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The importance of sexual and romantic development in understanding the developmental neuroscience of adolescence

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In this issue, papers by Shulman and colleaugues (2016); Nelson et al. (2016) present theoretical accounts of developmental changes in risk-taking behavior and in social behavior, respectively. Both papers synthesize a large volume of neuroimaging literature in order to illuminate mechanisms of developmental change, and they highlight the incredibly rapid pace of research in developmental cognitive neuroscience in advancing our understanding of adolescence. Yet it is crucial that neuroscience-based theories of adolescent development draw not only on neuroimaging studies, but also on the wealth of psychological, sociological, and anthropological data on adolescent development. In this commentary, we focus on some key aspects of the developmental science of adolescence that we believe warrant considerably more attention in "dual-process" and "imbalance" models of adolescent brain development. *Sex, love, and romance are core dimensions of adolescent development, with implications for adolescents' motivations, emotional experiences, social learning, decision making, and identity formation*.

1. Romantic and sexual relationships begin in adolescence

What is the purpose of adolescence? Adolescence begins when an individual begins to become capable of reproducing (i.e., at puberty), and the central adaptive challenge of the fertile period of life is to find and compete for mates and to reproduce. In Nelson and colleagues' theory, however, the focus of the "adolescent phase" of social development is described as "integration with larger groups of peers," and the adolescent phase is conceptualized as distinct from and as preceding the "reproductive/intimacy" phase. This characterization does not match what adolescents experience or what is known about adolescent behavior: Romance and sex are central preoccupations of adolescent life.

The marked increase in sexual interest appears to coincide with adrenarche, the first part of the hormonal cascade of puberty, which peaks, on average, at age 10 (Herdt and McClintock, 2000). Although less than 2% of adolescents are sexually active at age 12, that rate climbs to 71% by age 19 (Guttmacher Institute, 2014). Any parent or middle school teacher can attest to the fact that puberty is accompanied by a marked increase in discussions, internet searches, jokes, and curiosity related to sex. Adolescents are also bombarded by portrayals of sex across multiple types of media. For example, an estimated 70% of television intended for general audiences includes some type of sexual content (Kunkel et al., 2005).

Additionally, teenagers are interested in forming romantic relationships. In a recent study, 85% of participants reported being interested in romantic relationships before entering high school (Suleiman and Deardorff, 2015). Over one-third (36%) of adolescents have had a romantic relationship by age 13, and 70% by age 17 (Collins et al., 2009). On average, romantic relationships in adolescence, particularly during the early teenage years, are briefer and less emotionally intimate than adults' relationships (Seiffge-Krenke, 2003). Yet these romances are important learning opportunities that can positively contribute to identity development and increased competence in future romantic relationships (Furman and Shaffer, 2003; Furman et al., 2009). The framework outlined by Nelson et al. (2016) would benefit from reflecting that interest in sexual and romantic relationships begins quite early, during the transition into adolescence, and are influenced by the quality of previous and current relationships across multiple domains (e.g., with parents, peers, romantic partners) across all developmental stages (Furman et al., 2002).

2. Sexual development motivates risk-taking

Because late adolescence and early adulthood is a period of peak fertility, reproductive success or failure in this period has an outsize influence on lifespan reproductive fitness, and adolescent behaviors have undergone strong selection pressure. Through an evolutionary lens, then, the adolescent-typical spike in risk-taking is inextricably tied with the fact that adolescents are becoming sexually mature (Ellis et al., 2012). Consistent with this idea, developmental cognitive neuroscientists have begun to identify how increases in gonadal hormones at puberty may contribute to risk-taking behaviors by altering neural responses to reward (Braams et al., 2015). Pubertal hormones, and sexual development more broadly, may also contribute to risk-taking by ushering in a new and highly arousing set of social contexts—romantic and sexual situations.

