Neural Mechanisms of Young Adult Sexual Decision-Making and Risk Behavior

by

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Dissertation submitted in partial fulfillment of the requirements for the degree of doctorate of Philosophy in the Department of Psychology and Neuroscience in the Graduate School of Duke University

2015
ABSTRACT

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Abstract

Sexual risk behavior among young adults is a serious public health concern; 50% will contract a sexually transmitted infection (STI) before the age of 25. The current study collected self-report personality and sexual history data, as well as neuroimaging, experimental behavioral (e.g., real-time hypothetical sexual decision making data), and self-report sexual arousal data from 120 heterosexual young adults ages 18-26. In addition, longitudinal changes in self-reported sexual behavior were collected from a subset (n = 70) of the participants. The primary aims of the study were (1) to predict differences in self-report sexual behavior and hypothetical sexual decision-making (in response to sexually explicit audio-visual cues) as a function of ventral striatum (VS) and amygdala activity, (2) test whether the association between sexual behavior/decision-making and brain function is moderated by gender, self-reported sexual arousal, and/or trait-level personality factors (i.e., self-control, impulsivity, and sensation seeking) and (3) to examine how the main effects of neural function and interaction effects predict sexual risk behavior over time. Our hypotheses were mostly supported across the sexual behavior and decision-making outcome variables, such that neural risk phenotypes (heightened reward-related ventral striatum activity coupled with decreased threat-related amygdala activity) were associated with greater lifetime sexual partners at baseline measured and over time (longitudinal analyses). Impulsivity moderated the relationship between neural function and self-reported number of sexual partners at baseline and follow up measures, as well as experimental condom use decision-making.
arousal and sensation seeking moderated the relationship between neural function and baseline and follow up self-reports of number of sexual partners. Finally, unique gender differences were observed in the relationship between threat and reward-related neural reactivity and self-reported sexual risk behavior. The results of this study provide initial evidence for the potential role for neurobiological approaches to understanding sexual decision-making and risk behavior. With continued research, establishing biomarkers for sexual risk behavior could help inform the development of novel and more effective individually tailored sexual health prevention and intervention efforts.
Dedication

I dedicate this work to my parents, Jim and Susan Victor, and my brothers and sisters (Rob, Eric, Will, Ellie, and Carley), whose love and support throughout my life has meant the world to me.
Contents

Abstract .......................................................................................................................... iv
List of Tables .................................................................................................................... xi
List of Figures .................................................................................................................. xiii
Acknowledgements ......................................................................................................... xv
1. Introduction .................................................................................................................. 1
   1.1 The Triadic Model of Neurodevelopment and Risk Behavior ......................... 1
   1.2 The Intersection of Personality, Brain Function, and Risk Behavior ............. 6
   1.3 The Intersection of Brain Function, Sexual Arousal, Personality, and Sexual Risk Behavior .................................................................................................................. 9
       1.3.1 Neuroimaging studies examining sexual decision making and behavior outcomes in adolescents and young adults ................................................................. 11
   1.4 Theoretical Model: Extension of the Triadic Model to Sexual Risk Behavior .... 14
2. The Current Study ........................................................................................................ 18
   2.1 Study Aims ............................................................................................................ 19
3. Methods ....................................................................................................................... 23
   3.1 Pilot Data: Preliminary Analyses ....................................................................... 23
   3.2 Participants ........................................................................................................... 24
   3.3 Procedure ............................................................................................................. 27
       3.3.1 Neuroimaging Data Collection and Tasks ................................................... 28
       3.3.2 Online Study Part 1: Self-Report Questionnaire ......................................... 32
       3.3.3 Online Study Part 2: Experimental Data Collection ...................................... 33
       3.3.4 Online Follow Up Surveys .......................................................................... 37
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. Data Analyses</td>
<td>39</td>
</tr>
<tr>
<td>4.1 BOLD fMRI Data Acquisition and Preprocessing</td>
<td>39</td>
</tr>
<tr>
<td>4.2 BOLD fMRI Data Analysis</td>
<td>40</td>
</tr>
<tr>
<td>4.3 Sexual Decision Making Data: Calculating Outcome Scores</td>
<td>41</td>
</tr>
<tr>
<td>4.3.1 Calculating Changes in Self-Reported Sexual Arousal</td>
<td>44</td>
</tr>
<tr>
<td>4.4 Self-Report Sexual Behavior</td>
<td>45</td>
</tr>
<tr>
<td>4.5 Statistical Approach</td>
<td>47</td>
</tr>
<tr>
<td>5. Results</td>
<td>51</td>
</tr>
<tr>
<td>5.1 Main Effects of fMRI tasks</td>
<td>51</td>
</tr>
<tr>
<td>5.2 Gender and Racial Differences in Predictor and Outcome Variables</td>
<td>53</td>
</tr>
<tr>
<td>5.3 Relationship Between Amygdala and VS Activity to Sexual Decision Making and Self-Reported Risk Behavior</td>
<td>55</td>
</tr>
<tr>
<td>5.3.1 Sexual Decision Making Data</td>
<td>55</td>
</tr>
<tr>
<td>5.3.2 Self-Reported Risk Behavior</td>
<td>55</td>
</tr>
<tr>
<td>5.4 Gender as a Moderator</td>
<td>62</td>
</tr>
<tr>
<td>5.4.1 Sexual Decision Making Data</td>
<td>62</td>
</tr>
<tr>
<td>5.4.2 Self-Reported Risk Behavior</td>
<td>63</td>
</tr>
<tr>
<td>5.5 Sexual Arousal as a Moderator</td>
<td>66</td>
</tr>
<tr>
<td>5.5.1 Sexual Decision Making Data</td>
<td>66</td>
</tr>
<tr>
<td>5.5.2 Self-Reported Risk Behavior</td>
<td>66</td>
</tr>
<tr>
<td>5.6 Sexual Sensation Seeking as a Moderator</td>
<td>73</td>
</tr>
<tr>
<td>5.6.1 Sexual Decision Making Data</td>
<td>73</td>
</tr>
<tr>
<td>5.6.2 Self-Reported Risk Behavior</td>
<td>73</td>
</tr>
</tbody>
</table>
5.7 Self Control as a Moderator ................................................................................. 76
  5.7.1 Sexual Decision Making Data ........................................................................... 76
  5.7.2 Self-Reported Risk Behavior ........................................................................... 77
5.8 Impulsivity as a Moderator .................................................................................. 80
  5.8.1 Sexual Decision Making Data ........................................................................... 80
  5.8.2 Self-Reported Risk Behavior ........................................................................... 82

6. Discussion ............................................................................................................. 87
  6.1 Decision Making Findings .................................................................................. 87
  6.2 Baseline Self-Report Findings ........................................................................... 91
    6.2.1. Specific Aim 1 ............................................................................................... 91
    6.2.2. Specific Aim 2: Gender as a Moderator ......................................................... 96
    6.2.3. Specific Aim 2: Sexual Arousal as a Moderator ............................................. 97
    6.2.4. Specific Aim 2: Self Control as a Moderator ............................................... 98
    6.2.5. Specific Aim 2: Sensation Seeking as a Moderator ...................................... 99
    6.2.6. Specific Aim 2: Impulsivity as a Moderator ................................................ 99
    6.2.7. Baseline Condom Use ................................................................................... 100
  6.3 Longitudinal Self-Report Findings ..................................................................... 103
  6.4 Limitations ........................................................................................................ 105

7. Implications and Future Directions ...................................................................... 112

8. Conclusion .......................................................................................................... 115

Appendix A ............................................................................................................... 117
Appendix B ............................................................................................................... 118
Appendix C ............................................................................................................... 122
List of Tables

Table 1: Primary Variables of Interest: Measure/Scale and Data Collection Point........ 28
Table 2: SDMT and Longitudinal Data Points: Interpretation ................................. 42
Table 3: Descriptive Statistics for Sexual Decision Making Data Points......................... 44
Table 4: Descriptive Statistics for Self-Report Sexual Behavior Outcome Variables...... 47
Table 5: Correlation Table of Primary Variables of Interest........................................ 48
Table 6: Effects of Demographic Variables on Neural Activity.................................. 53
Table 7: Poisson Regression Results of Significant Two-Way Interactions Associated with Baseline Vaginal Partners................................................................. 57
Table 8: Summary of Specific Aim 1 Findings............................................................ 62
Table 9: Summary of Specific Aim 2 Findings: Gender as a Moderator ......................... 65
Table 10: Poisson Regression Results of Significant Three-Way Interactions for Whole Amygdala and VS (Arousal as a Moderator)....................................................... 69
Table 11: Poisson Regression Results of Significant Three-Way Interactions for Lamy x RVS (Arousal as a Moderator) ................................................................. 70
Table 12: Summary of Specific Aim 2 Findings: Arousal as a Moderator ...................... 72
Table 13: Summary of Specific Aim 2 Findings: Sensation Seeking as a Moderator...... 76
Table 14: Poisson Regression Results of Significant Two-Way Interactions Predicting Baseline Number of Partners (Self Control as a Moderator)................................. 78
Table 15: Summary of Specific Aim 2 Findings: Self Control as a Moderator ............... 80
Table 16: Poisson Regression Results of Significant Three Way Interactions Predicting Baseline and Change in Sexual Partners Over time (Impulsivity as a Moderator) ....... 84
Table 17: Summary of Specific Aim 2 Findings: Impulsivity as a Moderator............... 86
Table 18: Summary of SDMT Findings ......................................................................... 91
Table 19: Summary of Baseline Self-Report Findings.................................................. 102
Table 20: Summary of Longitudinal Self-Report Findings ........................................ 104
List of Figures

Figure 1: Heuristic representation of the adapted Triadic Model as a neural mechanism for the emergence of sexual risk behavior in young adults .................................................. 17

Figure 2: Hypothesized Relationship Between Study Variables ........................................ 20

Figure 3: Pilot Study Results: Interaction of Condom Use Decision Making and Arousal Manipulation ......................................................................................................................... 24

Figure 4: Example of VS Card Task ....................................................................................... 30

Figure 5: Example of Hariri Hammer (Amygdala) Task ......................................................... 32

Figure 6: Examples of Potential Partners in Sexual Decision Making Task ....................... 35

Figure 7: Procedure for Experimental Portion of the Online Study (Part 2) ....................... 37

Figure 8: Statistical Parametric Maps Illustrating Mean Bilateral Threat-Related Amygdala Activity (Top image) and Mean Bilateral Reward-Related VS Activity (Bottom Image) in DNS Parent Sample (N = 1005) ......................................................................................................................... 52

Figure 9: Gender Differences in Self-Reported Sexual Arousal to Video Manipulation .... 54

Figure 10: RLB x RVS Interaction Predicting Baseline Number of Partners .................. 59

Figure 11: RCM x LVS Interaction Predicting Baseline Number of Partners ................. 59

Figure 12: LCM x RVS Interaction Predicting Baseline Number of Partners ................. 60

Figure 13: RVS x Gender Interaction Predicting Baseline Number of Sexual Partners .. 64

Figure 14: VS x Gender Interaction Predicting Baseline Number of Sexual Partners .... 65

Figure 15: VS x Amygdala Interaction Predicting Baseline Number of Sexual Partners (High Arousal Participants Only) ......................................................................................................................... 71

Figure 16: VS x Amygdala Interaction Predicting Baseline Number of Sexual Partners (Low Arousal Participants Only) ......................................................................................................................... 71

Figure 17: Scatterplot of Relationship between Sensation Seeking Total Score and Baseline Number of Sexual Partners ......................................................................................................................... 74
Figure 18: VS x Amygdala Predicting Change in Sexual Partners Over Time (Participants High in Sensation Seeking Only)................................................................. 75

Figure 19: LVS x Self Control Predicting Baseline Number of Sexual Partners .......... 79

Figure 20: LCM x Impulsivity Predicting Condom Use Decision Making in SDMT..... 82

Figure 21: RLB x RVS Predicting Baseline Number of Sexual Partners (High Impulsive Participants Only) ................................................................. 85
Acknowledgements

I would like to thank Drs. Ahmad Hariri, Robert Thompson, Christina Meade, and Timothy Strauman for their guidance and support throughout the course of this research project. I am especially grateful to my mentors, Robert Thompson and Ahmad Hariri, for their enduring support both personally and professionally throughout graduate school. Both Drs. Thompson and Hariri provided me with invaluable guidance and encouragement to pursue my specific area of research and without their support this project (and many others) would not have been possible.

Dr. Thompson has been a mentor to me since I was a freshman at Duke over ten years ago! I feel honored to have received his guidance over the past decade and especially as his final graduate student before formally retiring.

Thank you also to Dr. Hariri for allowing me to use data collected from his parent protocol, the Duke Neurogenetics Study (DNS), to explore a unique and understudied research area. Finally, thank you to many members of the DNS lab (Spenser Radtke, Annchen Knot, Matthew Scult, Adam Gorka, and Adrienne Romer) for their invaluable assistance in data collection, processing, and analysis.
1. Introduction

Sexual risk behavior during adolescence and young adulthood continues to be a major public health concern in the United States, especially risk for contracting the human immunodeficiency virus (HIV) infection and other sexually transmitted infections (STIs) (CDC, 2012; Eaton et al., 2008). In terms of specific high-risk behavior, 24% of American women and 34% of American men between the ages of 20 and 24 report more than 5 lifetime sexual partners (Gavin et al., 2009). In addition, 55% of young adults between the ages of 21 and 30 who have had sex in the past year reported that they “seldom or “never” used condoms (Johnston, O’Malley, Bachman, & Schulenberg, 2010). In the United States, one in two sexually active young adults will contract an STI by the age of 25 and this age group will make up 28% of the new HIV cases each year (CDC, 2012; Eaton et al., 2008). Given these significant statistics, much research has been conducted to determine what factors are associated with greater likelihood to engage in sexual risk. The vast majority of this research has utilized psychosocial models, targeting key personality, social, and motivation/intention factors to understand risk behavior, while very few studies have investigated the intersection of cognitive, emotional, biological, and potential sexual partner factors impacting sexual decision making and risk behavior.

1.1 The Triadic Model of Neurodevelopment and Risk Behavior

Human neuroimaging studies show that a balance between the prefrontal cortex (PFC) and the limbic and striatal regions is integral to effective self-regulation skills (c.f.,
Hare, Camerer, & Rangel, 2009; Heatherton & Wagner, 2011; Staudinger, Erk, & Walter, 2011; Steinberg et al., 2009). Specifically, when bottom-up drives from the amygdala or VS bias information processing, self-regulatory failure increases (Hare, Camerer, & Rangel, 2009; Heatherton & Wagner, 2011). For instance, research has shown that circuits of the PFC implicated in self-regulation undergo a protracted development, while limbic (e.g., amygdala) and striatal (e.g., VS) circuits mediating appetitive drives appear to mature earlier and exhibit heightened sensitivity to rewards and emotional stimuli in comparison to adults (Casey, Getz, & Galvan, 2008; Ernst & Fudge, 2009; Ernst, Pine, & Hardin, 2006; Somerville, Jones, & Casey, 2010; Steinberg, 2008; c.f., Romer, 2010). More specifically, neuroimaging studies across development have observed an inverted U-shaped curve in VS activity associated with reward during adolescence and emerging adulthood (c.f., Ernst et al., 2005; Eshel et al., 2007; Galvan et al., 2006; Geier et al., 2009, 2010; Van Leijenhorst et al., 2010a,b; Christakou, Brammer, & Rubia, 2011; Padmanabhan, Geier, Ordaz, Teslovich, & Luna, 2011; Somerville, Hare, & Casey, 2011; however, also see Bjork et al., 2004; Bjork, Smith, Chen, & Hommer, 2010). In addition, adolescents and emerging adults show decreased amygdala activity to facial expressions of negative emotions (e.g., fear, sadness, disgust), as well as general negative cues (such as omission of a large monetary reward), relative to adults and children (e.g., Ernst et al., 2005; Guyer et al., 2008; Hare et al., 2008; Killgore, Oki, & Yurgelun-Todd, 2011; Monk et al., 2003; Pfeifer et al., 2011; Williams et al., 2006).
The Triadic Model is a developmental neural systems model wherein heightened reward-seeking behavior in adolescence and young adulthood is postulated to result from an imbalance between the VS and amygdala via immature “top-down” regulation from the prefrontal cortex (Ernst & Fudge, 2009; Ernst, Pine, & Hardin, 2006). The Triadic Model separates the subcortical system into separate modules—a positive (approach) and negative (avoidance) module (Ernst, Pine, & Hardin, 2006). These modules have different qualitative and quantitative patterns of functioning (Richards, Plate, & Ernst, 2013). The approach system is made up of the striatum, largely functioning in valence/salience value, motivation, motor response, and in response to positive affect and appetitive stimuli (for reviews see Kringelbach, 2005 and Wise, 2004), while the avoidance module includes the amygdala, a brain region shown to consistently respond to emotionally charged stimuli (Ernst, Pine & Hardin, 2006; for reviews see LeDoux, 2000; Phelps, 2006). Because the motivational and emotional subcortical connections develop earlier than do connections supporting prefrontal control and self-regulation, this model underscores how heightened risk behavior may result from a developmental imbalance such that there is a greater impact on the subcortical regions and thus a heightened sensitivity to emotional stimuli, reward, and potential risk taking behaviors (Ernst & Fudge, 2009; Somerville et al., 2010). In other words, the model proposes that risk behavior likely results from a biologically driven imbalance between increased sensation and novelty seeking, coupled with an immature “self-regulatory competence” (Steinberg, 2005).
This imbalance may not only reflect greater VS-related appetitive drives related to positive outcome expectancies, but also decreased response to danger or threat through reduced harm avoidance behavior (Ernst et al., 2005; Maggs, Almeida, & Galambos, 1995; Wills, Vaccaro, & McNamara, 1994; Wilson & Daly, 1985). Therefore, the Triadic Model considers both neural threat and reward sensitivity, wherein threat sensitivity reflects individual differences in neural circuits supporting avoidance of potentially threatening or dangerous stimuli related to the experience of negative arousal, while reward sensitivity reflects individual variability in neural circuits supporting the experience of heightened motivation and positive arousal to seek out rewards in one’s environment (Casey, Jones, & Somerville, 2011; Galvan, 2013). Unfortunately, delays in prefrontal maturation have been shown to support VS function while dampening amygdala response, possibly resulting in increased risk behavior when positive and negative stimuli or cues co-occur (Ernst, Romeo, & Andersen, 2009).

