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Feasibility of Functional Neuroimaging to Understand Adolescent Women's Sexual Decision Making



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A B S T R A C T

Purpose: For young women, new sexual experiences normatively increase after puberty and coincide with extensive changes to brain regions governing self-regulation of risk behavior. These neurodevelopmental changes could leave some young women vulnerable for negative sexual outcomes, including sexually transmitted infection and unintended pregnancy. We evaluated the feasibility of using functional neuroimaging to understand the sexual decision making of adolescent women.

Methods: Adolescent women (N = 14; 14–15 years) completed enrollment interviews, a neuroimaging task gauging neural activation to appetitive stimuli, and 30 days of prospective diaries following the scan characterizing daily affect and sexual behaviors. Descriptive and inferential statistics assessed the association between imaging and behavioral data.

Results: Young women were highly compliant with neuroimaging and diary protocol. Neural activity in a cognitive-affective network, including prefrontal and anterior cingulate regions, was significantly greater during low-risk decisions. Compared with other decisions, high-risk sexual decisions elicited greater activity in the anterior cingulate, and low-risk sexual decision elicited greater activity in regions of the visual cortex. Young women's sexual decision ratings were linked to their sexual history characteristics and daily self-reports of sexual emotions and behaviors.

Conclusions: It is feasible to recruit and retain a cohort of female participants to perform a functional magnetic resonance imaging task focused on making decisions about sex, on the basis of varying levels of hypothetical sexual risk, and to complete longitudinal prospective diaries following this task. Preliminary evidence suggests that risk level differentially impacts brain activity related to sexual decision making in these women, which may be related to past and future sexual behaviors.

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IMPLICATIONS AND CONTRIBUTION

This investigation demonstrates the feasibility of a neuroimaging paradigm examining sexual decision making in young women. A decision about whether to engage in sex incorporates degree of risk into decision making differently than in nonsexual decisions. Future research can use this paradigm to examine how brain function is related to subsequent sexual behavior.

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Learning to express and manage sexuality is a normative developmental task, particularly for young women [1]. During adolescence, young women encounter a variety of new sexuality-related experiences, including managing new romantic/sexual

relationships [2] and balancing heightened emotions and sexual desire/arousal [3]. These experiences facilitate their decisions about how and when to initiate partnered and nonpartnered sexual activity [4,5]. Although most young women navigate this process without issue, risky sexual behaviors can be associated with adverse outcomes, such as unintended pregnancy and sexually transmitted infections [6].

Although the factors contributing to risk behavior are varied and complex, neurocognitive models of decision making may account for some of the measurable differences in young people's risk behavior. Research suggests that decision making is impacted by timing differences in the maturation of reward- and control-related brain regions after puberty. During adolescence, reward-related brain regions have a heightened sensitivity compared with those during young adulthood, whereas prefrontal, control-related brain regions do not fully mature until the early 20s [7–9]. Some studies have proposed that this imbalance may contribute to an overvaluation of the immediate benefits of risk-taking and an undervaluation of the long-term negative consequences associated with those behaviors [10,11], although recent work has provided evidence of additional complexity in this model [12]. Functional magnetic resonance imaging (fMRI) studies have associated these differences with young people's increased choice of riskier options in laboratory decision-making tasks and with increased participation in a real-world risk-taking behavior, such as substance use [13,14].

Neuroimaging paradigms explicitly examining sexual decision making in adolescents are not yet available, but behavioral studies have demonstrated that perceived benefits of sex (e.g., popularity/social status, physical pleasure, intimacy) influence adolescents' participation in sex [15,16], whereas perceived social, moral, or health risks associated with sex are motivators for their sexual abstinence [17,18]. Moreover, neuroimaging studies in adults have demonstrated that sexual decisions recruit a network of reward-sensitive brain regions (striatum, particularly nucleus accumbens) and regions involved in motivation and evaluation of reward and risk, including orbitofrontal cortex, ventromedial prefrontal cortex, and anterior cingulate cortex (ACC) [19–30]. For instance, activity of higher nucleus accumbens and orbitofrontal cortex in response to sexual pictures correlates positively with higher sexual desire and greater sexual frequency [22]. Rupp et al. [29] demonstrated that adult women's ACC activation in response to pictures of high-risk adult men positively correlated with their subjective evaluation of sexual behavior. The ACC has also been implicated in a neural network regulating love and sexual desire [21], with higher activation in response to romantic partners, particularly as relationships progress [19,20], but this has not been studied in adolescent women.

