Sex and the Brain: Empirical Intersection of Neurocognition and Sexual Behavior

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This article is part of a special section on Sex and the Brain that appears in this issue

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Dear Editor

Unprotected sexual intercourse is an important behavioral risk that leads to a host of negative health outcomes. Sexually transmitted infections including HIV and unplanned pregnancy result in a tremendous public health burden, and one that is not shared equally. According to the American Centers for Disease Control, in 2016 there were over 2 million cases of gonorrhea, chlamydia, and syphilis reported—the highest number of cases ever in a single year [1]. In addition, there are health disparities by race/ethnicity, sexual orientation, and socioeconomic status such that the highest rates of sexually transmitted infections occur in people of color, men who have sex with men, and those of low socioeconomic status [2, 3]. Similarly, unplanned pregnancy differentially affects young women of color and of low socioeconomic status. Theory-based and empirically supported interventions to reduce sexual risk exist (for example, see a recent meta-analysis of school-based prevention programs by Chin et al. [4]), but the effects of these programs are typically small to moderate at best. Current interventions rely on traditional social cognitive theories of health behavior, and it is becoming

increasingly recognized that such perspectives, though useful, are limited in their ability to account for and change health behaviors [5–8].

A review of the published empirical and theoretical literature indicates growing evidence that brain-based perspectives may add an important and novel perspective to our attempts to change sexual risk behavior. This perspective has already been applied in a number of behavioral health areas including in substance use [9], internalizing disorders [10], eating behavior [11], and smoking cessation [12]. Thus, a special section focused on brain-based contributions to the reduction of sexual risk is a novel and timely addition to the literature, and will add meaningfully to the emerging field of “Health Neuroscience” that has recently gained traction [13].

Therefore, this special section of *Annals of Behavioral Medicine* has been dedicated to empirical research on the contributions of neurocognition to the study of risky sexual behavior and how best to decrease it. The special section includes emerging empirical research in the field of health neuroscience (brain–behavioral links) applied to risky sexual behavior. There are five empirical studies presented that highlight recent theorizing and research on brain-based mechanisms (e.g., structure, function, cognitive performance) that may account for variability in risky sexual behavior or that moderate and/or mediate the relationship of well-known risk factors (e.g., impulsivity, sexual arousal) to sexual risk. These studies include two groups highly at risk for negative outcomes of unprotected sexual intercourse, men who have sex with men and sexually active adolescents.

In a study of men who have sex with men, Huebner et al. highlight the importance of executive function and

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its malleability. They show that while baseline levels of executive function were not associated with condomless anal intercourse, men whose executive function was more depleted after a stressful interpersonal task reported more frequent condomless anal intercourse. Their findings speak clearly to the negotiation of safer sexual behavior as a prime example of a “stressful interpersonal situation” that requires self-regulatory resources in the heat of the moment. It may be that preventing the depletion of these resources in the context of emotionally laden interpersonal conversations about protection during sexual activity is a novel point for intervention.

In a study utilizing daily diary data with men who have sex with men, Rendina et al. showed that consistent with prior theory and research, participants who reported higher daily sexual arousal were more likely to report any sexual behavior and condomless anal sex. They also assessed performance on the Iowa Gambling Task, a well-established decision-making task, which highlights an individual’s implicit capacity to switch from more risky outcomes (greater losses) to less risky outcomes (greater gains) in the context of a card game. Interestingly, Iowa Gambling Task scores moderated the association of arousal to sexual behavior, such that men with higher scores showed a stronger relationship between arousal and sexual activity. They interpret these results from the perspective of the Somatic Marker Hypothesis, which suggests that decisions about risky sexual behavior are driven both by deliberative processing and by the more implicit processing that arises from one’s physiological state (e.g., arousal). These findings are in some sense paradoxical, in that they show that those with *better* executive functioning may be more attuned to and thus influenced by physiological sensations in the context of sexual activity.

Gardiner et al. explored the relationship between brain activation in reward and control centers during a delay-discounting task with both levels of and changes in risky sexual behavior (frequency of condomless sex) among adolescents. Delay discounting is the propensity to discount the value of rewards that are offered in the future (e.g., sexual health) as compared with those that are available immediately (e.g., sexual activity with an attractive partner). Using a monetary delay discounting task performed during functional magnetic resonance imaging, Gardiner et al. showed that greater activation in regions associated with both control and reward during the task was associated with lower levels of risky sex, but greater increases in risky sex over the course of a 3-month follow-up. Contrary to research in other developmental studies of risk behavior that showed asynchronous functional patterns between reward and control networks, in the domain of risky sexual behavior, these areas appear to work in concert.