Neurodevelopmental models, such as the Triadic Model, support accounts whereby adolescents and young adults may be able to cognitively appreciate the objective risk associated with a certain behavior, but environmental stimuli (e.g., peers, context), transient factors (e.g., maturational level), and/or internal emotional states (e.g., arousal) make it such that they are unable to regulate and make safe decisions (Casey, Jones, & Somerville, 2011; Ernst, Romeo, & Andersen, 2009; Geier & Luna, 2009; Hare et al., 2008; Richards, Plate, & Ernst, 2013; Steinberg, 2005, 2008). With regard to sexual risk,
this may look like a failure to use a condom, despite being unaware of a partner’s risk history.

Research conducted in our laboratory draws further support for the importance of separating subcortical regions (VS and amygdala) into separate, but interactional, influences on health risk behavior in young people. Nikolova and Hariri (2012) found that higher reward-related VS reactivity was associated with higher levels of problem drinking in young adults, but only if subjects also had lower threat-related amygdala reactivity. They have recently extended this work in a larger sample to demonstrate that the opposite pattern of low VS reactivity and high amygdala reactivity also predicts problem drinking (Nikolova, Mihic, & Hariri, 2013).

Given that many health risk behaviors occur in the context of both positive and negative cues (e.g., sex with a stranger could be interpreted as both exciting and dangerous), understanding how young adults evaluate situations simultaneously offering rewards and dangers (e.g., appetitive and aversive cues) is crucial for prevention and intervention efforts. Unfortunately, however, the literature investigating the neural processing of both appetitive and aversive cues in young adults is limited (Bogdan and Pizzagalli, 2006; Choi, Padmala, & Pessoa, 2014a; Choi, Padmala, Spechler, & Pessoa, 2014b; Ossewaarde et al., 2011; Park, Kahnt, Rieskamp, & Heekeren, 2011; Porcelli, Lewis, & Delgado, 2012; Talmi, Dayan, Kiebel, Frith, & Dolan, 2009). Therefore, studies like Nikolova et al.’s (2012; 2013) may provide initial evidence for how the intersection of aversive and appetitive brain-based phenotypes is critical for normal
behavioral responses and that an imbalance in either direction contributes to risky
decision making, possibly including sexual risk behavior.

1.2 The Intersection of Personality, Brain Function, and Risk Behavior

Three key stable traits implicated in risky sexual decision making in adolescents
and young adults are impulsivity, sensation seeking, and self-control. Cross sectional,
longitudinal, and experimental data has shown that trait impulsivity and sensation seeking
are positively correlated with sexual risk behavior (e.g., Carpenter, Andersen, Fowler, &
Maxwell, 2008; Deckman & DeWall, 2011; Derefinko et al., 2014; Dir, Coskunpinar, &
Cyders, 2014; Donohew et al., 2000; Hoyle, Fejafar, & Miller, 2000; Kalichman,
Heckman, & Kelly, 1996; Miller, Flory, Lynam, & Leukefeld, 2003), while trait self-
control is negatively correlated with sexual risk behavior (e.g., Gailliot, & Baumeister,

In addition, developmental neuroscientists have begun to investigate the
association of these key personality traits and brain function in understanding adolescent
and young adult health risk behavior. For instance, neuroimaging research has found
positive correlations with VS activation and impulsivity (Beaver et al., 2006; Buckholtz
et al., 2010) and sensation seeking (Bjork, Knutson, & Hommer, 2008; Nelson et al.,
2002; Zuckerman, 1994).

More recently, Cservenka, Herting, Mackiewicz, Seghete, Hudson, and Nagel
(2013) found that adolescents scoring high on trait sensation seeking showed significant
differences in PFC activity when comparing reward receipt versus reward absence, such
that high sensation seekers showed a hypo-responsive pattern to reward absence. The authors suggest that this decreased brain activity in the PFC in high sensation seeking adolescents could reflect deficits in attention to negative feedback during goal-directed behavior, which could have critical implications for sexual risk behavior.

Costumero et al. (2013) found that trait reward sensitivity correlated positively with VS reactivity to sexually explicit pictures in a sample of young adult heterosexual men. These results support the hypothesis that individuals who are more sensitive to rewarding cues (like erotic stimuli) may attribute greater reward value to the stimuli and have increased motivation to pursue sexual behaviors, even when they are potentially dangerous (McClure, York, & Montague, 2004; O’Doherty, 2004, Rolls & Grabenhorst, 2008). These studies, where laboratory based findings are compared to both real-life risk taking and personality constructs linked to risk taking in the same participants, supports the ecological validity of theory-driven laboratory based measures to better assess the causal mechanisms that may underlie risky health behaviors.

Spielberg, Olino, Forbes, & Dahl (2014) recently found that in a sample of 11-12 year old girls and 12-13 year old boys pubertal increases in testosterone over two years of early adolescence predicted increased activation in the amygdala and the VS to threatening faces. Moreover, the researchers found that increased threat reactivity over time in the amygdala was associated with decreased trait anxiety and increased trait sensation seeking only in adolescents who also showed increased VS reactivity to threat (Spielberg et al., 2014). The authors postulated that these seemingly paradoxical findings
support the notion that adolescence involves a maturational shift toward more complex processing of threatening cues, which may contribute to increased risk-taking behaviors (i.e., experiencing potentially threatening situations as rewarding) (Spielberg et al., 2014). Such research may be particularly pertinent for understanding sexual risk behavior, as threatening cues (e.g., not knowing one’s partner’s risk status or not having a condom available), may be experienced as novel and thrilling during young adulthood.

Davis et al. (2013) extended Nikolova’s (2013) work using graph theory analyses. The researchers found significant differences in the organization of resting state whole-brain networks as a function of trait impulsivity. More specifically, among individuals reporting low trait impulsivity, there were three separate functional connectivity modules: (1) visual cortical structures, (2) sensorimotor structures, and (3) cortical structures associated with cognitive control, emotion regulation, and attention focus clustering together with subcortical regions involved in appetitive drives (Davis et al., 2013). In contrast, individuals exhibiting high trait impulsivity showed a break in this third module such that the cortical control regions were isolated from subcortical drive regions, including the VS and amygdala (Davis et al., 2013). The authors pointed out that these differences in whole-brain functional organization provide support for a breakdown in effortful, cognitive control over drive for immediate rewards in highly impulsive young adults (Davis et al., 2013). The findings from our laboratory research underscore the important functional connectivity between the three brain regions of the Triadic Model: PFC, VS, and amygdala and further emphasize how the strengthening of connections
between these circuits may provide a mechanism to explain changes in risk taking and impulsivity across development (Casey & Jones, 2010).

### 1.3 The Intersection of Brain Function, Sexual Arousal, Personality, and Sexual Risk Behavior

While some adult literature suggests that difficulties in impulse control are associated with risky sexual behavior (e.g., Clift, Wilkins, & Davidson, 1993; Pinkerton & Abramson, 1995), very few neuroimaging studies have been conducted to examine the relationship between impulse control, sexual arousal, and sexual behavior or decision-making (Demos, Heatherton, & Kelley, 2012; Goldenberg, Telzer, Lieberman, Fuligni, & Galvan, 2013; Rupp et al., 2009a). Sexual arousal is a key component of “in the moment” sexual decision-making and is defined as the physical (i.e., genital response) and psychological (i.e., sexual desire) readiness to perform a sexual behavior (Rosen & Beck, 1988). Importantly, adolescence and young adulthood represent a crucial phase in sexual development, as individuals are beginning to associate certain environmental and personal cues (e.g., bodily features, etc.) with genitally-induced sexual pleasure (Georgiadis, Kringelbach, & Pfaus, 2012; Pfaus et al., 2012).

While adolescents and young adults appear to be able to pre-contemplate and prepare for sexual encounters (Rheece et al., 2010), they are often unable to translate rationale forethought into action “in the moment” that would lead them to abstinence or proper condom use (Reyna & Farley, 2006). Researchers have hypothesized that sexual arousal in particular biases individuals toward sexual risk behavior (i.e., condom use, whether or not to have sex), highlighting the importance of better understanding the
cognitive breakdown occurring during these emotionally salient “heat of the moment” situations (Bancroft et al., 2004; Blanton & Herrard, 1997; Ditto, Pizarro, Epstein, Jacobson, & MacDonald, 2006; Gerrard, Gibbons, & Bushman, 1996).

Cross-sectional and experimental research findings underscore the important role of sexual arousal in impeding self-regulation, often resulting in increased sexual risk behavior (e.g., Abbey, Saenz, & Buck, 2005; Ariely & Loewensteine, 2006; Bateson & Healy, 2005; Boldero, Moore, & Rosenthal, 1992; Derefenko et al., 2014; George et al., 2009; Imhoff & Schmidt, 2014; Janssen, Goodrich, Petrocelli, & Bancroft, 2009; Lindgren, Shoda, & George, 2007; MacDonald, MacDonald, Zanna, & Fong, 2000; Prause, Stanley, & Finn, 2011). Experimental findings with heterosexual young adults found that increases in sexual arousal also led to greater intent to engage in sexual behavior with a new partner (Prause et al., 2011) and lower reported likelihood of using a condom (Ariely & Loewensteine, 2006). Most recently, Derefenko et al. (2014) found that among young men greater physiologic arousal (using skin conductance measures) to sexual stimuli was related to ever having engaged in sex with a stranger. Finally, Macapagal, Janssen, Fridberg, Finn, & Heiman (2011) found that more impulsive young adults failed to inhibit a response more often than their less impulsive peers in a go/no-go task after viewing sexually arousing videos.

While these studies have provided important insight into the intersection of biological and contextual factors in shaping sexual decision making and risk behavior, most experimental studies have focused exclusively on men, potentially because research
has shown men have a higher sex drive (Baumeister, Catanese, & Vohs, 2001) and have more clear appetitive responses to sexual stimuli compared to heterosexual women (Chivers, Rieger, Latty, & Bailey, 2004). Given the key differences in sexual behavior and functioning between genders (c.f., Galperin et al., 2013), as well as gender norms for sexual behavior within the United States (see review by Crawford & Popp, 2003), and recent proposals that men and women have different sexual cognitions (Ogas & Gaddam, 2012), we specifically aimed to investigate potential gender differences in sexual behavior related to neural function and sexual arousal.

1.3.1 Neuroimaging studies examining sexual decision making and behavior outcomes in adolescents and young adults

In the past two decades more extensive research has been conducted on the relationship between the brain’s response to erotic material and/or the anticipation of a sexual encounter in adult samples (see extensive review of neuroimaging findings by Stoleru, Fonteille, Cornelius, Joyal, & Moulier, 2012). For instance, functioning neuroimaging studies provide evidence that just showing young adults physically attractive photos (Aharon et al., 2001; Cloutier, Heatherton, Whalen, Kelly, 2008) or sexually explicit images or video clips (Hamann, Herman, Nolan, & Wallen, 2004; Karama et al., 2002) activates the ventral striatum and amygdala. Moreover, extensive neuroimaging meta-analyses conducted by Stoleru et al. (2012) and Sescousse, Caldu, Segura, and Dreher (2013) provide ample evidence for the important role this brain region plays during explore to sexually explicit material and subsequent self-reported sexual arousal. Sescousse et al. (2013) examined how erotic rewards reflect similar, yet
unique, functional brain activations to other primary and secondary rewards, including food and monetary rewards. Across 87 studies (26 of which included erotic material), the amygdala responded exclusively to erotic pictures and videos compared to food and monetary rewards. These findings likely reflect the extent to which sexual stimuli are affectively laden reinforcers (i.e., greatly impacting amygdala response) (Sescousse et al., 2013).

In the only fMRI study in which subjects were making hypothetical sexual decisions in the scanner (i.e., extent to which subject is willing to have sex with the person presented in the photo), Rupp et al. (2009a) found that young adult heterosexual women had stronger activation in the anterior cingulate cortex (ACC), a region involved in conflict monitoring and top-down regulatory control (Carter et al., 1998), when making sexual decisions about low risk-men versus high-risk men, suggesting that greater effortful control may be necessary to offset risky sexual decision-making. In addition, ACC activity was positively related to women’s subjective ratings of their likelihood of having sex with high-risk men.

Most recently, Goldenberg et al. (2013) found that sexually riskier adolescents, based on self-reported contraception use at last sexual encounter, showed less activation in the PFC (specifically right inferior frontal gyrus) during response inhibition in a standard go/no-go task. These studies provide initial support for the role of sexual decision-making and risk behavior in the context of the Triadic Model, such that young
adults appear to engage cognitive control areas of the brain to a greater extent in decisions presenting potentially greater sexual risk.

With regard to sexual risk behavior and the VS, Demos, Heatherton, and Kelley (2012) used an event-related cue-reactivity paradigm wherein fifty-eight college freshman women viewed still shot images of animals, food, people drinking alcohol, people in sexual scenes, people in nonsexual and nondrinking scenes, and environmental scenes. The results showed that VS reactivity to sexual images correlated positively with increases in sexual activity six months later and individual scores of sexual desire (Demos et al., 2012). More specifically, greater VS reactivity at baseline correlated with an increase in number of sexual partners six months later. These real-world longitudinal findings in risk behavior are consistent with Galvan et al.’s (2007) study including a large sample of 12-24 year olds, in which individual differences in self-report intent to engage in future risky behaviors (e.g., heavy drinking, aggressive and illegal behaviors, irresponsible academic work/behaviors) was positively correlated with VS activity in anticipation of reward during a delayed response two-choice task.

Given the lack of imaging studies relating brain function to real-world health risk behavior (Berkman & Falk, 2013; Berkman, Falk, & Lieberman, 2011; Chambers & Potenza, 2003; Chua et al., 2011; Demos, Heatherton, & Kelley, 2012; Goldenberg et al., 2013; Nikolova et al., 2013), especially sexual risk behavior, there is clearly a great need for further research examining the brain mechanisms by which sexual decisions are made and how brain activation to sexual cues influences subsequent real-world sexual
behavior. Given the unique motivational and emotional circumstances surrounding sexual decision making in particular, as well as the critiques and suggestions regarding the Triadic Model (see Crone & Dahl, 2012; Luciana & Segalowitz, 2014), the current study not only probes the relationship between the VS and amygdala in understanding sexual decision making and risk behavior, but also investigates how these neural circuits are influenced by individual personality (i.e., stable traits such as sensation seeking), situational (i.e., potential sexual partner characteristics), and physiologic (i.e., sexual arousal) factors.

1.4 Theoretical Model: Extension of the Triadic Model to Sexual Risk Behavior

Figure 1 presents a theoretical extension of the Triadic model, based on that proposed by Ernst & Fudge (2009). In this adapted model, we represent how sexual risk behavior is a product of integrating approach and avoidance signals (e.g., reflecting individual differences in threat and reward sensitivity) from the ventral striatum and central nucleus amygdala, respectively, and the reciprocal modulation of these signals via the prefrontal cortex. The adult pattern shows a balanced system wherein the PFC provides appropriate top-down regulation to effect balance between signals from the ventral striatum and amygdala and, subsequently, in approach and avoidance, to help facilitate adaptive decision-making and mitigation of risk. In contrast, the adolescent/young adult pattern is characterized by less developed PFC regulation coupled with increased dopamine modulation, resulting in an imbalance between approach signals from the ventral striatum and avoidance signals from the amygdala. This imbalance is
especially evident when salient social and motivational factors are present for adolescents and young adults in the context of decision-making. We propose the social and emotional factors are especially important in understanding decision making in the context of sexual risk behavior as these decisions are often made in highly arousing situations, where individuals are weighing relationship and other peer-related values, and depend on specific factors related to a potential sexual partners (e.g., risk of partner, attractiveness, relationship status, etc.). Of note, this model (under review, Development and Psychopathology) represents the role of dopamine and the PFC impacting the ventral striatum and amygdala. However, as the current study is the first to test and understand this model specific to sexual risk behavior, we are only examining the role of the VS, amygdala, and individual personality and motivational contexts (e.g., individual personality factors and differences in sexual arousal and sexual partner characteristics). It is our goal that future studies will investigate the role of the PFC and dopamine, as well as additional social and motivational factors, in the context of sexual decision-making and risk behavior.

