



Neural mechanisms of impulse control in sexually risky adolescents



Diane Goldenberg^{a,1}, Eva H. Telzer^{b,1}, Matthew D. Lieberman^a,
Andrew Fuligni^{a,c}, Adriana Galván^{a,d,*}

^a Department of Psychology, University of California, Los Angeles, 1285 Franz Hall, Box 951563, Los Angeles, CA 90095, USA

^b Department of Psychology, University of Illinois at Urbana-Champaign, 603 East Daniel Street, Champaign, IL 61820, USA

^c Department of Psychiatry and Biobehavioral Sciences, University of California, Los Angeles, 760 Westwood Plaza, Los Angeles, CA 90024, USA

^d Brain Research Institute, University of California, Los Angeles, 695 Charles Young Dr. S., Los Angeles, CA 90095, USA

ARTICLE INFO

Article history:

Received 22 March 2013

Received in revised form 10 June 2013

Accepted 11 June 2013

Keywords:

Adolescence

Brain development

Impulse control

Risky sexual behavior

ABSTRACT

The consequences of risky sexual behavior are of public concern. Adolescents contribute disproportionately to negative consequences of risky sexual behavior. However, no research has examined the neural correlates of impulse control and real-world engagement in risky sexual behavior in this population. The aim of the present study was to examine this question. Twenty sexually active adolescents performed an impulse control task during a functional magnetic resonance imaging (fMRI) scan and risky sexual behaviors were assessed through self-report. Sexual riskiness ratings were negatively associated with activation in the prefrontal cortex during response inhibition. These results suggest that diminished engagement of impulse control circuitry may contribute to sexual riskiness in adolescents.

Published by Elsevier Ltd.

1. Introduction

Risky sexual behavior is a phenotypic manifestation of risky decision-making that has far-reaching consequences for individual health and public concern. In particular, unprotected sex such as a lack of condom use can place individuals at greater risk of sexually transmitted infections (STIs) as well as unintended pregnancy (Centers for Disease Control and Prevention [CDC], 2011). The vast majority of sexually active people across age groups are aware of the preventive efficacy of condom use, yet many do not use them on a consistent basis (Browne and Minichiello, 1994). Recent reports suggest that both adolescents and adults are

more likely to use condoms than in the past (Reece et al., 2010), yet every year there are 19 million new cases of STIs in the United States (CDC, 2011). Adolescents contribute disproportionately to those rates—although they represent only 25% of the sexually active population, young people contribute to nearly half of all new cases of STIs and an estimated \$10.9 billion annually in teen pregnancy costs each year (see Guttmacher Institute, 2013; CDC, 2011). These startling statistics suggest that despite widespread knowledge of the preventive benefits of contraceptive use, many adolescents fail to translate this knowledge into action (Parsons et al., 2000). Given the prevalence of unsafe sexual behavior among adolescents, it is of concern to pinpoint key factors underlying sexual risky behaviors that may result in STIs and unintended pregnancy.

Adolescence is a unique developmental period characterized by social, motivational, affective, and cognitive changes (Crone and Dahl, 2012), all of which likely contribute to lack of contraceptive use. Previous research has focused on potential social and motivational factors that

* Corresponding author at: Department of Psychology, UCLA, Los Angeles, CA 90095, USA. Tel.: +1 310 206 4850.

E-mail addresses: agalvan@ucla.edu, agalvan@psych.ucla.edu (A. Galván).

¹ Equal author contribution.

may contribute to risky sexual decision-making (Parsons et al., 2000; Aalsma et al., 2006); however, the role of cognitive processes in adolescent sexual risk-taking is less clear. There is some suggestion in the adult literature that impulse control difficulties are associated with risky sexual behavior (Eysenck, 1976; Clift et al., 1993; Pinkerton and Abramson, 1995). A recent behavioral study with adults used the go/no-go task to examine impulse control in the presence of sexual stimuli across four counterbalanced conditions (Macapagal et al., 2011). In the study, participants viewed a sexual or neutral video before performing a go/no-go task with sexual or neutral stimuli. Impulsivity was assessed with the Eysenck Personality Questionnaire (Eysenck et al., 1985). Although no relationship was found between impulsivity and task performance in neutral conditions, more impulsive individuals committed significantly more errors (i.e., failure to inhibit a response) than less impulsive individuals when attempting to inhibit a button press for sexual stimuli, specifically after viewing the sexually arousing video (Macapagal et al., 2011). In other words, poor task performance in highly impulsive individuals was specific to sexually arousing stimuli. The authors suggest that impulsivity may involve a tendency to respond to motivationally or emotionally salient stimuli (Evenden, 1999).