Using procedures similar to Gardiner et al., in which participants engage in an executive functioning task during functional magnetic resonance imaging, Barkley-Levenson

et al. examined neural activation during the color-word Stroop task as a mediator of the link between impulsivity and risky sexual behavior among men who have sex with men. The Stroop task is a measure of response inhibition, or the capacity for an individual to inhibit otherwise prepotent (automatic) behaviors, which is thought to capture executive functions believed to be mediated primarily by the prefrontal cortex. Although there were no behavioral differences in task performance between safe (those who never engaged in condomless anal sex) and risky (those who engaged in condomless anal sex in the past 90 days) men, there were differences in brain response during the task. Findings suggested more activation in frontal regions for sexually risky participants, and these activation differences statistically mediated the relationship between impulsivity and risky sexual behavior. Compellingly, it is interesting to note that even though conducted with a different sample and task, the direction of association, namely more activation being associated with more risky behavior, is the same as that found in Gardiner et al.

Adding on to the body of work on brain function in the context of risky sex, Feldstein Ewing et al. explored the role of brain structure. Here, the authors rely on current thinking in developmental cognitive neuroscience to explore the relationship of volumes of key socioemotional (e.g., amygdala, hippocampus) and reward structures (e.g., nucleus accumbens) that change dramatically during adolescence. In a sample of sexually active adolescents, they measured brain structure via magnetic resonance imaging and assessed condom use. Given the critical role of puberty during this developmental time period, it is perhaps not surprising that pubertal development emerged as an important moderator between brain structure and risky sex. Adolescents further along in pubertal development showed stronger negative relationships between brain volumes in limbic regions (amygdala and hippocampus) and condom use, supporting the notion that the “pruning” process that occurs during adolescence may track with better sexual decision making. Importantly, these authors did not find associations between condom use and volume in areas of *reward* or *cognitive control*, as has been found in studies of other adolescent risk behavior including substance use. This suggests sexual risk may occupy a unique space in the acquisition of relatively more adult and normative behaviors that occurs during adolescence.

These five empirical manuscripts underscore the importance of considering the role of brain structure, brain function, and neurocognition more broadly as contributing factors to both levels of and change in risky sexual behavior. They further highlight the value in considering sexual behavior as a unique and important behavior in its own right, rather than one example of the broad category of “risky decision making,” subsumed under the umbrella of other risk behaviors. Previous empirical and

theoretical examinations of the role of neurocognitive structure and function in the study of health risk have, for decades, defaulted to equating decisions about sexual behavior with a panoply of other health risk decisions, including substance use or driving too fast, for example. The data contained in the studies herein lend support to the notion that we need to examine the neurocognitive contribution to decision making about sexual intercourse as its own independent line of inquiry.

The next step in this line of work is to consider how these data could illuminate new perspectives on prevention and intervention. Clearly, these studies do not provide conclusive evidence for particular modifications one might make to current interventions to reduce risky sexual behavior. However, they do suggest that prevention and intervention programs that target modifications in frontal and executive functioning, and importantly, in social/emotional functioning, may be avenues to fostering healthy sexual decisions across contexts and populations. The exciting next step will be to see exactly how these brain-based perspectives could enhance our ability to strengthen decision making in sexual risk contexts, particularly for populations who are at increased risk for morbidity and mortality as a result of unprotected sexual behavior (e.g., low socioeconomic status, racial/ethnic minority, men who have sex with men). Furthermore, in line with recent strength-based movements in the field of health and developmental decision science, we encourage perspectives that examine contexts under which even objectively “risky” sexual decisions may be adaptive [14, 15] and need not set individuals on a path for terminal and negative health outcomes. In other words, we would advocate that future work support the importance of helping individuals move toward incorporating protective behaviors into their sexual lives, rather than pathologizing the decision to have sex.

Acknowledgements The authors’ time was supported by the National Institutes of Health (NINR R01NR013332 to MPIs: Feldstein Ewing & Bryan). The funding source had no involvement in the collection, analysis, interpretation of data, the writing of the report, and the decision to submit the article for publication.

Compliance with Ethical Standards

Authors’ Statement of Conflict of Interest and Adherence to Ethical Standards Authors Angela D. Bryan and Sarah W. Feldstein Ewing declare that they have no conflict of interest. All procedures, including the informed consent process, were conducted in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000.

Authors’ Contributions The authors contributed equally to the writing of this letter to the editor.

Ethical Approval The authors declare that all research procedures were conducted in accordance with ethical standards, including the

Declaration of Helsinki and its later amendments. In the work presented as part of this special section from two studies in which they were directly involved, the local institutional review boards and the federal Office of Human Research Protection approved all aspects of the study, and a certificate of confidentiality was obtained to protect participants and encourage full disclosure.

Informed Consent Both adolescent participant assent and parental consent via digital audio recording over the telephone were obtained prior to involvement in the studies.

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