Furthermore, this model represents a more precise subregion of the amygdala – the central nucleus. One limitation of the Triadic Model as it has been originally proposed is that it does not reflect the fact that the amygdala is both structurally and functionally heterogenous with multiple subregions participating in the generation of both approach and avoidance behaviors (Whalen & Phelps, 2009). Very briefly, the basolateral complex of the amygdala (BLA) has been proposed to serve as a “sensory gateway” to
not only the central nucleus of the amygdala (CeA), which mediates reflexive and autonomic responses to threatening stimuli, but also the ventral striatum, which supports approach behavior toward rewarding stimuli. Thus, certain subregions of the amygdala may show increased activity to positive/rewarding stimuli, while other show increased activity to threatening/harmful stimuli. Morrison and Salzman (2010) (also see Belova, Paton, & Salzman (2008)), posit that neurons in the amygdala encode “state value,” including valence inputs from an array of internal and external sources (e.g., context specific, as well as individual specific such as hunger cues). We therefore hypothesize that increased threat-related reactivity of the amygdala, particularly the CeA, should contribute to decreased sexual risk behaviors (see Figure 1), while increased reward-related reactivity of the amygdala, particularly the BLA, should contribute to increased risk. Unfortunately, measurement of such subregional specificity of amygdala development and function, while critical for understanding the emergence of risk behavior, has not been generally adopted in the research on sexual risk behavior. Therefore, the current study will explore multiple subregions of the amygdala in the hopes to better delineate the subregional specificity of the amygdala within the Triadic Model.
Figure 1: Heuristic representation of the adapted Triadic Model as a neural mechanism for the emergence of sexual risk behavior in young adults.

17
2. The Current Study

The current study demonstrates innovation and adds to the existing literature in three key ways: (1) it includes a unique experimental paradigm wherein hypothetical sexual decision making is measured both before and after exposure to sexually explicit cues, (2) it investigates multiple components of sexual decision making and behavior (e.g., potential partner characteristics (i.e., attractiveness ratings and risk status in the sexual decision making task), as well as arousal, and personality factors), and (3) it is the first study to date to specifically examine the relationship between brain function, self-report sexual risk behavior, and real-time hypothetical sexual decision making.

Ultimately, research into the neurobiological and neurodevelopmental understanding of sexual risk is not only highly innovative, but has the potential to significantly advance our understanding of emerging adult sexual risk taking, which to date has primarily been limited to self-report survey measures.

Using a within-subjects design, we were able to not only maximize power, but also more accurately determine how self-reported sexual arousal, as well as potential partner characteristics, affect individual differences in sexual decision-making. In addition, by incorporating personality factors into an experimental design, we were better able to determine how self-control, impulsivity, and sensation seeking function as either main effects on sexual decision-making, or moderate the impact of brain function-risk behavior relationships. By empirically integrating relevant personality, affective (i.e., self-reported emotions and arousal during decision making tasks), and potential sexual
partner characteristics, we were able to create a more complete understanding of sexual decision-making.

Finally, in addition to experimentally-based sexual decision making and baseline self-reported sexual histories, participants were asked to complete additional questions related to their sexual behavior every six months for one year, which provided us with valuable longitudinal data points to better understand what factors might predict changes in real-world sexual risk behavior over time.

2.1 Study Aims

The current study investigated the relationship between brain function and sexual decision-making under arousal, as well as the relationship between brain function and real-world sexual risk behavior among emerging adults. The motivating research question was: How does brain function (e.g., neural phenotypes) interact with individual differences in sexual arousal and personality factors to affect risky sexual decision-making and behavior? The goal of this research was to integrate evidence from the rich literature on adolescent brain function supporting the anticipation of and response to threats and rewards. This study directly manipulated, using a within-subject design, the emotionally charged “hot” context in which sexual decisions are often made to provide a better understanding of the unique role of arousal, brain function, and personality traits in sexual decision making and behavior. See Figure 2 for the hypothesized relationship between the study variables.
The specific aims and hypotheses of the study were:

Specific Aim 1: Predict differences in sexual decision-making in response to sexually explicit audio-visual cues as a function of brain function.

Hypothesis 1: Individuals who exhibit higher reward-related ventral striatum (VS) activity coupled with lower threat-related amygdala activity (e.g., high VS/low amygdala), or lower reward-related ventral striatum reactivity coupled with higher threat-related amygdala activity (e.g., low VS/high amygdala), will make greater risky sexual decisions following arousal.
Specific Aim 2: Test whether the association between brain function and sexual decision-making is moderated by gender, self-reported sexual arousal, and/or personality factors (i.e., sensation seeking, self-control, and impulsivity).

Hypothesis 2A: Individuals with high VS/low amygdala or low VS/high amygdala phenotypes, who also report greater increases in sexual arousal, will make riskier sexual decisions.

Hypothesis 2B: Individuals with high VS/low amygdala or low VS/high amygdala phenotypes, who also report greater risk-related personality factors (e.g., sensation seeking, impulsivity) and/or lower protective-related factors (e.g., self-control), will make riskier sexual decisions following arousal.

Hypothesis 2C: Men with high VS/low amygdala or low VS/high amygdala phenotypes will make riskier sexual decisions compared to women.

Specific Aim 3: Examine how the main effect of brain function and interaction effects (gender, self-reported arousal, and personality trait factors) predict sexual risk behavior over time.

Hypothesis 3: The significant main effects and interactions hypothesized in Aims 1 and 2 will be associated with actual sexual risk behavior over time, such that men, individuals with greater risk-related neural phenotypes (e.g., high amygdala/low VS activity or low amygdala/high VS activity), risk-related personality factors (e.g., sensation seeking, impulsivity), and greater self-reported arousal to sexually-explicit cues
will engage in greater sexual risks over time, including lower reported condom use and greater increases in number of sexual partners.
3. Methods

3.1 Pilot Data: Preliminary Analyses

Psychophysiologic, behavioral, and personality data was collected from 132 heterosexual young adults (ages 18-26) for pilot testing of the protocol in a psychophysiologic laboratory task. We found the audio-visual sexually explicit stimuli elicited significantly greater levels of physiological arousal (as measured by galvanic skin response) and self-reported sexual arousal compared to baseline measures ($F(1, 69) = 48.15, p < .001; F(1, 131) = 37.28, p < .001$, respectively). We conducted multi-level modeling analyses (where personality traits were modeled at level 1, physiologic arousal (exposure to video clips) was modeled at level 2) to determine how physiologic arousal and individual differences in personality factors interacted and served as main effects in hypothetical sexual decision making of oral sex, vaginal sex, and condom use. We found that exposure to the video clips and increases in sexual arousal predicted decisions regarding whether or not someone would engage in sexual behavior, while personality characteristics predicted condom use. Significant cross-level interactions occurred between video exposure (e.g., arousal manipulation) and personality trait factors. For instance, video exposure interacted with self-control ($B = .02, SE = .009, p < .05$) such that persons high in self-control showed greater willingness to use condoms post arousal, compared to participants low in self-control. In all, behavioral results from this pilot study lend strong support for the pursuit of the proposed research study, helping to
further elucidate the extent to which brain function is involved in risky sexual decision-making.

![Figure 3: Pilot Study Results: Interaction of Condom Use Decision Making and Arousal Manipulation](image)

**Note.** Likelihood of condom use: 1 = Very Unlikely and 4 = Very Likely

### 3.2 Participants

Eligible participants were recruited exclusively from the Duke Neurogenetics Study (DNS), an ongoing parent protocol, via email once they completed the fMRI portion of the study. DNS has the following exclusion criteria: contradiction to have MRI (e.g. ferromagnetic foreign bodies or medical devise such as cardiac pacemakers); current
treatment for medical conditions affecting cerebral metabolism and blood flow (e.g. hypertension) or taking psychotropic medications (e.g. SSRIs); inability to understand the procedures and sign the consent form; inability to remain still or physically tolerate the positioning and movement constraints of the MRI scanner; inability to perform required behavioral tasks under scanning conditions; women participants who are pregnant; participants who are claustrophobic. Diagnosis of any current DSM-IV Axis I disorder or select Axis II disorders (antisocial personality disorder and borderline personality disorder), assessed with the electronic Mini International Neuropsychiatric Interview (Sheehan et al., 1998) and Structured Clinical Interview for the DSM-IV subtests (First Spitzer, Gibbon, & William, 1996) were not an exclusion, as the DNS seeks to establish broad variability in multiple behavioral phenotypes related to psychopathology. Two additional exclusion criteria were used for the current study: 1) participants who did not identify as heterosexual; 2) participants uncomfortable with or unwilling to watch and listen to sexually explicit audio video clips. Only heterosexual participants were included as only sexual behaviors between a man and a woman were depicted in the audio video clips.

Any heterosexual participant having completed the DNS at anytime was eligible, as long as they were currently under the age of 26 and self-identified as heterosexual. Therefore, some participants were enrolled immediately following their completion of the DNS, while others were enrolled years later ($M=283.01$ days, $SD=342.37$; range=0 days–4.01 years).
The final sample included 120 participants ($M_{age} = 20.23, SD = 1.52$). An additional 26 participants were excluded for excessive head motion (more than 3 mm in any direction) during the fMRI tasks. Five participants failed to complete the entire sexual decision making task ($M_{age} = 20.33, SD= 1.36, 73\%$ women). An additional 22 participants ($M_{age} = 20.50, SD= 1.19, 68\%$ women) did complete the decision making task, but failed to pass the validity check for the video exposure during the decision making task (i.e., reported watching less than 80% of the video clip and/or was unable to correctly identify the letter on the screen). Therefore, while 120 participants were included in the self-report outcome analyses, only 93 ($62\%$ female, $M_{age} = 20.22, SD = 1.59$) were included in the sexual decision-making task analyses. Of the 120 participants, 70 ($66\%$ female, $M_{age} = 19.89, SD = 1.33$) completed at least one follow up survey and were included in longitudinal analyses.

The participants were predominately women ($n = 75, 63\%$). Fifty-one percent of the sample identified as Caucasian ($n = 61$), 31% as Asian Americans, ($n =37$), 9% as African American ($n = 11$), 9% ($n = 11$) as Latino/Hispanic, and 9% ($n = 11$) reported other racial backgrounds. Forty-eight percent ($n = 56$) of the participants reported being single at baseline, 14% ($n = 17$) were in a casual (not exclusive) romantic relationship, and 39% ($n = 47$) were in a committed (exclusive) relationship. No participants were married. No participants met criteria for a personality disorder and 18 (15%) participants from our final sample met criteria for at least one Axis I disorder (1 Agoraphobia, 1 Alcohol Abuse, 5 Alcohol Dependence, 1 Substance Abuse, 1 Substance Dependence, 1
Bipolar Disorder Not Otherwise Specified, 1 Bipolar II, 5 Past Major Depressive Episode, 1 Panic Disorder, 1 Social Phobia). These individuals did report significantly more sexual partners at baseline \( t(118)=-2.03, p=.04; M \) of 4.22 partners compared to 2.65) compared to participants without a DSM-IV diagnosis, but did not report significantly more partners over time (i.e., at follow up \( t(68)=.09, p=.92 \)). Participants with a mental health diagnosis did not report significant differences in condom use at baseline or follow up compared to participants without a DSM-IV diagnosis \( t(81)=.64, p=.53; t(40)=1.04, p=.31 \), respectively). Given these findings, mental health status was controlled for in all self-report sexual behavior analyses. Individuals with a DSM-IV diagnosis did not significantly differ from participants without a mental health diagnosis on any of the sexual decision making variables \( t \) values ranged from \( df = 91 \) = -1.57 to .84, \( p \) values ranged from .12 to .88).

### 3.3 Procedure

Any individual who completed the DNS was emailed about an opportunity to participate in a separate two-part online study. Interested individuals emailed a study g-mail address to receive additional information about the study. Potential participants were asked to complete three eligibility questions: 1) when they completed the MRI scan for the DNS (to confirm completion of the DNS), 2) their sexual orientation (to confirm identification of heterosexual sexual orientation), and 3) whether they felt comfortable watching four minutes of sexually explicit audio-video clips. The primary variables of interest are listed in Table 1.
Table 1: Primary Variables of Interest: Measure/Scale and Data Collection Point

<table>
<thead>
<tr>
<th>Construct/Variable of Interest</th>
<th>Measure/Scale</th>
<th>Data Collection Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Behavioral Sexual Decision Making (SDM) Outcomes</td>
<td>Hypothetical SDM task (Rupp et al., 2009a,b)</td>
<td>Experimental Online Study - Part 2</td>
</tr>
<tr>
<td>Brain function</td>
<td>Ventral striatum and amygdala activity during two fMRI tasks (Brown, Manuck, Flory, &amp; Hariri, 2006; Hariri et al., 2006)</td>
<td>Parent Protocol (DNS) fMRI</td>
</tr>
<tr>
<td>Trait Impulsivity</td>
<td>30-item Barratt Impulsiveness Scale (Patton, Stanford, &amp; Barratt, 1995)</td>
<td>Parent Protocol (DNS) computer survey</td>
</tr>
<tr>
<td>Trait Sensation Seeking</td>
<td>10-item Sexual Sensation Seeking Scale (Kalichman et al., 1994)</td>
<td>Online Study – Part 1</td>
</tr>
<tr>
<td>Trait Self-Control</td>
<td>12-item Brief Self-Control Scale (Tangney, Baumeister, &amp; Boone, 2004)</td>
<td>Online Study – Part 1</td>
</tr>
<tr>
<td>Demographics</td>
<td>age, gender, race/ethnicity</td>
<td>Online Study #1</td>
</tr>
<tr>
<td>Past (Lifetime) &amp; Current Sexual History</td>
<td>Baseline and vaginal number of sexual partners and condom use; STI and unplanned pregnancy history; pornography use and frequency</td>
<td>Online Study #1 &amp; Online follow up surveys (two administered every 3-6 months after baseline study completion)</td>
</tr>
<tr>
<td>Self-reported sexual arousal</td>
<td>1 PANAS item (completed at baseline and again after each sexually explicit video)</td>
<td>Experimental Online Study - Part 2</td>
</tr>
</tbody>
</table>

3.3.1 Neuroimaging Data Collection and Tasks

All participants enrolled in the current study previously completed the DNS, which collects measures of brain structure and function, including reward-related VS and threat-related amygdala activity. A modified fMRI paradigm based on the work of
Delgado, Nystrom, Fissell, Noll, and Fiez (2000) was used to probe VS activity in response positive and negative feedback-associated monetary reward. The blocked-design paradigm consisted of a pseudorandom presentation of trials wherein participants played a card guessing game and received positive or negative (i.e., win or loss) feedback for each trial. All participants were told that their performance on the card game would determine a monetary reward to be received at the end of the game. During each trial, participants had 3 s to guess, via button press, whether the value of a visually presented card was higher or lower than 5 (using their index and middle finger, respectively). After a choice was made, the numerical value of the card was presented for 500 ms and followed by appropriate feedback (green upward-facing arrow for positive feedback; red downward-facing arrow for negative feedback) for an additional 500 ms. Upon receiving positive feedback (i.e., a green arrow), participants were required to respond via button press (either index or middle finger) to engage consummatory processes that may be necessary to elicit VS activation. No response was required upon negative feedback (i.e., a red arrow). A crosshair was then presented for 3 s, for a total trial length of 7 s. Each block was comprised of five trials, with three blocks each of predominantly positive feedback (75% correct) and three of predominantly negative feedback (25% correct) interleaved with three control blocks. During control blocks, participants were instructed to simply make alternating button presses during the presentation of an ‘x’ (3 s) which was followed by an asterisk (500 ms) and a yellow circle (500 ms). Each block was preceded by a 2 s instruction of ‘Guess Number’ (for positive or negative feedback
blocks) or ‘Press Button’ (for control blocks), resulting in a total block length of 38 s and a total task length of 342 s. Participants were unaware of the fixed outcome probabilities associated with each block and were led to believe that their performance would determine their net monetary gain. Instead, all participants received $10. The DNS includes one incongruent trial within each task block (e.g., one of four trials during positive feedback blocks is incorrect, resulting in negative feedback) to prevent participants from anticipating the feedback for each trial and to maintain participants’ engagement and motivation to perform well. See Figure 4 for example of VS card task.

Figure 4: Example of VS Card Task
A well-established faces task (Hariri, Bookheimer, Mazziotta, 2000; Manuck, Brown, Forbes, & Hariri, 2007) was used to probe amygdala activity. The paradigm consisted of a total of nine experimental blocks, two blocks each of matching and labeling affect interleaved with five control blocks, each lasting 32.5 s for a total scan length of 4:53 min. For each affect condition, 12 different images were used, six per block, three of each gender, all derived from a standard set of pictures of facial affect (Ekman & Friesen, 1976). Six different sets of geometric forms were used in the control condition. Images were presented for a period of five seconds in a randomized fashion for all conditions and the paradigm was counterbalanced across participants. During imaging, participants responded by pressing one of two buttons with their right hand, allowing us to determine accuracy and reaction time. See Figure 5 for a visual example of the Hammer Task. In addition to the neuroimaging data, the Barratt Impulsivity Scale was collected from the DNS protocol (see Appendix A for specific items).
3.3.2 Online Study Part 1: Self-Report Questionnaire

Eligible participants were emailed a link to complete part 1 of the online study, a 45-minute survey including self-report questionnaires designed to measure personality trait differences, as well as current and past sexual behavior. Participants completed the
online survey using Qualtrics software. The specific items of each questionnaire/measure are listed in Appendix B. The self-report sexual behaviors included in analyses were: lifetime number of vaginal sexual partners (scored as actual number of partners reported) and average condom use (scored on a 1-4 likert scale where 1 = never use condoms to 4 = always use condoms/on every occasion).