Given that risky sexual decisions often occur under emotionally and motivationally salient contexts, these choices may be particularly vulnerable to difficulties in impulse control (Reyna and Farley, 2006). Additionally, adolescents appear to be especially sensitive to motivational influences, perhaps leaving them more vulnerable to risky decision-making in general (Galvan et al., 2007) and risky sexual behavior in particular (Reyna and Farley, 2006). Indeed, although there is some evidence that adolescents pre-contemplate, deliberate, and prepare for sexual encounters (Reece et al., 2010), they are often unable to translate forethought into action in the heat of the moment (Reyna and Farley, 2006). An examination of the cognitive processes and traits that contribute to risky sexual decision-making in adolescents may prove useful in understanding the development of these behaviors.

Advances in neuroimaging have enabled researchers to establish a neural basis for risky decision-making during adolescence, a developmental period of significant brain maturation (Somerville and Casey, 2010). There is evidence that frontal regions implicated in regulatory processes undergo a protracted development, while subcortical limbic regions display heightened sensitivity to emotional stimuli and reward, potentially leaving adolescents vulnerable to risky decision-making (Casey et al., 2008). This developmental imbalance between neural systems likely grants adolescents greater cognitive flexibility (Crone and Dahl, 2012), though may leave adolescents less able to inhibit impulses, especially in emotionally arousing contexts. This may be represented behaviorally through a failure to inhibit the impulse to engage in sexual intercourse despite a lack of contraceptives. The remodeling of fronto-striatal regions implicated in regulatory and motivational processes has been tied to forms of risk-taking during adolescence, such as substance use (Clark et al., 2008) and gambling (Chambers and Potenza, 2003). Yet

the connection between risky sexual behavior and the regulatory mechanisms in the brain remains unexamined in adolescents, despite the prevalence and gravity of the consequences of these behaviors.

The goal of the present study was to examine the association between naturalistic levels of contraceptive use and neural correlates of impulse control during a basic go/no-go task performed during functional magnetic resonance imaging (fMRI) in adolescents. Neural correlates of impulse control have previously been assessed using the go/no-go task and linked to real-world behaviors in a sample of smokers attempting to quit (Berkman et al., 2011). Using the adolescents' self-report of protection against unwanted pregnancy grants the ability to examine how individual differences in neural correlates of impulse control relate to this behavior. We hypothesized that adolescents reporting greater levels of risky sexual behavior (i.e., less contraceptive use) would exhibit less activation in frontal regions involved in regulation, as shown previously in adults (Aron and Poldrack, 2006) and adolescents (Cohen et al., 2010).

2. Methods

2.1. Participants

Forty eight adolescents participated in an fMRI scan. Only sexually experienced adolescents ($n=20$) were included in the current analyses, as we wished to examine individual variability in self-reported sexual risk taking, as measured by contraceptive use, and its relationship to neurocognitive indicators of inhibition. The rate of sexually active adolescents in our sample (42%) is similar to national trends (CDC, 2011). Participants ranged in age from 15–17 years ($M_{age} = 16.36$; 7 males, 13 females). All subjects were right-handed, free of metal, and reported no current medication except birth control. Participants completed written consent and assent in accordance with UCLA's Institutional Review Board and were compensated for their participation.

2.2. Questionnaire measures

2.2.1. Risky sexual behavior

Although multiple variables were collected to assess risky sexual behavior (e.g., number of partners, age of first sexual intercourse), riskiness level of contraceptive method used was selected to assess risky sexual decision-making. The reason for focusing on this variable is because lack of contraceptive use, more so than other behaviors, most directly relates to contraction of STIs or unintended pregnancy (CDC, 2011) and in-the-moment impulsive decisions (Donohew et al., 2000). Behaviors were assessed through self-report and questions were phrased with respect to "sexual intercourse," the definition of which was left to the adolescent (e.g., "The last time you had sexual intercourse, what contraceptive method did you or your partner use? (Choose all that apply).") Contraceptive use options included: no method was used, condoms, birth control pills patch or shot (Depo-Provera), withdrawal, some other method. A composite score, or "sexual riskiness rating," was then created from the participants' response. A higher

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