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As described by Shulman et al. (2016), emotional arousal and social contexts increase neural sensitivity to reward and bias decision-making towards greater risk-taking. Sex is obviously a highly arousing experience, and for many adolescents, simply thinking about sexual activity or being in physical proximity to someone they find sexually attractive can be highly arousing. Additionally, Nelson et al. describe that the amygdale undergoes a U-shaped developmental profile, with increased social responsiveness to social stimuli during the onset of adolescence and a decline into adulthood. Given adolescents' unique attunement to social stimuli, and the sensitivity of their decision-making to emotional arousal, sexual contexts and experiences (broadly defined) are critical–and understudied–factors that likely influence adolescents' brain activation and decision-making around risk and reward. At the same time, research with adults has found that looking at the face of a romantic partner is actually associated with a *deactivation* of the amygdale (Diamond and Dickenson, 2012). This finding raises intriguing questions about how involvement in a romantic relationship may modulate adolescent brain responses to emotional stimuli. Currently, there is relatively little evidence regarding how sexual and romantic experiences intersect to shape adolescent neural development or the neural underpinnings of adolescent risk-taking, despite the centrality of sexual and romantic relationships to this period of life.

3. Sex is not necessarily risky

Although risky behaviors may be motivated by sexual contexts, having sex is not necessarily a risky or problematic behavior (Harden, 2014). Developing a romantic and sexual identity is focus of adolescence and sex can be a healthy, normative part of adolescent life. Almost all adolescents have some sexual experience and by age 19, the majority have had vaginal intercourse (Guttmacher Institute, 2014). Certainly, there are potential negative or unwanted consequences to sex (e.g., sexually transmitted infection, unintended pregnancy) that disproportionately affect adolescents. But cross-national research indicates that, given adequate access to contraception and sexual education, many–perhaps most–teenagers are capable of having sex with limited negative consequences (Harden, 2014; Santelli et al., 2008). Researchers in multiple disciplines have recognized that *healthy* sexual development in adolescence cannot be equated with simply abstaining from all sexual contact or avoiding STIs. Rather, the extent to which having sex can be considered "risky" or "healthy" depends crucially on both the individual and context: is the sex "pleasurable and safe, free of coercion, discrimination and violence" (World Health Organization, 2006 p. 5). Further, the decision to have unprotected intercourse to increase emotional intimacy with a partner may not be at all impulsive but instead be a clearly deliberated plan. These nuances in adolescents' sexual experiences are unlikely to be captured through laboratory tasks. Thus, defining and understanding the neurobiological underpinnings of sexual risk-taking versus normative sexual behavior will require innovative data collection strategies to measure real-world behavior.

4. Peer relationships, romantic relationships, and sexual relationships are mutually interacting

Rather than being sequential and distinct phases, the development of peer relationships, romantic relationships, and sexual relationships are simultaneous and mutually interacting. Early romantic and sexual relationships are shaped by the characteristics of the adolescent's peer group (Cavanagh, 2007; Suleiman and Deardorff, 2015) and by the quality of relationships with parents (Schalet, 2011). At the same time, growing interest in sexual and romantic relationships introduces a new element to peer group dynamics–competition for partners. In addition to integrating with peers (which Nelson et al. 's conceptualize as the central task of the adolescent period), teenagers also *compete* for status and dominance. Status-oriented social behavior, including aggression, is correlated with gonadal hormones (Rowe et al., 2004; Terburg and van Honk, 2013)—consistent with the idea that sexual development and behavior toward same-sex peers are tightly interwoven. Early romantic and sexual experiences that occur in the context of parental scaffolding, offer an opportunity for important developmental learning. Nelson et al. 's framework for social development can be refined to include both prosocial behavior (attachment, play, integration, and pair bonding) and antisocial behavior, as both change in key ways over the early lifespan.

5. Conclusions

In sum, developmental cognitive neuroscience models of adolescent behavior will be strengthened as they integrate results from lab-based neuroimaging tasks with data about adolescents' real-world experiences, especially those related to romantic and sexual behavior. Teenagers' dating relationships are often trivialized, and their sexual experiences are often viewed as problematic and risky entanglements that are best avoided altogether. Yet sex and love are important concerns to most adolescents, and sexual and romantic development is a critical dimension of what makes adolescence a distinct period of the lifespan. A deeper understanding of the developmental social and affective neuroscience underpinnings of these fundamental aspects of adolescent maturation can provide crucial insights into unique opportunities for learning and early intervention relevant to adolescent risk taking, health, and well-being.

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