Participants completed the 13-item Brief Self-Control Scale (BSCS; Tangney, Baumeister, & Boone, 2004) to assess trait self-control. Participants were asked to answer each item with a 5-point likert scale where 1 = not at all and 5 = very much. The scale was internally consistent (α = .82). Sexual sensation seeking was measured with the 10-item Sexual Compulsivity Scale (Kalichman et al., 1994). The scale used a 4-point likert scale format, where 1 = not at all like me and 4 = very much like me. The scale was internally consistent (α = .86). Impulsivity was measured with the Barratt Impulsiveness Scale (BIS; Patton et al., 1995), a 30-item questionnaire using a 4-point likert scale where 1 = rarely/never and 4 = almost always/always. The BIS assesses impulsivity on 3 subscales: motor impulsivity (the tendency to act without thinking), cognitive impulsivity (the readiness to make quick cognitive decision) and nonplanning impulsivity (the degree of focus on only the present). While subscale scores were created, the total score (using all items) yielded the highest alpha (.70), and therefore was used in moderation analyses.

3.3.3 Online Study Part 2: Experimental Data Collection

If a participant completed the Part 1 online survey, he or she was emailed at least 10 hours later a link to complete the second online survey: the experimental portion. For
In this portion of the study, participants were directed to complete the study in a private room where they would be comfortable watching two short sexually explicit video clips. Participants were instructed to turn the volume up on their personal computers. Participants completed Part 2 of the study using Qualtrics survey software.

For Part 2 of the study, participants were asked to complete a hypothetical sexual decision-making task developed by Rupp and colleagues (2009a,b). For this task, participants were presented with 44 pictures of attractive faces of the opposite sex derived from an existing stimulus set (Rupp et al., 2009a,b). The sexual decision making task (SDMT) was identical to Rupp et al.’s (2009a,b) task, except an additional 2 risk-related questions were added (e.g., oral sex question and condom use). While pictures were presented (22 faces in the first round), participants were asked to answer four questions about each face they saw on the screen: (1) how sexually attractive is this person to you? (2) how likely would you be to have vaginal or (3) oral sex with this person? and (4) how likely would you be to use a condom if you engaged in vaginal sex with this person? In the upper right hand corner of each picture, three sources of risk information were provided: number of oral and vaginal sexual partners this person has had in the past and consistency of his or her condom use in the past (low risk = 2-5 oral and vaginal sexual partners, usually/always used condoms; high risk= 10-13 oral and vaginal sexual partners, rarely/never used condoms). See Figure 6 for examples of high and low risk potential sexual partners for the sexual decision making task (Note: high risk partner = top photo; low risk partner = bottom photo).
Figure 6: Examples of Potential Partners in Sexual Decision Making Task.

Following the sexual decision making task, participants were asked to complete a 7-10 minute delay-discounting task (Mitchell, 1999) in which participants made choices between smaller immediate rewards (ranging from $1 to $100) and larger delayed
rewards (ranging from $20 to $500 and from 1 to 500 days). This task served as a
distraction task during interstimulus intervals before and after the arousal manipulation
(i.e., exposure to sexually arousing video clips).

Next, participants watched two 120-second audio-video clips. The video clips
were similar in content to those used in Karama, Armony, & Beauregard (2011) and
Karama et al. (2002) studies. While attempts were made to obtain the video clips used in
Karama et al.’s (2002, 2011) studies, these videos were in black and white and dated
(e.g., hair styles and clothing was representative of the 1990s). Therefore, erotic videos
publicly available online offered the potential advantage of being in color with sound and
more modern actors/actresses, while also including the same content as previous audio-
video stimuli used in sexual arousal research. Wondershare video editing software was
used to convert and edit the videos in order for them to be altered to 2 minutes in length.
The video clips consisted of sexual interactions (vaginal or oral sex) between a man and a
woman. Approximately one minute into each video clip a validity check was inserted, in
which a letter flashed onto the screen for approximately 1/10th of a second. Participants
were asked at the end of the video clip to indicate what percentage of the video they
watched (0-100%) and to write the letter they saw flash onto the screen. Any participant
that reported watching less than 80% of the video clip and/or was unable to correctly
identify the letter on the screen was not included in the final data analysis.

Immediately following each of the 120-second video clips, participants were
asked to complete the hypothetical sexual decision making task (with 22 new faces) and
the delay-discounting task again. Participants received a $20.00 Amazon gift card for completing both portions of the study. Figure 7 provides an overview of the procedures for the experimental online portion of the study. The specific items and directions for the Part 2 online survey are listed in Appendix C.

Figure 7: Procedure for Experimental Portion of the Online Study (Part 2)

3.3.4 Online Follow Up Surveys

Approximately six months after completing the experimental online study- part 2, participants were emailed a link to complete a 7-item follow up survey about their current
and recent (previous 3-6 months) sexual behaviors (e.g., number of vaginal sexual partners, average condom use, etc.). They were emailed again at the one-year baseline study completion mark for the final follow up survey. Participants received a $10.00 Amazon gift card for each follow up survey they completed. See Appendix D for specific items included in the follow up surveys.
4. Data Analyses

4.1 BOLD fMRI Data Acquisition and Preprocessing

Each participant was scanned using a research-dedicated GE MR750 3T scanner equipped with high-power high-duty-cycle 50-mT/m gradients at 200 T/m/s slew rate, and an eight-channel head coil for parallel imaging at high bandwidth up to 1MHz at the Duke-UNC Brain Imaging and Analysis Center. A semi-automated high-order shimming program was used to ensure global field homogeneity. A series of 34 interleaved axial functional slices aligned with the anterior commissure-posterior commissure (AC-PC) plane were acquired for full-brain coverage using an inverse-spiral pulse sequence to reduce susceptibility artifact (TR/TE/flip angle=2000 ms/30 ms/60; FOV=240 mm; 3.75×3.75×4 mm voxels; interslice skip=0). Four initial RF excitations were performed (and discarded) to achieve steady-state equilibrium. To allow for spatial registration of each participant’s data to a standard coordinate system, high-resolution three-dimensional structural images were acquired in 34 axial slices co-planar with the functional scans (TR/TE/flip angle=7.7 s/3.0 ms/12; voxel size=0.9×0.9×4 mm; FOV=240 mm, interslice skip=0).

Images for each participant were realigned to the first volume in the time series to correct for head motion, spatially normalized into a standard stereotactic space (Montreal Neurological Institute template) using a 12-parameter affine model (final resolution of functional images=2 mm isotropic voxels), and smoothed to minimize noise and residual difference in gyral anatomy with a Gaussian filter, set at 6-mm full-width at half-
maximum. Voxel-wise signal intensities were ratio normalized to the whole-brain global mean. Variability in single-subject whole-brain functional volumes was determined using the Artifact Recognition Toolbox (http://www.nitrc.org/projects/artifact_detect). Individual whole-brain BOLD fMRI volumes meeting at least one of two criteria were flagged and regressed out when determining task-specific effects: 1) significant mean-volume signal intensity variation (i.e., within volume mean signal greater or less than 4 standard deviations of mean signal of all volumes in time series), and 2) individual volumes where scan-to-scan movement exceeded 2 mm translation or 2° rotation in any direction.

4.2 BOLD fMRI Data Analysis

The general linear model of SPM8 (University College London, United Kingdom; http://www.fil.ion.ucl.ac.uk/spm) was used to conduct fMRI analyses. Individual contrast images from the amygdala and VS paradigms were used in second-level random effects models accounting for scan-to-scan and participant-to-participant variability to determine mean condition-specific regional responses using one-sample t-tests. The following amygdala and VS regions were included in analyses: Whole Amygdala (average of left and right activation), Left and Right Amygdala (Lamy & Ramy), Left and Right Central Medial Amygdala (LCM & RCM), Left and Right Lateral Basal Amygdala (LLB and RLB), Whole VS (average of left and right activation), and Left and Right VS (LVS & RVS). Linear contrasts employing canonical hemodynamic response functions were used to estimate differential effects of feedback (i.e., reward in the Ventral Striatum task;
general threat-related activity in the Amygdala task) from the contrasts of positive > negative feedback for VS and all faces > shapes for Amygdala nuclei. A combined statistical threshold of \( p<0.05 \), corrected across the amygdala and VS, and \( \geq 10 \) contiguous voxels was applied to the above contrasts. Our amygdala regions of interest were defined using the automatic anatomical labeling option in the Wake Forest University PickAtlas (Wake Forest University School of Medicine, Winston-Salem, NC). Our VS regions of interest were defined using a 10mm sphere centered around \( x=\pm 12 \), \( y=12 \), \( z=-10 \) (Nikolova & Hariri, 2012; Carré et al., 2013). In addition to producing the necessary values for our regression models, extracting parameter estimates from functional clusters activated by our paradigms rather than clusters specifically correlated with our dependent and independent variables of interest eliminates the possibility of any correlation coefficient inflation that may result when an explanatory covariate is used to select a region of interest (Viviani, 2010).

4.3 Sexual Decision Making Data: Calculating Outcome Scores

Decision making data points from the experimental online survey (e.g., pre-video and post-video attractiveness ratings and oral, vaginal, and condom use decisions) were averaged across individual items to create the following outcomes, based on subtracting the mean pre-video decisions from the mean post-video decisions (e.g., Oral Sex Decisions, Vaginal Sex Decisions, Attractiveness Ratings, and Condom Use Decisions. In addition, high-risk and low-risk decisions were also created based on the 22 high-risk faces in the SDMT and the 22 low-risk faces in the SDMT, such that there are three
difference scores (DS) for each outcome (e.g., high risk DS vaginal sex decisions, low risk DS vaginal sex decisions, etc.). Scores were coded from -3 to +3, such that -3 = greater desire on average to engage in vaginal/oral sex or to not use a condom post arousal manipulation and +3 = greater desire on average to abstain from vaginal/oral sex and greater desire to use a condom post arousal manipulation. Importantly, likelihood of engaging in vaginal or oral sex was measured using a likert scale such that higher numbers indicate a greater likelihood of engaging in vaginal or oral sex with a potential sexual partner. In contrast, condom use was measured using a likert scale such that higher numbers indicate lower risk behavior, or a greater likelihood of using a condom with a potential sexual partner. A score of 0 equals no change on average in decision making after the arousal manipulation. To facilitate interpretation of difference/change scores for both the SDMT and longitudinal analyses, see Table 2.

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>More Negative</th>
<th>More positive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attractiveness Decision Making</td>
<td>Less sexually attracted to potential partners post arousal manipulation</td>
<td>More sexually attracted to potential partners post arousal manipulation</td>
</tr>
<tr>
<td>Vaginal Sex Decision Making</td>
<td>Safer; decreased desire to engage in vaginal sex post arousal manipulation</td>
<td>Riskier; increased desire to engage in vaginal sex post arousal manipulation</td>
</tr>
<tr>
<td>Condom Use Decision Making</td>
<td>Riskier; decreased desire to use a condom post arousal manipulation</td>
<td>Safer; increased desire to use a condom post arousal manipulation</td>
</tr>
<tr>
<td>Change in Sexual Partners Over Time</td>
<td>N/A</td>
<td>Riskier; increase in sexual partners over time</td>
</tr>
<tr>
<td>Change in Condom Use Over Time</td>
<td>Riskier; decrease in condom use consistency during sexual behaviors</td>
<td>Safer; increase in condom use consistency during sexual behaviors</td>
</tr>
</tbody>
</table>
To minimize the number of statistical comparisons and because there were not significant differences in ratings of likelihood to engage in oral versus vaginal sex with potential partners (overall $t(92) = .69, p = .49$; comparing high risk only $t(92) = -.46, p = .64$; comparing low risk only $t(92) = -.88, p = .38$), only ratings of likelihood to engage in vaginal sex were included in analyses.

To determine if separate analyses should be conducted for sexual decisions made about low risk versus high risk partners, a series of paired sample t-tests were conducted. There were no significant differences in decision making between low and high-risk potential partners (attractiveness: $t(92) = -1.04, p = .30$ ($M$ low risk difference score = .02, $M$ high risk difference score = -.03; vaginal sex intent: $t(92) = -.28, p = .78$ ($M$ low risk difference score = .06, $M$ high risk difference score = .05; condom use intent: $t(92) = -.87, p = .39$ ($M$ low risk difference score = .01, $M$ high risk difference score = -.02).

Given these findings, only total difference scores (across high and low risk decisions) were included in analyses of decisions regarding attractiveness, vaginal sex intent, and condom use intent.

Since 28% ($n = 34$) of the participants in our study were sexually inexperienced, we conducted independent sample t-tests to determine if sexual experience significantly altered sexual decision-making in the task. There were no significant differences in decision making pre and post video manipulation between the sexually experienced and inexperienced participants (Attractiveness DS: $t(91) = -.85, p = .40$; Vaginal sex: $t(91) =$
-.03, $p = .97$; Condom use: $t(91) = -.75, p = .46)$. See Table 3 for descriptive statistics regarding decision-making outcome variables used for the regression analyses.

**Table 3: Descriptive Statistics for Sexual Decision Making Data Points**

<table>
<thead>
<tr>
<th>Sexual Decision Making Task (n = 93)</th>
<th>Min</th>
<th>Max</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Difference Score in Attractiveness Decisions</td>
<td>-0.55</td>
<td>0.55</td>
<td>0.00</td>
<td>0.24</td>
</tr>
<tr>
<td>Difference Score in Vaginal Sex Decisions</td>
<td>-0.60</td>
<td>0.82</td>
<td>0.06</td>
<td>0.28</td>
</tr>
<tr>
<td>Difference Score in Condom Use Decisions</td>
<td>-0.73</td>
<td>0.68</td>
<td>-0.02</td>
<td>0.20</td>
</tr>
</tbody>
</table>

*Note. Difference score = Decisions made post arousal manipulation minus decisions made pre arousal manipulation*

**4.3.1. Calculating Changes in Self-Reported Sexual Arousal**

Participants were asked at the beginning of the online survey and after watching each of the sexually explicit audio-video clips to rate their level of sexual arousal using a 5-point likert scale where 1 = not at all and 5 = very much. Change in self-reported sexual arousal after exposure to the video clips was computed by subtracting each participant’s baseline sexual arousal rating from his or her sexual arousal rating post video-clip exposure. Importantly, the post-sexual arousal rating was computed by averaging each of the participant’s sexual arousal ratings following exposure to the two video clips. Therefore, a score of 0 equals no change in sexual arousal following exposure to the video clips, while a negative score indicates a decrease in sexual arousal and a positive score indicates an increase in sexual arousal. The mean sexual arousal rating at baseline was 1.49 ($SD = .83$) and the mean sexual arousal post the arousal manipulation was 3.22 ($SD = 1.16$). The mean change in sexual arousal rating was 1.65 ($SD = 1.15$).
Sixty-four percent \((n = 74)\) of participants reported having ever watched pornographic videos. Of those, most \((81\%)\) reported watching pornography 1-3 times a month. Women were significantly more likely to have never watched pornography \((\chi^2 (2, 120) = 16.88, p < .001)\). Men reported watching pornography more frequently than women \((\text{men: } M = 4.18 (SD = 1.00), \text{women: } M = 2.41 (SD = 1.30),\) where 1 = not in the past month and 6 = everyday in the past month).

Given that 37\% of our sample reported having never watched pornography, we conducted a 2 (Decision Making Pre-Arousal, Decision Making Post-Arousal) x 2 (Ever Watched Pornography: Yes, No) repeated measures ANOVA to determine if these individuals made significantly different choices in the sexual decision making task post arousal. There were no significant differences in post arousal sexual decision making based on history of having ever watched pornography \((\text{Attractiveness DS: } F(1, 92) = .15, p = .70; \text{Vaginal sex: } F(1, 92) = 2.94, p = .09; \text{Condom use: } F(1, 92) = .15, p = .70)\). There were also no significant differences between individuals reporting a history of having ever watched pornography and individuals that have not in self-reported ratings of sexual arousal at baseline \((t (91) = -1.28, p = .21)\), immediately following exposure to the video clips \((t (91) = -1.86, p = .07)\), or in change scores of sexual arousal \((t (91) = -1.27, p = .18)\).

### 4.4 Self-Report Sexual Behavior

It is notoriously difficult to best quantify sexual risk and the field remains divided on what measures best reflect risk for contracting STIs and unplanned pregnancies.
(Catania et al., 2005; Schroder, Carey, & Vanable, 2003). Following recommendations by Catania et al. (2005), the present study examined four independent risk variables separately, rather than trying to use a summary indicator. The specific behaviors targeted (baseline and follow up number of sexual partners and condom use) have been well utilized in the sexual risk-taking literature as indicators of behavior associated with STIs and unplanned pregnancies (Bancroft et al., 2004). The individual difference analyses were limited by the samples’ behavioral profile, such that while the majority of participants reported having engaged in oral and vaginal sex at least once, sexual risk behaviors and negative sexual health outcomes in the sample in general were low. Only three participants (3%) reported a history of an unplanned pregnancy (occurring at ages 17, 21, and 22) and only 4 participants (3.3%) reported having contracted an STI (including Chlamydia, HPV, and trichomoniasis).