The brain's reward network also interacts with visual and attention regions tasked with perceiving stimuli (i.e., potential mates), as reflected by greater visual cortex activity for salient, rewarding stimuli in adults [31,32]. Other visual regions, such as the fusiform gyrus, could also play a role during sexual decision making, as they are influential in recognition of facial identity and facial expression [33].

Accordingly, we conducted a pilot study to evaluate the feasibility of an fMRI and behavior study of sexual decision making in midadolescent women. Specifically, we investigated how high-risk sexual decisions differed from low-risk sexual decisions, compared with nonsexual decisions, and whether neural activity was linked to sexual attitudes or behaviors. On the

basis of the strong association between reward value and sexual cues in existing literature, we expected that (1) sexual decision making would be more closely tied with activation in visual and striatal regions than during other types of decisions and (2) high-risk sexual decisions would more strongly engage anterior cingulate and orbitofrontal regions.

Methods

Participants and study design

Participants (N = 14; 14–15 years) were adolescent women recruited from three primary care adolescent health clinics in Indianapolis, IN. These clinics serve primarily lower- and middle-income families in areas with high rates of early childbearing and sexually transmitted infection. Exclusion criteria included non-English speaking, acute intoxication at scan time, pregnancy (confirmed via urine test), known psychiatric illness (except mild/moderate anxiety or depression), not having started menstruating, and MRI contraindications. Neither sexual experience nor sexual orientation was a criterion for entry; all young women reported male partners during the diaries.

Young women completed three arms of data collection: (1) an enrollment interview; (2) an fMRI procedure; and (3) 30 daily prospective diaries after the scan. This research was approved by the Institutional Review Board of Indiana University/Purdue University Indianapolis. Informed consent was obtained from each participant, and permission was obtained from a parent or legal guardian.

Measures

Enrollment interview. Enrollment interviews assessed demographic, medical history, sexual beliefs, sexual behavior history, and psychological attributes. Sexual behavior history included number of lifetime sexual partners, number of sexual partners anticipated in the next 5 years, and sexual behavior past 30 days (kissing, sexual dreams, solo masturbation, mutual masturbation, petting, oral sex, vaginal sex, and anal sex). For comparison purposes, we dichotomized all behaviors (reported/not reported). Psychological attributes included body satisfaction (five-point scale, single item, very dissatisfied to very satisfied) and *impulsivity* (additive index, 24 semantic differential type items; e.g., “When faced with a potentially dangerous event... [I take my time...I instantly react],” “I like to take risks [not at all to a lot],” “A menacing dog approaches [I confront it—I run away]”).

Daily diaries. Each diary consisted of a single bar-coded sheet, on which participants identified (using initials, first names, or nicknames) up to five “partners,” including boyfriends, dating partners, friends, and sexual partners. To represent both ongoing and potential sexual relationships, prior sexual activity was not a criterion for naming partners.

Individual affect included positive mood (three items; $\alpha = .86$; e.g., “I felt happy”), negative mood (three items; $\alpha = .83$; e.g., “I felt unhappy”), and feeling in love and sexual interest (both one item). Partner-specific affect was partner support (four items; $\alpha = .95$; e.g., “He let me know he cared about me”) and partner negativity (five items; $\alpha = .83$; e.g., “He made me feel bad about myself”). Partner-specific coital and noncoital sexual behaviors included (all no/yes) touched partner's genitals, partner touched [my] genitals, received oral sex, gave oral sex, vaginal sex, and *anal sex*.

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