deliberating if and when to act on behalf of others. As

motivational and cognitive control systems become more mature and the salience of social status considerations wane during adulthood, PSRT behaviors may instead arise only among individuals with high trait-level risk-taking and prosocial tendencies. Thus, although present from childhood through adulthood, PSRT behaviors may occur most frequently during adolescence given the host of behavioral and neural changes in social cognitive processing that occur during this sensitive developmental window.

5.5. Methodological considerations for Prosocial Risk Taking

Given the novelty of this proposed area of study, there is no well-defined or established way to measure PSRT. While some existing self-report measures and behavioral paradigms have approximated subcomponents of the concept, truly capturing PSRT may require novel techniques, such as new self-report measures and creative experimental manipulations in conjunction with fMRI. In this section, we briefly discuss considerations of how to appropriately measure PSRT.

Behavioral tasks measuring PSRT will require the presence of an unknown risk incurred by oneself to positively affect another individual, thereby containing the two core components that we suggest comprise PSRT behaviors. While current behavioral tasks have measured each of these components separately, no study to date has fully captured both of them (summarized in Table 2). We have identified two studies that measure other-oriented decision making in a relatively risky environment. While neither task fully meets our criteria for measuring PSRT, these tasks are as close to PSRT as we can identify in the literature.

In one study, Kwak et al. (2014) employed a modified version of the Iowa Gambling Task in which each card deck contained a win/loss outcome for both the participants and a charity. In this paradigm, participants had the choice to make a decision that would potentially benefit other individuals (i.e., a charity) at the risk of incurring a loss to themselves. However, participants had the opportunity to receive material gains for themselves while the other individuals also stood to incur a cost from the participants' risky choices. Thus, while the task included both a risk taking and prosocial component, losses sometimes affected other individuals while rewards were also won by the participants, therefore not fully capturing our definition of PSRT.

In the second study, Braams and colleagues (Braams et al., 2014; Braams and Crone, 2016) utilized a task in which participants made predictions about the outcome of coin tosses in order to earn a reward for themselves or another individual. While this manipulation allowed others to benefit from the participants' gambles, it was not capturing PSRT because the task did not measure risk taking (i.e., there was a 50–50 probability between heads and tails and thus neither decision was inherently riskier or safer than the other), and the negative outcomes associated with each gamble also affected the other individual. In other words, we propose that a paradigm measuring PSRT requires the reward be exclusive to the beneficiary and the potential risk to be exclusive to the participant. These tasks incorporate elements of PSRT, but do not fully meet the criteria previously suggested (see Table 2).

Another methodological consideration is ensuring that the motivations behind the two proposed components of PSRT behavior result from: 1) more other-oriented (e.g., improve another's well-being) than selfish-oriented (e.g., reciprocity benefits) prosociality and 2) an uncertain risk incurred by oneself (e.g., potential loss of social status) instead of by another individual. In order to exclude alternative motives for either of the PSRT components, it is essential to design experimental tasks and self-report measures that not only quantify the primary reasons for engaging in PSRT behavior, but also capture their patterns across varying social contexts. Neuroimaging techniques and carefully manip-

ulated behavioral tasks are especially recommended as these methods may avoid potential confounds (e.g., social desirability biases) inherent with self-report measures. The development and implementation of novel measurement techniques are needed in order to empirically verify the existence of PSRT, explore its behavioral and neural correlates, and determine the implications of PSRT behaviors on adolescent adjustment.

Given that PSRT sits at the nexus of risk taking and prosocial behaviors, it is intriguing to speculate whether engaging in PSRT results in more psychological distress or improved well-being. Risk-taking behaviors have been traditionally associated with detriments to well-being (e.g., Mahalik et al., 2013; Centers for Diseases Control & Prevention, 2012), though some contemporary researchers acknowledge its adaptive role for learning and skill acquisition (e.g., Spear, 2000; Goldenberg et al., 2016; Humphreys et al., 2013; McCormick and Telzer, in press). In contrast, prosocial behaviors reliably improve well-being (e.g., Morelli et al., 2015; Weinstein and Ryan, 2010; Aknin et al., 2012). One consideration for determining the implications of PSRT behaviors is the effect of temporal factors: PSRT behaviors may result in psychological distress immediately after the event when the risks incurred are especially salient, but may grow into a sense of meaning or satisfaction at a later time when the perceived benefits for the other individual start to outweigh the costs. Indeed, prior work has shown that the rewards of helping others are not immediately evident, such that VS activation during prosocial decision making predicts long-term (but not short-term) health benefits (Telzer et al., 2013a, 2014). Another consideration is the uncertain consequences associated with PSRT behaviors across different social contexts: while incurring social costs for another individual may improve one's relationship and result in positive well-being in one situation, the same action may embarrass that individual and result in negative well-being in another situation (e.g., where the help was ostensibly unwanted). While we offer speculations about the implications of PSRT behaviors on adolescent well-being, empirical scrutiny is required to verify these predictions.

6. Conclusions

Previous research has primarily studied risk taking and prosociality in isolation. However, examining interactions between these characteristic adolescent behaviors, in conjunction with increased social sensitivity and neurobiological development, may update our understanding of adolescence as more a time of opportunity and less a period of heightened risk and vulnerability. Drawing on developmental, cognitive, and social neuroscience research, we suggest that another facet of adolescent risk taking is the additional integration of prosocial and social status goals. Despite emerging evidence that social and neural processes undergoing significant development may also confer positive decision making (e.g., Schriber and Guyer, 2016), little is known about how interactions between risk taking and prosociality influence adolescent outcomes.

In this review, we propose a new area for study, Prosocial Risk Taking, to describe the intersection of prosocial and risk-taking behaviors. Extensive research in animals and humans converge on developmental increases in risk taking, other-oriented prosociality, and social sensitivity, with peaks in adolescence; these complex social processes are supported by hyperactive reward systems and still-maturing social brain and regulatory networks. Based on these findings, we suggest that adolescence may be a particularly sensitive period for Prosocial Risk Taking. Prosocial Risk Taking may be an interesting area of study that has been overlooked in the literature that could help explain how ongoing ontogenetic changes in the adolescent brain may create not only vulnerabilities, but also

opportunities for healthy development. A closer examination of how Prosocial Risk Taking develops during this sensitive window may provide important insight into the mechanisms that differentiate positive and negative developmental outcomes.

Author contributions

K.T. Do, J.F. Guassi Moreira, and E.H. Telzer contributed equally to the intellectual content of the manuscript. K.T. Do and J.F. Guassi Moreira drafted the manuscript and E.H. Telzer provided critical revisions.

Conflict of interest

None.

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