Follow up sexual behavior data was collected from 70 participants. Follow up change scores were created based on the difference between participants’ reports of vaginal sexual partners and condom use at the latest follow up minus their baseline report of sexual partners and average condom use. Participants completed an average of 1.48 follow up assessments and the average time between baseline and the last follow up measure was 11.08 months ($SD = 6.5$ months). A score of 0 equals no new partners or no change in condom use during the longitudinal data collection period. A negative number (e.g., -1 to -3) indicates a decrease in condom use consistency over time, while a positive
number (+1 to +3) indicates an increase in condom use consistency over time. See Table 4 for descriptive statistics regarding sexual behavior included in analyses.

Table 4: Descriptive Statistics for Self-Report Sexual Behavior Outcome Variables

<table>
<thead>
<tr>
<th>Self-Report Sexual Behavior Outcome Variable (n = 120)</th>
<th>n</th>
<th>M</th>
<th>SD</th>
<th>Possible Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>At least one vaginal sexual partner</td>
<td>86</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lifetime vaginal partners</td>
<td>120</td>
<td>2.88</td>
<td>3.07</td>
<td>0 to 10</td>
</tr>
<tr>
<td>Average vaginal sex condom use</td>
<td>83</td>
<td>3.16</td>
<td>1.01</td>
<td>1 to 5</td>
</tr>
<tr>
<td>Change in vaginal partners over time</td>
<td>70</td>
<td>0.70</td>
<td>1.50</td>
<td>0 to 8</td>
</tr>
<tr>
<td>Change in vaginal condom use over time</td>
<td>42</td>
<td>0.50</td>
<td>1.40</td>
<td>-3 to 3</td>
</tr>
</tbody>
</table>

Note. These data points reflect changes after winsorizing outliers. Condom use is coded such that 1 = never, not on any occasions and 5 = always, on every occasion

4.5 Statistical Approach

Preliminary analyses were conducted to test for relations between demographics and those variables most relevant to the study aims (i.e., VS, amygdala, personality variables, sexual decision making and self-report variables). This was accomplished with chi-square tests, t-tests and/or ANOVAs. Bivariate correlations can be found in Table 5.
Hierarchical multiple regressions were conducted for all normally distributed outcome variables, including all the decision-making variables and the self-report condom use variables (at baseline and follow up). These analyses were conducted within IBM SPSS Statistics 20.00. For each outcome, models were constructed in steps. For instance, to test whether gender moderated the relationship between brain function and risky sexual decision making (Hypothesis 2), step 1 included main effects (amygdala and VS activity, gender), step 2 included all two-way interaction terms (amygdala x VS, VS x gender, amygdala x gender), and step 3 included all three-way interaction terms.
(amygdala x VS x gender). All continuous predictor variables were standardized prior to analyses to ease interpretation.

Baseline and follow up reports (i.e., change in) of number of vaginal sexual partners were distributed non-normally (skewness = 3.18, SE = 0.21, Kurtosis = 14.87, SE = 0.42, skewness = 3.47, SE = .28, Kurtosis = 13.94, SE = 0.55; respectively). We therefore tested our hypotheses regarding these variables using generalized linear modeling (GzLM) in SPSS 20.0. Interpretation of GzLM is similar to ordinary least squares regression models, although a test of overall model fit is used in place of an $F$ test. For all dependent variables, we specified the Poisson distribution, which is appropriate for count data (i.e., non-negative integers) with positive skew. Each outlier was transformed (winsorized) to equal the 97.5 percentile of the change in partners’ distribution (Tukey, 1962; Wilcox, 1994).

Age and mental health status (e.g., met criteria for a DSM-IV diagnosis) were included as control variables in all models predicting baseline and follow up self-report sexual behaviors to ensure that these factors did not confound the hypothesized relations. All continuous predictor variables were standardized prior to analyses to ease interpretation of regression results. Identical to the linear regressions, in each model, main effects were entered, then two-way and three-way interactions. Only effects surviving Bonferroni corrections for multiple comparisons were considered further (Specific Aim 1: $p < .01$; Specific Aim 2 and 3 for self-report data: $p < .006$; Specific Aim 2 and 3 for decision making data: $p < .007$). For all models, any significant
interactions were probed using the plotting methods of Aiken and West (1991), Dawson (2014), and Dawson and Richter (2006).
5. Results

5.1 Main Effects of fMRI tasks

As expected, our fMRI paradigms elicited robust threat-related amygdala and reward-related VS activity across the entire parent sample of 1,005 participants. See Figure 8 for statistical parametric maps from the DNS parent sample illustrating mean bilateral threat-related amygdala activity (top image; N=1005; x=-22, y=-6, z=-18, t=42.5, p<.000001, k=167) and mean bilateral reward-related VS activity (bottom image; N=1005; x=-12, y=8, z=-8, t=14.2, p<.000001, k=296). Activation clusters are overlaid onto a canonical structural brain image in the axial plane.
Figure 8: Statistical Parametric Maps Illustrating Mean Bilateral Threat-Related Amygdala Activity (Top image) and Mean Bilateral Reward-Related VS Activity (Bottom Image) in DNS Parent Sample (N = 1005)

Among our participants, there were no significant effects of gender, age, or race (comparing Caucasian, Asian American, African American, and Other groups) on VS or amygdala activity (see Table 6).
Table 6: Effects of Demographic Variables on Neural Activity

<table>
<thead>
<tr>
<th>Variable</th>
<th>Gender</th>
<th>Age</th>
<th>Race</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>t</td>
<td>df</td>
<td>p</td>
</tr>
<tr>
<td>LVS</td>
<td>118</td>
<td>0.79</td>
<td>0.43</td>
</tr>
<tr>
<td>RVS</td>
<td>118</td>
<td>1.26</td>
<td>0.21</td>
</tr>
<tr>
<td>LAmy</td>
<td>118</td>
<td>0.18</td>
<td>0.86</td>
</tr>
<tr>
<td>RAmy</td>
<td>118</td>
<td>-0.06</td>
<td>0.95</td>
</tr>
<tr>
<td>LCM</td>
<td>118</td>
<td>0.69</td>
<td>0.49</td>
</tr>
<tr>
<td>RCM</td>
<td>118</td>
<td>0.91</td>
<td>0.36</td>
</tr>
<tr>
<td>LLB</td>
<td>118</td>
<td>-1.67</td>
<td>0.09</td>
</tr>
<tr>
<td>RLB</td>
<td>118</td>
<td>-0.70</td>
<td>0.49</td>
</tr>
<tr>
<td>Whole Amygdala</td>
<td>118</td>
<td>1.50</td>
<td>0.14</td>
</tr>
<tr>
<td>Whole VS</td>
<td>118</td>
<td>-1.47</td>
<td>0.14</td>
</tr>
</tbody>
</table>

5.2 Gender and Racial Differences in Predictor and Outcome Variables

There were no gender differences in baseline number of vaginal sexual partners or in change in vaginal partners over time ($t$ (118) = .72, $p = .47$; $t$ (68) = .75, $p = .46$, respectively). There were also no gender differences in baseline or follow up condom use ($t$ (81) = -.37, $p = .71$; $t$ (40) = .56, $p = .58$, respectively). With regard to the personality variables, there were no gender differences in self-reported self-control ($t$ (118) = -1.58, $p = .12$). However, men reported significantly higher sexual sensation seeking scores ($t$ (118) = -3.03, $p = .003$; men $M = 30.02$, $SD = 7.74$, women $M = 25.20$, $SD = 8.83$) and lower impulsivity scores ($t$ (118) = 2.19, $p = .03$; men $M = 60.34$, $SD = 6.28$, women $M = 63.96$, $SD = 9.85$) compared to women. Across the decision making task, there were no significant gender differences in vaginal sex intent ($t$ (91) = -1.17, $p = .25$), attractiveness decision making ($t$ (91) = -0.01, $p = .99$), condom use decision making ($t$ (91) = .31, $p = .76$).

A 2 (pre-video sexual arousal, post-video sexual arousal (average of two separate ratings)) X 2 (men, women) repeated measures ANOVA was conducted to determine if
the video manipulation increased sexual arousal and whether there existed gender differences in this effect. As predicted, the video manipulation elicited a significant mean increase in sexual arousal from pre-video ratings ($F(1, 91) = 217.01, p < .001$). There was also a significant gender x sexual arousal interaction ($F(1, 91) = 9.02, p = .003$), such that men showed a significantly greater increase in self-reported sexual arousal post-video manipulation ($M = 3.71, SD = 1.11$) compared to women ($M = 2.79, SD = 1.09$) (See Figure 9).

![Figure 9](image.png)

**Figure 9: Gender Differences in Self-Reported Sexual Arousal to Video Manipulation**

There were no race-related differences in baseline number of vaginal sexual partners or in change in vaginal partners over time ($F(3, 116) = 2.59, p = .06; F(3, 66) = .49, p = .69$, respectively). There were also no race-related differences in baseline or follow up condom use ($F(3, 79) = .59, p = .62; F(3, 63) = .10, p = .96$, respectively). With regard to the personality variables, there were no significant differences in self-
reported impulsivity ($F(3, 115) = .26, p = .85$) or sensation seeking ($F(3, 116) = .51, p = .68$). However, there were significant differences in self-control ($F(3, 116) = 2.88, p = .039$). Caucasian participants reported significantly higher levels of self-control ($M = 44.47, SD = 7.75$) compared to Asian Americans ($M = 39.59, SD = 7.53$). Finally, there were no significant race-related differences on change in self-reported sexual arousal ($F(3, 89) = 2.15, p = .10$), or any of the decision-making task outcomes (attractiveness decision making: $F(3, 89) = .47, p = .70$; vaginal sex decision making: $F(3, 89) = 1.22, p = .31$; condom use decision making: $F(3, 89) = 2.18, p = .08$).

5.3 Relationship Between Amygdala and VS Activity to Sexual Decision Making and Self-Reported Risk Behavior

5.3.1 Sexual Decision Making Data

Across the decision-making outcome variables (attractiveness ratings, vaginal sex intent, and condom use intent), only the main effect of right VS was significant and survived Bonferroni corrections in all models predicting vaginal sex decision-making. Inconsistent with our hypotheses, participants with higher reward-related right VS activity rated potential sexual partners as less sexually attractive following the arousal manipulation (unstandardized regression coefficients across all models including amygdala nuclei, $b = -.02, SE = .01, t(89)$ range = -3.23 to -2.82, $p$ range = .001-.006).

5.3.2 Self-Reported Risk Behavior

Both covariates (age and DSM-IV diagnosis) were the only significant factors to survive Bonferroni corrections in all models predicting the relationship between brain
function (VS and amygdala data points) and baseline number of sexual partners (For Age: $N = 120$, $b$ in all models = .17, $SE$ $b$ in all models = .03, Wald $\chi^2$ range across models = 24.60-27.04, $p$ all models < .001; For Mental Health Status: $N = 120$, $b$ across models = -.40 to -.43, $SE$ $b$ in all models = .13, Wald $\chi^2$ range across models = 8.93-10.54, $p$ all models = .03 to <.001). Older participants and participants meeting criteria for a DSM-IV diagnosis reported significantly greater sexual partners at baseline. In addition, three interactions were significantly related to baseline number of sexual partners and survived Bonferroni corrections: LCM x RVS (Wald $\chi^2$ (5, $N=120$) = 49.51, $p$ <.001), RCM x LVS (Wald $\chi^2$ (5, $N=120$) = 49.51, $p$ <.001), and RLB x RVS (Wald $\chi^2$ (5, $N=120$) = 49.99, $p$ <.001) (See Table 7).
Table 7: Poisson Regression Results of Significant Two-Way Interactions Associated with Baseline Vaginal Partners

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>SE B</th>
<th>Wald</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSM-IV Diagnosis</td>
<td>-0.43</td>
<td>0.13</td>
<td>10.54**</td>
</tr>
<tr>
<td>Age</td>
<td>0.17</td>
<td>0.03</td>
<td>26.18***</td>
</tr>
<tr>
<td>RVS</td>
<td>-0.01</td>
<td>0.01</td>
<td>1.09</td>
</tr>
<tr>
<td>LCM</td>
<td>0.02</td>
<td>0.01</td>
<td>1.40</td>
</tr>
<tr>
<td>RVS x LCM</td>
<td>0.01</td>
<td>0.00</td>
<td>8.08**</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>SE B</th>
<th>Wald</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSM-IV Diagnosis</td>
<td>-0.35</td>
<td>0.13</td>
<td>6.82**</td>
</tr>
<tr>
<td>Age</td>
<td>0.17</td>
<td>0.03</td>
<td>25.66***</td>
</tr>
<tr>
<td>LVS</td>
<td>0.03</td>
<td>0.01</td>
<td>4.33</td>
</tr>
<tr>
<td>RCM</td>
<td>0.01</td>
<td>0.01</td>
<td>0.47</td>
</tr>
<tr>
<td>LVS x RCM</td>
<td>-0.01</td>
<td>0.00</td>
<td>8.50**</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>SE B</th>
<th>Wald</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSM-IV Diagnosis</td>
<td>-0.3</td>
<td>0.14</td>
<td>4.65*</td>
</tr>
<tr>
<td>Age</td>
<td>0.17</td>
<td>0.03</td>
<td>27.04***</td>
</tr>
<tr>
<td>RVS</td>
<td>0</td>
<td>0.01</td>
<td>0.06</td>
</tr>
<tr>
<td>RLB</td>
<td>-0.01</td>
<td>0.02</td>
<td>0.13</td>
</tr>
<tr>
<td>RVS x RLB</td>
<td>-0.01</td>
<td>0.00</td>
<td>9.40**</td>
</tr>
</tbody>
</table>

*p < .05, **p < .01, ***p < .001

To interpret these interactions, we calculated simple regression slopes between amygdala and VS data points by estimating scores one standard deviation above the mean (e.g., high/heightened activity) and one standard deviation below the mean (e.g., low/decreased activity). The RCM x LVS and RLB x RVS interactions were partially consistent with our hypotheses, in so much that participants with high threat-related RCM/RLB and low reward-related LVS/RVS reported significantly greater baseline sexual partners compared to participants high in both RCM and LVS activity or low in
both RCM and LVS activity. However, the simple slopes for the opposite neural risk phenotypes (i.e., high VS + low amygdala) were not significantly different from zero and therefore were not significantly associated with greater baseline sexual partners. See Figures 10 and 11 for graphical representation of two-way interactions where high reactivity=1 SD above the mean; low reactivity=1 SD below the mean (plotted values are adjusted for age and mental health status). Also see Figures 10 and 11 for statistical parametric maps from the DNS parent sample illustrating threat-related RLB amygdala activity (N=1005; x=26, y=-6 z=-20, t=47.1, p<.000001, k.=218), threat-related RCM amygdala activity (N=1005; x=28, y=-12 z=-12, t=29.9, p<.000001, k.=61), and reward-related RVS activity (N=1005; x=12, y=10, z=-8, t=13.3, p<.000001, k.=239) and LVS activity (N=1005; x=-12, y=8, z=-8, t=14.2, p<.000001, k.=296). Activation clusters are overlaid onto a canonical structural brain image in the axial plane.
The opposite pattern was observed in the significant LCM x RVS interaction, such that participants high in both reward-related RVS and threat-related LCM or low in
both RVS and LCM reported significantly greater baseline sexual partners compared to participants with low/high and high/low neural phenotypes. See Figure 12 for statistical parametric map from the DNS parent sample illustrating threat-related LCM amygdala activity (N=1005; x=-24, y=-10 z=-14, t=30.9, p<.000001, k,E=45) and reward-related RVS activity (N=1005; x=12, y=10, z=-8, t=13.3, p<.000001, k,E=239). Activation clusters are overlaid onto a canonical structural brain image in the axial plane. Below the canonical structural brain image is the two-way interaction where high reactivity=1 SD above the mean; low reactivity=1 SD below the mean (plotted values are adjusted for age and mental health status).

![Figure 12: LCM x RVS Interaction Predicting Baseline Number of Partners](image)

For longitudinal analyses (i.e., change in number of partners over time), greater threat-related right lateral basal amygdala (RLB) activity was significantly associated
with greater increases in sexual partners over time (Wald $\chi^2(5, N=70)=22.20, p<.001, b=.19$, Wald $\chi^2=14.53, p<.001$ in RLB x LVS model; Wald $\chi^2(5, N=70)=18.98, p<.001 b=.19$, Wald $\chi^2=13.49, p<.001$ in RLB x RVS model).

No predictors were significantly associated with baseline condom use. For longitudinal analyses of condom use (i.e., change in condom use over time), only the covariate age survived Bonferroni corrections ($N = 42, b$ range = -.51 to -.61, $SE b$ range=.15 to .16, $p$ range .002 to < .001). Older participants at baseline used condoms more frequently on average over time compared to younger participants. A summary of all significant findings for Specific Aim 1 are listed in Table 8.
Table 8: Summary of Specific Aim 1 Findings

<table>
<thead>
<tr>
<th>Summary of Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Specific Aim 1</strong></td>
</tr>
<tr>
<td>Do risk-related neural phenotypes predict sexual risk behavior/decision-making?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DV</th>
<th>Findings</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline Vaginal Partners</td>
<td>Age &amp; DSM-Diagnosis (main effects) for whole amygdala and VS as well as specific amygdala nuclei with left and right VS</td>
<td>Older subs and subs with a mental health diagnosis = greater baseline partners</td>
</tr>
<tr>
<td></td>
<td>RLB x RVS</td>
<td>High RLB/low RVS and opposite pattern = greater baseline partners</td>
</tr>
<tr>
<td></td>
<td>RCM x LVS</td>
<td>High RCM/low LVS and opposite pattern = greater baseline partners</td>
</tr>
<tr>
<td></td>
<td>LCM x RVS</td>
<td>High on both or low on both = greater baseline partners</td>
</tr>
<tr>
<td>Change in Vaginal Partners (Longitudinal Analyses)</td>
<td>RLB (across all models)</td>
<td>Higher RLB activity = greater increases in partners over time</td>
</tr>
<tr>
<td>Vaginal Sex Decision Making (SDMT)</td>
<td>RVS (across all models)</td>
<td>Higher RVS = less desire to engage in vaginal sex post arousal manipulation</td>
</tr>
</tbody>
</table>

*Note.* SDMT = Sexual Decision Making Task; unless noted with SDMT the variable is self-report risk behavior

### 5.4 Gender as a Moderator

#### 5.4.1 Sexual Decision Making Data

Across the decision-making outcome variables (attractiveness ratings, vaginal sex intent, and condom use intent), no predictors were significant and survived Bonferroni corrections.
5.4.2 Self-Reported Risk Behavior

Gender (as a main effect or moderator) did not survive Bonferroni corrections in models including self-reported baseline condom use, change in condom use over time, or change in sexual partners over time. However, the two-way interaction of Gender x RVS was significant in the model including RLB for baseline sexual partners \( (b = .12, SE = .04, \text{Wald } \chi^2 = 9.03, p = .003) \), such that women with relatively (1 SD below the mean) low reward-related RVS activity reported significantly greater sexual partners at baseline (Wald \( \chi^2(9, N=120)=64.60, p<.001 \)). See Figure 13 for both graphical representation of RVS x Gender interaction predicting baseline sexual partners as well as statistical parametric map (activation clusters overlaid on canonical structure brain image in the axial plane) from the DNS parent sample illustrating reward-related RVS activity (N=1005; x=12, y=10, z=−8, \( t=13.3 \), \( p<.000001 \), k=239; high reactivity=1 SD above the mean; low reactivity=1 SD below the mean (plotted values are adjusted for age and mental health status).
When conducting whole amygdala x whole VS x gender analyses, the two-way interaction Gender x VS was significant (although not meeting Bonferroni corrections) (Wald $\chi^2(9, N=120)=51.97, p<.001; b = .10, SE = .04$, Wald $\chi^2 = 6.13, p = .01$). Again, women with relatively decreased reward-related VS activity reported significantly greater sexual partners at baseline; however in this interaction, men with relatively high VS activity also reported significantly greater increases in partners at baseline. See Figure 14 for both the graphical representation of the VS x Gender interaction predicting baseline sexual partners as well as the statistical parametric map (activation clusters overlaid on canonical structure brain image in the axial plane) from the DNS parent sample illustrating reward-related VS activity ($N=1005; x=12, y=10, z=-8, t=13.3, p<.000001$, $k=239$; high reactivity=1 $SD$ above the mean; low reactivity=1 $SD$ below the mean)
(plotted values are adjusted for age and mental health status). A summary of all significant findings for Specific Aim 2 (Gender as a Moderator) are presented in Table 9.

Figure 14: VS x Gender Interaction Predicting Baseline Number of Sexual Partners

Table 9: Summary of Specific Aim 2 Findings: Gender as a Moderator

<table>
<thead>
<tr>
<th>Summary of Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Specific Aim 2: Gender</strong></td>
</tr>
</tbody>
</table>
| *Does gender moderate the relationship between neural phenotypes and sexual risk behavior/decision-making?*

<table>
<thead>
<tr>
<th>DV</th>
<th>Findings</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline Vaginal Partners</td>
<td>For whole amygdala and VS: Gender x VS ($p = .01$)</td>
<td>Men high in VS, but women low in VS = greater baseline partners</td>
</tr>
<tr>
<td>Baseline Vaginal Partners</td>
<td>Gender x RVS (w/in RLB x RVS x gender model)</td>
<td>Women low in RVS = greater baseline partners</td>
</tr>
</tbody>
</table>

*Note.* SDMT = Sexual Decision Making Task; unless noted with SDMT the variable is self-report risk behavior
5.5 Sexual Arousal as a Moderator

5.5.1 Sexual Decision Making Data

Across the decision-making outcome variables (attractiveness ratings, vaginal sex intent, and condom use intent), no predictors were significant and survived Bonferroni corrections.

5.5.2 Self-Reported Risk Behavior

Arousal (as a main effect or moderator) did not survive Bonferroni corrections in models including self-reported baseline condom use or change in condom use over time. However, the three-way interaction (Amygdala x VS x Gender) in whole amygdala and VS regression analyses was significantly associated with both baseline (Wald $\chi^2(9, N=120)=49.31, p<.001$) and change in sexual partners over time (Wald $\chi^2(9, N=70)=28.78, p<.001$) (See Table 10).

To interpret the significant three-way interactions, the two-way interactions were examined by participants above and below the median in arousal (e.g., self-reported sexual arousal post video manipulation in the sexual decision making task minus baseline self-reported arousal ratings pre-video manipulation). For participants high in arousal, those with relatively high (1 $SD$ above the mean) VS and amygdala indicated greater baseline partners, as well as significantly greater sexual partners over time. In contrast, for participants low in arousal, those with relatively high amygdala and relatively low (1 $SD$ below the mean) VS and the opposite neural phenotype (low amygdala and high VS) reported greater baseline partners. In the change in sexual partners model, however,
participants low in arousal had no significant main effects or interactions of brain function associated with sexual risk behavior. See Figure 15 for graphical representation of the VS x Amygdala interaction for high arousal participants predicting baseline sexual partners (note: a similar pattern is represented by the VS x Amygdala interaction for participants high in arousal predicting change in number of sexual partners over time). See Figure 16 for graphical representation of the VS x Amygdala interaction for low arousal participants predicting baseline sexual partners. Figure 15 and 16 also shows a statistical parametric map (activation clusters overlaid on canonical structure brain image in the axial plane) from the DNS parent sample illustrating mean bilateral threat-related amygdala activity (N=1005; x=-22, y=-6 z=-18, t=42.5, p<.000001, k=167) and mean bilateral reward-related VS activity (N=1005; x=-12, y=8, z=-8, t=14.2, p<.000001, k=296); high reactivity=1 SD above the mean; low reactivity=1 SD below the mean (plotted values are adjusted for age and mental health status).

When examining models including specific amygdala nuclei and right and left VS, the three-way interaction Lamy x RVS x Arousal was significantly associated with both baseline number of sexual partners (Wald $\chi^2(9, N=120)=23.29, p<.001$) and change in sexual partners over time (Wald $\chi^2(9, N=70)=22.00, p<.001$), although these interactions did not survive Bonferroni corrections ($p = .04$ and .03, respectively) (See Table 11). The results revealed consistent findings with the whole amygdala and VS interactions, such that participants high in arousal with high RVS and high Lamy reported
the greatest number of baseline partners and reported significantly greater increases in sexual partners over time.

The main effect of RLB remained significant for longitudinal analyses (i.e., change in number of partners over time), such that greater threat-related RLB activity was significantly associated with reports of increased sexual partners over time (Wald $\chi^2(9, N=70)=24.76, p<.001$, $b=.40$, Wald $\chi^2 = 11.25, p = .001$ in RLB x RVS x Arousal model; Wald $\chi^2(9, N=70)=21.00, p<.001$ $b=.23$, Wald $\chi^2 = 10.24, p = .001$ in RLB x LVS x Arousal model). A summary of all significant findings for Specific Aim 2 (Arousal as a Moderator) are presented in Table 12.
Table 10: Poisson Regression Results of Significant Three-Way Interactions for Whole Amygdala and VS (Arousal as a Moderator)

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>SE B</th>
<th>Wald</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSM-IV Diagnosis</td>
<td>-0.17</td>
<td>0.17</td>
<td>1.01</td>
</tr>
<tr>
<td>Age</td>
<td>0.17</td>
<td>0.04</td>
<td>21.99***</td>
</tr>
<tr>
<td>VS</td>
<td>0.01</td>
<td>0.02</td>
<td>0.42</td>
</tr>
<tr>
<td>Amygdala</td>
<td>0.1</td>
<td>0.04</td>
<td>4.76*</td>
</tr>
<tr>
<td>Arousal</td>
<td>-0.02</td>
<td>0.06</td>
<td>0.52</td>
</tr>
<tr>
<td>VS x Amygdala</td>
<td>-0.02</td>
<td>0.02</td>
<td>1.39</td>
</tr>
<tr>
<td>VS x Arousal</td>
<td>-0.02</td>
<td>0.02</td>
<td>0.61</td>
</tr>
<tr>
<td>Amygdala x Arousal</td>
<td>0.09</td>
<td>0.05</td>
<td>2.87</td>
</tr>
<tr>
<td>VS x Amygdala x Arousal</td>
<td>0.06</td>
<td>0.02</td>
<td>12.25***</td>
</tr>
</tbody>
</table>

**Baseline Number of Sexual Partners**

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>SE B</th>
<th>Wald</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSM-IV Diagnosis</td>
<td>-0.87</td>
<td>0.57</td>
<td>2.32</td>
</tr>
<tr>
<td>Age</td>
<td>-0.35</td>
<td>0.19</td>
<td>3.33</td>
</tr>
<tr>
<td>VS</td>
<td>0.20</td>
<td>0.07</td>
<td>6.47*</td>
</tr>
<tr>
<td>Amygdala</td>
<td>0.26</td>
<td>0.11</td>
<td>5.35*</td>
</tr>
<tr>
<td>Arousal</td>
<td>0.18</td>
<td>0.19</td>
<td>0.86</td>
</tr>
<tr>
<td>VS x Amygdala</td>
<td>0.12</td>
<td>0.05</td>
<td>6.66*</td>
</tr>
<tr>
<td>VS x Arousal</td>
<td>0.24</td>
<td>0.09</td>
<td>7.69**</td>
</tr>
<tr>
<td>Amygdala x Arousal</td>
<td>0.31</td>
<td>0.15</td>
<td>4.49*</td>
</tr>
<tr>
<td>VS x Amygdala x Arousal</td>
<td>0.31</td>
<td>0.1</td>
<td>10.23***</td>
</tr>
</tbody>
</table>

**Change in Number of Sexual Partners**

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>SE B</th>
<th>Wald</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSM-IV Diagnosis</td>
<td>-0.87</td>
<td>0.57</td>
<td>2.32</td>
</tr>
<tr>
<td>Age</td>
<td>-0.35</td>
<td>0.19</td>
<td>3.33</td>
</tr>
<tr>
<td>VS</td>
<td>0.20</td>
<td>0.07</td>
<td>6.47*</td>
</tr>
<tr>
<td>Amygdala</td>
<td>0.26</td>
<td>0.11</td>
<td>5.35*</td>
</tr>
<tr>
<td>Arousal</td>
<td>0.18</td>
<td>0.19</td>
<td>0.86</td>
</tr>
<tr>
<td>VS x Amygdala</td>
<td>0.12</td>
<td>0.05</td>
<td>6.66*</td>
</tr>
<tr>
<td>VS x Arousal</td>
<td>0.24</td>
<td>0.09</td>
<td>7.69**</td>
</tr>
<tr>
<td>Amygdala x Arousal</td>
<td>0.31</td>
<td>0.15</td>
<td>4.49*</td>
</tr>
<tr>
<td>VS x Amygdala x Arousal</td>
<td>0.31</td>
<td>0.1</td>
<td>10.23***</td>
</tr>
</tbody>
</table>

* p < .05, ** p < .01, *** p < .001
Table 11: Poisson Regression Results of Significant Three-Way Interactions for Lamy x RVS (Arousal as a Moderator)

**Baseline Number of Sexual Partners**

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>SE B</th>
<th>Wald</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSM-IV Diagnosis</td>
<td>-0.19</td>
<td>0.17</td>
<td>1.31</td>
</tr>
<tr>
<td>Age</td>
<td>0.18</td>
<td>0.04</td>
<td>23.29***</td>
</tr>
<tr>
<td>RVS</td>
<td>-0.03</td>
<td>0.02</td>
<td>1.97</td>
</tr>
<tr>
<td>Lamy</td>
<td>0.04</td>
<td>0.03</td>
<td>1.60</td>
</tr>
<tr>
<td>Arousal</td>
<td>0</td>
<td>0.06</td>
<td>0</td>
</tr>
<tr>
<td>RVS x Lamy</td>
<td>0.02</td>
<td>0.01</td>
<td>4.75*</td>
</tr>
<tr>
<td>RVS x Arousal</td>
<td>-0.03</td>
<td>0.02</td>
<td>3.84</td>
</tr>
<tr>
<td>Lamy x Arousal</td>
<td>0.05</td>
<td>0.04</td>
<td>1.89</td>
</tr>
<tr>
<td>Lamy x RVS x Arousal</td>
<td>0.02</td>
<td>0.01</td>
<td>3.96*</td>
</tr>
</tbody>
</table>

**Change in Number of Sexual Partners**

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>SE B</th>
<th>Wald</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSM-IV Diagnosis</td>
<td>-0.97</td>
<td>0.6</td>
<td>2.63</td>
</tr>
<tr>
<td>Age</td>
<td>-0.53</td>
<td>0.2</td>
<td>6.68*</td>
</tr>
<tr>
<td>RVS</td>
<td>0.42</td>
<td>0.17</td>
<td>6.12*</td>
</tr>
<tr>
<td>Lamy</td>
<td>0.18</td>
<td>0.12</td>
<td>2.40</td>
</tr>
<tr>
<td>Arousal</td>
<td>0.17</td>
<td>0.19</td>
<td>0.81</td>
</tr>
<tr>
<td>RVS x Lamy</td>
<td>0.43</td>
<td>0.23</td>
<td>3.55</td>
</tr>
<tr>
<td>RVS x Arousal</td>
<td>0.57</td>
<td>0.25</td>
<td>5.31*</td>
</tr>
<tr>
<td>Lamy x Arousal</td>
<td>0.37</td>
<td>0.19</td>
<td>3.84</td>
</tr>
<tr>
<td>Lamy x RVS x Arousal</td>
<td>0.75</td>
<td>0.36</td>
<td>4.40*</td>
</tr>
</tbody>
</table>

*p < .05, **p < .01, ***p < .001
Figure 15: VS x Amygdala Interaction Predicting Baseline Number of Sexual Partners (High Arousal Participants Only)

Figure 16: VS x Amygdala Interaction Predicting Baseline Number of Sexual Partners (Low Arousal Participants Only)
Table 12: Summary of Specific Aim 2 Findings: Arousal as a Moderator

<table>
<thead>
<tr>
<th>Summary of Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Specific Aim 2: Sexual Arousal</strong></td>
</tr>
<tr>
<td><strong>Does sexual arousal moderate the relationship between neural phenotypes and sexual risk behavior/decision-making?</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DV</th>
<th>Findings</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline Vaginal Partners</td>
<td>Lamy x RVS x arousal</td>
<td>High RVS + High Lamy + High Arousal = greater baseline partners</td>
</tr>
<tr>
<td>For whole amygdala and VS:</td>
<td>Amy x VS x arousal</td>
<td>Among participants high in arousal: High VS + High Amy = greater baseline partners; Among participants low in arousal: High Amy + Low VS and Low Amy + High VS = greater baseline partners</td>
</tr>
<tr>
<td>Change in Vaginal Partners (Longitudinal Analyses)</td>
<td>Lamy x LVS &amp; RVS x Arousal ( p = .03, .04 )</td>
<td>Among participants high in arousal: High VS + High Amy = greatest change in partners over time; for those low in arousal no factors are associated with change in partners</td>
</tr>
<tr>
<td>RLB (w/in RLB x LVS/RVS x Arousal)</td>
<td>Higher RLB = greater increase in partners over time</td>
<td></td>
</tr>
<tr>
<td>For whole amygdala and VS:</td>
<td>Amy x VS x arousal</td>
<td>Among participants high in arousal: High VS + High Amy = greatest change in partners over time; for those low in arousal no factors are associated with change in partners</td>
</tr>
</tbody>
</table>

*Note. SDMT = Sexual Decision Making Task; unless noted with SDMT the variable is self-report risk behavior*
5.6 Sexual Sensation Seeking as a Moderator

5.6.1 Sexual Decision Making Data

Across the decision-making outcome variables (attractiveness ratings, vaginal sex intent, and condom use intent), no predictors were significant and survived Bonferroni corrections.

5.6.2 Self-Reported Risk Behavior

Sensation seeking was the only factor to survive Bonferroni corrections in all models predicting the relationship between brain function (all VS and amygdala data points) and baseline number of sexual partners ($N = 120$, $b$ in all models $= .06$, $SE b$ in all models $= .01$, Wald $\chi^2$ range across models $= 62.98 - 77.79$, $p$ all models $< .001$), such that participants with higher sensation seeking total scores reported significantly greater baseline partners (see Figure 17). In addition to the main effect of sensation seeking, the two-way interaction of whole Amygdala x Sensation Seeking (within the whole amygdala x whole VS x sensation seeking model) was significantly associated with baseline number of sexual partners (Wald $\chi^2 (9, N=120) = 125.91$, $p < .001$). Participants high (1 $SD$ above the mean) in both threat-related amygdala activity and sensation seeking reported significantly greater baseline sexual partners ($b = .01$, $SE b = .01$, Wald $\chi^2 = 7.76$, $p = .005$). Sensation seeking (as a main effect or moderator) did not survive Bonferroni corrections in models including self-reported baseline condom use or change in condom use over time.
For longitudinal analyses, the three-way interaction of whole Amygdala x whole VS x Sensation Seeking was significantly associated with change in sexual partners over time (Wald $\chi^2(9, N=70)=22.76, p<.001$). To interpret the interaction, the amygdala x VS two-way interactions were probed separately by participants above and below the median in sensation seeking total score. For participants high in sensation seeking, those with relatively high (1 SD above the mean) threat-related amygdala activity and relatively low (1 SD below the mean) reward-related VS activity reported significantly greater sexual...
partners over time. In contrast, for participants low in sensation seeking, neither VS nor amygdala activity (or the interaction of the two) were significantly associated with change in sexual partners over time. See Figure 18 for graphical representation of the VS x Amygdala interaction for high sensation seeking participants predicting change in sexual partners over time. Figure 18 also shows a statistical parametric map (activation clusters overlaid on canonical structure brain image in the axial plane) from the DNS parent sample illustrating mean bilateral threat-related amygdala activity (N=1005; x=-22, y=-6, z=-18, t=42.5, p<.000001, k=167) and mean bilateral reward-related VS activity (N=1005; x=-12, y=8, z=-8, t=14.2, p<.000001, k=296); high reactivity=1 SD above the mean; low reactivity=1 SD below the mean (plotted values are adjusted for age and mental health status).

![Figure 18: VS x Amygdala Predicting Change in Sexual Partners Over Time (Participants High in Sensation Seeking Only)](image)
A summary of all significant findings for Specific Aim 2 (Sensation Seeking as a Moderator) are presented in Table 13.

Table 13: Summary of Specific Aim 2 Findings: Sensation Seeking as a Moderator

<table>
<thead>
<tr>
<th>DV</th>
<th>Findings</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline Vaginal Partners</td>
<td>Sensation Seeking (Main Effect across all models of whole amygdala &amp; VS and specific amygdala nuclei &amp; left and right VS)</td>
<td>Higher Sensation Seeking = greater baseline partners</td>
</tr>
<tr>
<td>Change in Vaginal Partners (Longitudinal Analyses)</td>
<td>For whole amygdala and VS: Amygdala x Sensation Seeking</td>
<td>High Sensation Seeking + High Amygdala = greater baseline partners</td>
</tr>
<tr>
<td>Change in Vaginal Partners (Longitudinal Analyses)</td>
<td>For whole amygdala and VS: VS x Amygdala x Sensation Seeking</td>
<td>No factors associated with DV among low sensation seekers; among high sensation seekers: high Amy + low VS = greater change in partners over time</td>
</tr>
</tbody>
</table>

Note. SDMT = Sexual Decision Making Task; unless noted with SDMT the variable is self-report risk behavior.

5.7 Self Control as a Moderator

5.7.1 Sexual Decision Making Data

Across the decision-making outcome variables (attractiveness ratings, vaginal sex intent, and condom use intent), only the main effect of right VS survived Bonferroni corrections in all models predicting vaginal sex decision-making (unstandardized regression coefficients across all models including specific amygdala nuclei and right VS.
$b$ range = -.02 to -.03, $SE = .01$, Wald $\chi^2$ range = -3.31 to -3.23, $p$ range = .001-.005).

Inconsistent with our hypotheses, participants with higher reward-related right VS activity rated potential sexual partners as *less sexually attractive* following the arousal manipulation.

### 5.7.2 Self-Reported Risk Behavior

No effects survived Bonferroni in whole Amygdala and whole VS models with self-control; however, the two-way interaction LVS x Self Control was significantly associated with baseline number of sexual partners in LCM and Ramy models (although did not survive Bonferroni corrections; Wald $\chi^2(9, N=120)=56.44, p<.001$, LCM model; Wald $\chi^2(9, N=120)=54.79, p<.001$, Ramy model) (See Table 14). Participants relatively (1 SD above the mean) high in LVS and relatively low (1 SD below the mean) in self-control reported significantly greater sexual partners at baseline. See Figure 19 for graphical representation of the LVS x Self-Control interaction in the Ramy x LVS x Self Control model (note, this pattern of findings is consistent with the LCM x LVS x Self Control model). Figure 19 also shows a statistical parametric map (activation clusters overlaid on canonical structure brain image in the axial plane) from the DNS parent sample illustrating reward-related left VS activity (N=1005; $x=-12$, $y=8$, $z=-8$, $t=14.2$, $p<.000001$, $k=296$); high reactivity=1 SD above the mean; low reactivity=1 SD below the mean (plotted values are adjusted for age and mental health status). Self-control (as a main effect or moderator) did not survive Bonferroni corrections for models predicting self-reported baseline condom use.
Table 14: Poisson Regression Results of Significant Two-Way Interactions Predicting Baseline Number of Partners (Self Control as a Moderator)

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>SE B</th>
<th>Wald</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSM-IV Diagnosis</td>
<td>-0.25</td>
<td>0.14</td>
<td>3.12</td>
</tr>
<tr>
<td>Age</td>
<td>0.19</td>
<td>0.03</td>
<td>31.54***</td>
</tr>
<tr>
<td>LVS</td>
<td>0.03</td>
<td>0.01</td>
<td>4.09*</td>
</tr>
<tr>
<td>Ramy</td>
<td>0.01</td>
<td>0.02</td>
<td>0.18</td>
</tr>
<tr>
<td>Self Control</td>
<td>-0.02</td>
<td>0.01</td>
<td>4.50*</td>
</tr>
<tr>
<td>LVS x Ramy</td>
<td>-0.01</td>
<td>0.01</td>
<td>0.83</td>
</tr>
<tr>
<td>LVS x Self Control</td>
<td>0.00</td>
<td>0.00</td>
<td>4.80*</td>
</tr>
<tr>
<td>Ramy x Self Control</td>
<td>-0.01</td>
<td>0.00</td>
<td>2.59</td>
</tr>
<tr>
<td>Ramy x LVS x Self Control</td>
<td>0.00</td>
<td>0.00</td>
<td>3.36</td>
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</table>

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>SE B</th>
<th>Wald</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSM-IV Diagnosis</td>
<td>-0.29</td>
<td>0.14</td>
<td>4.22*</td>
</tr>
<tr>
<td>Age</td>
<td>0.20</td>
<td>0.04</td>
<td>31.01***</td>
</tr>
<tr>
<td>LVS</td>
<td>0.03</td>
<td>0.01</td>
<td>3.85</td>
</tr>
<tr>
<td>LCM</td>
<td>0.02</td>
<td>0.02</td>
<td>1.94</td>
</tr>
<tr>
<td>Self Control</td>
<td>-0.02</td>
<td>0.01</td>
<td>4.65*</td>
</tr>
<tr>
<td>LVS x LCM</td>
<td>0.01</td>
<td>0.00</td>
<td>2.13</td>
</tr>
<tr>
<td>LVS x Self Control</td>
<td>0</td>
<td>0</td>
<td>4.27*</td>
</tr>
<tr>
<td>LCM x Self Control</td>
<td>0</td>
<td>0</td>
<td>3.34</td>
</tr>
<tr>
<td>LCM x LVS x Self Control</td>
<td>0</td>
<td>0</td>
<td>0.26</td>
</tr>
</tbody>
</table>

*p < .05, **p < .01, *** p < .001
Figure 19: LVS x Self Control Predicting Baseline Number of Sexual Partners

For longitudinal analyses (i.e., change in number of partners over time), greater threat-related RLB activity was significantly associated with reports of increased sexual partners over time in models including RLB and VS (Wald $\chi^2(9, N=70)=27.53, p<.001, b=.20$, Wald $\chi^2=14.03, p = .001$ in RLB x LVS x Self Control model; Wald $\chi^2(9, N=70)=26.0, p = .002 b=.19$, Wald $\chi^2=11.79, p = .001$ in RLB x RVS x Self Control model).

For longitudinal analyses of condom use (i.e., change in condom use over time), only the main effect of RVS was significant (although did not survive Bonferroni corrections) in the LCM x RVS x Self Control and LLB x RVS x Self Control models ($F(9, 32) = 3.52, p = .004, b= -.14, SE b = .06, p = .02$ in LCM x RVS x Self Control model; $F(9, 32) = 3.77, p = .003, b= -.11, SE b = .05, p = .03$ in LLB x RVS x Self Control model).
Control model). Participants with relatively higher reward-related RVS activity (1 SD above the mean) used condoms less frequently/consistently on average over time compared to participants lower in reward-related RVS activity. A summary of all significant findings for Specific Aim 2 (Self Control as a Moderator) are presented in Table 15.

**Table 15: Summary of Specific Aim 2 Findings: Self Control as a Moderator**

<table>
<thead>
<tr>
<th>Summary of Findings</th>
<th>Findings</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Specific Aim 2: Self Control</strong> Does self control moderate the relationship between neural phenotypes and sexual risk behavior/decision-making?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DV</td>
<td>Findings</td>
<td>Interpretation</td>
</tr>
<tr>
<td>Baseline Vaginal Partners</td>
<td>LVS x Self Control (w/in Ramy &amp; LCM models) ($p = .03, .04$)</td>
<td>High LVS + low Self Control = greater baseline partners</td>
</tr>
<tr>
<td>Change in Vaginal Partners (Longitudinal Analyses)</td>
<td>RLB (w/in RLB x LVS/RVS x Self Control)</td>
<td>Higher RLB = greater increases in partners over time</td>
</tr>
<tr>
<td>Change in Condom Use (Longitudinal Analyses)</td>
<td>RVS (w/in LCM &amp; LLB x Self Control models) ($p = .02, .03$)</td>
<td>Higher RVS = less consistent condom use over time</td>
</tr>
<tr>
<td>Vaginal Sex Decision Making (SDMT)</td>
<td>RVS (all specific Amygdala nuclei models)</td>
<td>Higher RVS = less desire to engage in vaginal sex post arousal manipulation</td>
</tr>
</tbody>
</table>

*Note. SDMT = Sexual Decision Making Task; unless noted with SDMT the variable is self-report risk behavior*

### 5.8 Impulsivity as a Moderator

#### 5.8.1 Sexual Decision Making Data

Across the decision-making outcome variables (attractiveness ratings, vaginal sex intent, and condom use intent), only one two-way interaction (LCM x Impulsivity)
survived Bonferroni corrections in both RVS and LVS models predicting condom use decision-making. Consistent with our hypotheses, participants with higher (1 SD above the mean) LCM activity, who also had a relatively higher (1 SD above the mean) total impulsivity score indicated less consistent condom use in the decision making task post arousal manipulation ($F(6, 86) = 2.44, p = .03, b = -.001, SE b = .00, t = -3.24, p = .002$ in LCM x LVS x Impulsivity model; ($F(6, 86) = 2.23, p = .04, b = -.001, SE b = .00, t = -3.32, p = .001$ in LCM x RVS x Impulsivity model). See Figure 20 for graphical representation of the LCM x Impulsivity interaction in the LCM x LVS x Impulsivity model (note, this pattern of findings is consistent with the LCM x RVS x Impulsivity model). Figure 20 also shows a statistical parametric map (activation clusters overlaid on canonical structure brain image in the axial plane) from the DNS parent sample illustrating threat-related LCM activity (N=1005; x=-24, y=-10, z=-14, $t=30.9$, $p<.00001$, $k=45$); high reactivity=1 SD above the mean; low reactivity=1 SD below the mean.
5.8.2 Self-Reported Risk Behavior

Impulsivity (as a main effect or moderator) did not survive Bonferroni corrections in models including self-reported baseline condom use or change in condom use over time. However, when examining models including specific amygdala nuclei and right and left VS, the three-way interaction RLB x RVS x Impulsivity was significantly associated with both baseline number of sexual partners (Wald $\chi^2(9, N=120)=89.70, p<.001$) and change in number of partners over time (Wald $\chi^2(9, N=70)=33.68, p<.001$) (although note, the latter interaction did not survive Bonferroni corrections) (See Table 16). To interpret the significant three-way interactions, the two-way interactions were examined by participants above and below the median in impulsivity. For participants high in impulsivity, those with relatively high (1 $SD$ above the mean) reward-related RVS activity and relatively low (1 $SD$ below the mean) threat-related RLB activity indicated
greater baseline partners and significantly greater increases in partners over time. The opposite neural phenotype (relatively low RVS and relatively high RLB) also was associated with significantly greater baseline partners and increases in partners over time. In contrast, for participants low in impulsivity, heightened RLB activity was the only factor associated with greater baseline partners and increases in partners over time. See Figure 21 for graphical representation of the RVS x RLB interaction for high impulsivity participants predicting baseline sexual partners (note this same pattern is present in the three-way interaction predicting change in sexual partners over time). Figure 21 also shows a statistical parametric map (activation clusters overlaid on canonical structure brain image in the axial plane) from the DNS parent sample illustrating threat-related RLB activity (N=1005; x=26, y=-6 z=-20, t=47.1, p<.000001, k=218) and reward-related RVS activity (N=1005; x=12, y=12, z=10, t=13.3, p<.000001, k=239); high reactivity=1 SD above the mean; low reactivity=1 SD below the mean (plotted values are adjusted for age and mental health status).
Table 16: Poisson Regression Results of Significant Three Way Interactions Predicting Baseline and Change in Sexual Partners Over time (Impulsivity as a Moderator)

<table>
<thead>
<tr>
<th>Baseline Number of Sexual Partners</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Variable</strong></td>
</tr>
<tr>
<td>DSM-IV Diagnosis</td>
</tr>
<tr>
<td>Age</td>
</tr>
<tr>
<td>RVS</td>
</tr>
<tr>
<td>RLB</td>
</tr>
<tr>
<td>Impulsivity</td>
</tr>
<tr>
<td>RVS x RLB</td>
</tr>
<tr>
<td>RVS x Impulsivity</td>
</tr>
<tr>
<td>RLB x Impulsivity</td>
</tr>
<tr>
<td>RLB x RVS x Impulsivity</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Change in Number of Sexual Partners</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Variable</strong></td>
</tr>
<tr>
<td>DSM-IV Diagnosis</td>
</tr>
<tr>
<td>Age</td>
</tr>
<tr>
<td>RVS</td>
</tr>
<tr>
<td>RLB</td>
</tr>
<tr>
<td>Impulsivity</td>
</tr>
<tr>
<td>RVS x RLB</td>
</tr>
<tr>
<td>RVS x Impulsivity</td>
</tr>
<tr>
<td>RLB x Impulsivity</td>
</tr>
<tr>
<td>RLB x RVS x Impulsivity</td>
</tr>
</tbody>
</table>

*p < .05, **p < .01, *** p < .001
A summary of all significant findings for Specific Aim 2 (Impulsivity as a Moderator) are presented in Table 17.
Table 17: Summary of Specific Aim 2 Findings: Impulsivity as a Moderator

<table>
<thead>
<tr>
<th>DV</th>
<th>Findings</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline Vaginal Partners</td>
<td>RLB x RVS x Impulsivity</td>
<td>Low Impulsive participants: Higher RLB = greater baseline partners; for high impulsive participants: low RLB + high RVS = greater baseline partners Low Impulsive participants: Higher RLB = greater increases in sexual partners over time; for high impulsive participants: low RLB + high RVS = greater increases in sexual partners over time</td>
</tr>
<tr>
<td>Change in Vaginal Partners</td>
<td>RLB x RVS x Impulsivity (p = .04)</td>
<td></td>
</tr>
<tr>
<td>Condom Use Decision Making (SDMT)</td>
<td>LCM x BIS (w/in RVS and LVS models)</td>
<td>Impulsivity = less consistent condom use post arousal manipulation;</td>
</tr>
</tbody>
</table>

*Note.* SDMT = Sexual Decision Making Task; unless noted with SDMT the variable is self-report risk behavior.
6. Discussion

6.1 Decision Making Findings

Most first-time sexual encounters are preceded by marked increases in sexual arousal and some consideration of relative risk based on a potential partner’s sexual history. In addition, individual variability in neural function and stable trait-level personality variables can predict sexual risk behavior. Yet, no previous scientific evidence has directly tested the intersection of these crucial physiologic, neurological, partner, and personal factors. Unfortunately, the findings regarding our sexual decision making experiment were limited (See Table 18).

Inconsistent with specific aim 1, participants high in reward-related RVS reported less willingness to engage in vaginal sex with potential partners after the arousal manipulation. While these findings may appear counterintuitive, previous research has shown that mixed emotional responses (simultaneously positive and negative) to sexual stimuli is common (Cacioppo & Berntson, 1994; Larsen & McGraw, 2011; Peterson & Janssen, 2007; Staley & Prause, 2013) and research has shown that ambiguity in sexual relationships (which is likely occurring during the SDMT since participants are not told they are currently exclusively dating the potential partner) is often associated with increased stress and confusion (Bisson & Levine, 2009; Bogle, 2008; Glenn & Marquadt, 2001). Therefore, it is possible that the sexual arousal manipulation resulted in mixed positive and negative responses and the findings reflect more disgust-related avoidance of
potential sexual encounters, instead of positive (sexual) arousal-related approach behaviors.

To investigate whether negative arousal could be driving the negative relationship between RVS and vaginal sex decision-making, we re-ran the models with change in disgust as a main effect and an interaction effect with RVS and whole amygdala. While inclusion of disgust factors did not improve or significantly alter the predictive power of the RVS effects, there was a main effect of disgust, such that participants who became more disgusted by the arousal manipulation were less willing to engage in vaginal sex post arousal manipulation (whole model with disgust: $F(7, 85) = 3.16, p = .005$, RVS main effect: $B = -.03, p = .004$; disgust main effect $B = -.14, p = .02$; disgust x RVS $B = -.02, p = .26$). We also ran the models again including only the sexually experienced participants. Surprisingly, the RVS effect was actually strengthened ($b = -.04, p < .001$). Given that the results and follow up analyses remain puzzling, future research concerning the relationship between neural function and sexual decision making should continue to investigate what potential moderators and mediators may be impacting this unusual positive reward-related response with decreased risk behavior association.

The second significant SDMT finding is partially consistent with our hypotheses regarding Specific Aim 2 (impulsivity as a moderator). Participants relatively high (1 SD above the mean) in impulsivity and threat-related LCM activity, reported greater inconsistent condom use post arousal manipulation. While we hypothesized that impulsivity would moderate the relationship between VS and amygdala activity such that
high impulsive participants who also had relatively high VS activity and relatively low amygdala activity would make riskier (i.e., more inconsistent condom use) decisions post arousal manipulation, the finding that greater VS activity was associated with safer decision making in vaginal sex decisions, may be indicative of why the three-way interaction was not significant.

In addition, the LCM x Impulsivity interaction may be reflecting partner dynamics such that individuals high in impulsivity may be quickly making assumptions that potential partners do not want to use condoms and there is a heightened threat-related response from the amygdala to avoid conflict and please a potential sexual partner. Individual analyses examining condom use decisions based on high risk potential partners (e.g., partners with a history of inconsistent or no condom use) further supports this hypothesis, as the LCM x Impulsivity interaction is stronger in the regression predicting condom use decisions about high risk potential partners (LCM x impulsivity B = -.001, p = .02), versus the regression predicting condom use decisions about low risk potential partners (e.g., partners with a history of consistent condom use) (LCM x impulsivity B = -.001, p = .04). Therefore, while we would expect heightened amygdala response to serve as a protective factor in sexual decision making, individual’s high in impulsivity may be making quick judgments about potential partner intentions or desires and in order to avoid conflict or decrease a potential partner’s willingness to engage in sex, these participants choose to forgo condom use.
Contrary to our hypotheses, no predictors were related to participants’ decisions regarding the sexual attractiveness of potential partners (e.g., attractiveness decision-making). This is particularly surprising given previous research reporting increased amygdala and VS response to attractive faces (Aharon et al., 2001; Cloutier, Heatherton, Whalen, Kelly, 2008). The lack of findings across the SDMT outcome variables underscores potential limitations of both the experimental task, as well as the participant sample (see limitations section below). In general, the participants engaged in few risky decisions in the SDMT. The mean level of condom use in the task was almost at the maximum (e.g., greatest desire to use a condom was indicated by a 4 on the likert scale) across participants: 3.79 (SD = .32) pre arousal manipulation and 3.77 (SD = .37) post arousal manipulation. In addition, participants were relatively unwilling to engage in vaginal sex with potential partners in the SDMT both before and after the arousal manipulation (Vaginal sex decisions pre arousal $M = 1.98$ (SD = .58), post arousal $M = 2.04$ (SD = .58), where 1 = very unlikely and 4= very likely). Given that participants self-reported less consistent condom use in their sexual histories ($M = 3.16$, $SD = 1.01$), the SDMT is likely not accurately reflecting participant’s actual sexual decision making. Again, this could be due to the nature of the task itself (i.e., making hypothetical sexual decisions regarding potential partners one does not know/has never met), or it could reflect the relative low-risk sample of participants. Because recruitment efforts were limited by allowing participants of any current romantic relationship to participate (e.g., exclusive/committed, casual/open, single), our participants may not engage in one-night
stands or casual sex at a rate that would be reflected well in the task itself. Despite the fact that sexual activity with a nonromantic partner is common among young adults (Furman & Shafer, 2011) and generally accepted and encouraged (Paul, McManus, & Hayes, 2000), it is possible that our participants viewed casual sexual relationships negatively and were therefore not representative of the typical young adult. The lack of findings may also reflect social desirability bias, in so much that participants do not want to appear sexually promiscuous to researchers.

Table 18: Summary of SDMT Findings

<table>
<thead>
<tr>
<th>DV</th>
<th>Findings</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vaginal Sex Decision Making</td>
<td>RVS (across all models)</td>
<td>Higher RVS = less desire to engage in vaginal sex post arousal manipulation</td>
</tr>
<tr>
<td>Condom Use Decision Making</td>
<td>LCM x BIS (w/in RVS and LVS models)</td>
<td>High LCM + High Impulsivity = less consistent condom use post arousal manipulation</td>
</tr>
</tbody>
</table>

Note. *p* values are reported for any significant findings that did not survive Bonferroni corrections (<.006)

6.2 Baseline Self-Report Findings

6.2.1. Specific Aim 1

Self-reported number of baseline sexual partners was the most robust outcome variable and many of the findings were consistent with our hypotheses (See Table 19). Firstly, the covariates age and mental health status were significantly associated with all two-way neural interactions (amygdala x VS data points). Older participants and participants with a DSM-IV diagnosis were more likely to report greater sexual partners
at baseline, which is consistent with previous research indicating young adults meeting criteria for a mental health disorder also report greater sexual risk behavior (e.g., early sexual debut, sex with multiple partners, unprotected sex) (Ramrakha, Caspi, Dickson, Moffitt, & Paul 2000; Shrier, Harris, Sternberg, & Beardslee, 2001; Smith, 2001).

Hypotheses for Specific Aim 1 were partially supported in two significant interactions, and inconsistent with one significant two-way interaction. First, the two-way interactions for RLB x RVS and RCM x LVS were consistent with Nikolova et al.’s (2013) findings, such that participants with relatively heightened threat-related RLB and RCM activity and relatively decreased reward-related LVS and RVS activity reported the greatest baseline partners. While the relationship between decreased VS activity and increased risk-taking may seem counterintuitive, these findings are consistent with those of Bogdan and Pizzagalli (2006) and Nikolova, Bogdan, Brigidi, and Hariri (2012). Bogdan and Pizzagalli (2006) found that among young adult females, stress (associated with the threat of shock in an experimental task) impaired reward responsiveness. Moreover, self-report measures of anhedonia predicted stress-induced hedonic deficits after controlling for anxiety symptoms. Extending these findings to real-world health risk behavior, Nikolova et al. (2012) found that recent life stress interacted with VS reactivity to predict self-reported state positive affect wherein young adults with higher levels of recent life stress reported lower positive affect if participants exhibited relatively low reward-related VS reactivity. Therefore, in our study, it may be that participants with relatively low reward-related VS and relatively heightened threat-related amygdala...
activation engage in sexual risk behavior to “self-medicate” or compensate for low levels of positive affect and/or increased anhedonic symptoms associated with acute stress.

To further investigate this hypothesis, participants’ total average impact scores on the Life Events Scale for Students (LESS, Clements & Turpin, 1996) was collected from the larger DNS parent sample. The LESS is an empirically derived inventory of 46 stressful life events wherein participants are asked to indicate whether they experienced common stressful life events within the past 12 months (yes/no) and the extent of the event’s impact on their current life functioning (life plans and self-perception) using a 1-4 likert scale where 1 = minor impact and 4 = severe impact. The impact scores were set to zero for events that did not occur. Examples of some of the stressful life events listed include breaking up with a boy/girlfriend, failing a course, family health problems, and financial problems. The LESS Average impact score captures the average impact of all events that occurred within the past year.

A Poisson regression was conducted to determine if recent life stress (i.e., LESS total average impact scores) moderated the relationship between neural function and baseline sexual partners. Age, gender, and DSM-IV diagnosis were entered as covariates. Interestingly, the three-way interaction of LESS x whole VS x whole Amygdala was significantly associated with baseline number of sexual partners (Wald $\chi^2(9, N=120)=53.80, p<.001$, three-way interaction: $b=-.03$ Wald $\chi^2=3.97, p = .05$), such that young adults who experience high (above the median) recent life stress and also exhibit low reward-related VS and high threat-related amygdala activity report greater baseline
partners. These findings are in line with research showing that both early life stress and experimentally manipulated acute stress are associated with reductions in reward-related striatal reactivity (Bogdan, Santesso, Fagerness, Perlis, & Pizzagalli, 2011; Dillon et al., 2009) and increased risk for major depressive disorder (Heim, Owen, Plotsky, & Nemeroff, 1997). Therefore, our results support the speculation that individuals with the neural phenotype of low reward-related VS activity coupled with heightened threat-related amygdala activity engage in sexual risk behavior (e.g., increased sexual partners) to modulate stress-related reductions in anxiety and/or depression symptomatology. For instance, Bancroft et al. (2003) found that among gay men, anxiety was negatively related to use of prophylactics and positively related to increased need for sexual activity, such as higher numbers of partners and attempts at partner acquisition. Further studies are necessary to better understand this neural phenotype’s relationship to sexual risk behavior, as this may be a particularly important understanding for why individuals who report greater mental health symptoms engage in increased sexual risk behaviors (Ramrakha, Caspi, Dickson, Moffitt, & Paul 2000; Shrier, Harris, Sternberg, & Beardslee, 2001; Smith, 2001). Moreover, these findings may reflect important neurobiological differences in behavioral and biological stress responses between men and women (Maciejewski, Prigerson, & Mazure, 2001; Weiss, Longhurst, & Mazure, 1999), which may further support the fact that depression occurs nearly twice as often in women compared to men (Kessler, McGonagle, Swartz, Blazer, & Nelson, 1993).
We acknowledge, however, that since our measures of sexual risk are based on retrospective self-reports, the directionality of the association between amygdala reactivity and sexual risk behavior cannot be determined on the basis of these analyses. It is possible that individuals with high amygdala reactivity and low VS are more likely to experience highly impactful stressful life events in the context of sexual risk behavior.

In addition to the RLB x RVS and RCM x LVS interactions, another two-way interaction was significantly associated with baseline sexual partners: LCM x RVS. Inconsistent with our hypotheses and previous research, individuals relatively high (1 SD above the mean) on both LCM and RVS or relatively low (1 SD below the mean) on both LCM and RVS reported greater baseline sexual partners. The nature of these differences is unexpected and warrants further consideration. One hypothesis for these findings is that there exists gender-related differences, given previous research findings that women with relatively high reward-related VS activity indicate greater increases in sexual partners over time, but only when paired with high amygdala activity as well (Victor, Sansosti, Bowman, & Hariri, under review). To explore if similar gender differences may be occurring in the RVS x LCM interaction for baseline partners, we re-ran the regressions again by gender. Consistent with the longitudinal findings under review, the interaction of RVS x LCM was significant for women ($B = .01, p = .03$), but not for men ($B = .01, p = .19$). These gender differences indicate that the amygdala may play differential roles for men and women.
6.2.2. Specific Aim 2: Gender as a Moderator

Gender moderated the relationship between neural function and baseline sexual partners, such that women relatively low in reward-related VS activity and men relatively high in VS activity reported significantly greater baseline partners. Similar to the hypotheses regarding specific aim 1 findings, the differential VS findings by gender may support cross-sectional and longitudinal research showing that women’s sexual activity in the context of non-romantic (casual) relationships is more commonly associated with poorer psychosocial adjustment, including low self-esteem and greater endorsement of depressive symptoms, compared to men (Furman & Collibee, 2014; Grello, Welsh, & Harper, 2006; Paul et al., 2000). These findings are also in line with developmental research pointing to gender differences in sensation seeking and impulsivity, where men report higher levels of sensation seeking and risk taking, while women report higher levels of negative urgency (impulsivity in response to extreme negative emotions) (Dir et al., 2014). Therefore, women low in VS may be seeking out new sexual experiences as a way to increase positive affect.

It is also possible that neural risk phenotypes for men reflect the competition hypothesis, wherein neural activation related to appetitive and avoidance drives operate in a push-pull or “trade off” fashion as they compete for limited processing resources (Pessoa, 2009). In contrast, neural risk phenotypes among women may reflect the salience hypothesis (Choi et al., 2014b), where activation is consistent with motivational salience and therefore women may be responding to both positive and negative signals in...
the environment when making sexual decisions (e.g., the threat of contracting an STI is present, but also the excitement of a new sexual experience).

6.2.3. Specific Aim 2: Sexual Arousal as a Moderator

Partially consistent with our hypotheses, sexual arousal moderated the relationship between neural activity to threat and reward and baseline sexual partners. Among participants high in arousal (e.g., reporting significant increases in sexual arousal post arousal manipulation), relatively high reward-related VS and threat-related amygdala activity was associated with significantly greater baseline partners. Surprisingly, the hypothesized neural risk phenotypes (high Amygdala + low VS or low Amygdala + high VS) were associated with greater baseline partners among low arousal participants only. One hypothesis for these counterintuitive findings is that the heightened arousal experienced by some participants reflects both positive and negative cues; for instance, a participant may feel sexually aroused (which could drive VS-related responses), but also feel embarrassed or uncomfortable with their response to the video manipulation (which could drive amygdala-related responses). To explore the latter negative affect response, we re-ran the whole amygdala x whole VS x arousal regression separately for participants who indicated they have and then for participants who indicated they have not ever watched pornography. Among participants who reported having never watched pornography, the three-way interaction was no longer significant ($B = .04, p = .30$); however the interaction of VS x arousal was significant, such that participants low in arousal, but high in reward-related VS activity reported significantly
greater baseline partners \((B = -.07, p = .01)\). Among participants who reported having watched pornography, the three-way interaction was very significant \((B = .10, p < .001)\). In probing the interaction, our hypotheses are supported, in so much that participants high in arousal who have both relatively high VS and relatively low amygdala response (or the opposite neural phenotype: low VS + high amygdala) report significantly greater baseline partners. Among participants low in arousal, those with relatively low VS and relatively high amygdala activity reported greater baseline partners. These findings suggest that if sexual arousal is experienced as pleasurable (which is likely the case for participants indicating past and more frequent experience with pornographic material), heightened arousal, in addition to increased reward-related VS and decreased threat-related amygdala activity, results in a greater willingness to engage in sexual encounters with new partners (e.g., greater baseline number of sexual partners). In contrast, participants low in arousal appear to be driven by threat-avoidant signals from the amygdala, possibly reflecting the “self-medicating” hypothesis discussed in specific aim 1.

### 6.2.4. Specific Aim 2: Self Control as a Moderator

While self-control did not moderate the relationship between both neural signals from the VS and the amygdala in relation to baseline sexual partners, the significant two-way interaction Self Control x VS was consistent with our hypotheses. Participants with lower trait-level self-control and relatively higher reward-related VS response reported significantly greater baseline partners. These results are consistent with Demos et al.’s
(2012) and Galvan et al’s (2007) findings where heightened VS response was associated with increased health risk behavior.

6.2.5. Specific Aim 2: Sensation Seeking as a Moderator

Consistent with previous research, participants with higher trait level sensation seeking reported significantly greater sexual risk behavior (c.f., Carpenter, Andersen, Fowler, & Maxwell, 2008; Derefinko et al., 2014; Donohew et al., 2000; Hoyle, Fejafar, & Miller, 2000; Kalichman, Heckman, & Kelly, 1996; Miller, Flory, Lynam, & Leukefeld, 2003; Zapolski et al., 2009). Contrary to our hypotheses, sensation seeking did not moderate the relationship between neural function and sexual behavior in the pattern we expected (e.g., high VS + low amygdala + high sensation seeking = greater baseline partners). Instead, participants relatively high in sensation seeking and threat-related amygdala activity reported the greatest baseline sexual partners. While these findings are unexpected, it is possible that whole amygdala activity in this significant interaction is taking into account both negative and positively-valenced environmental/contextual inputs and participants high in sensation seeking are more sensitive to potentially rewarding stimuli, such as new sexual encounters/opportunities. In this way, the whole amygdala activity may be reflecting more reward-related drives from the BLA toward the VS.

6.2.6. Specific Aim 2: Impulsivity as a Moderator

Consistent with our hypotheses, impulsivity moderated the relationship between neural function and baseline sexual partners, such that participants high in impulsivity
(above the median) with relatively (1 SD below the mean) low threat-related amygdala and relatively (1 SD above the mean) high reward-related VS activity reported greater baseline sexual partners. Among participants low in impulsivity (below the median), relatively higher BLA activity was associated with greater baseline sexual partners. While the latter finding among low impulsive participants may seem inconsistent with our hypotheses, the BLA, unlike the CeA, serves as a “sensory gateway” to the VS, supporting reward-related approach behavior.

6.2.7. Baseline Condom Use

No predictors were significantly associated with baseline condom use. While it is unclear why neither neural, nor stable trait level personality measures, were significantly associated with condom use, these findings may reflect recall and social desirability bias, such that participants who engage in unprotected sex either do not accurately recall and report this information (possibly due to alcohol and substance use during the sexual encounters), or they feel uncomfortable or embarrassed disclosing the information in a research study. To date, only one study has explored the relationship between neural function and contraception use (Goldenberg et al., 2013) and found that adolescents self-reporting inconsistent condom use at last sexual encounter exhibited decreased activation in the PFC (specifically right inferior frontal gyrus) during response inhibition in a standard go/no-go task. Given this initial support for the PFC’s role in executive control and planning in condom use decision making, it is possible that the PFC drives condom use decision making before reward-related drives from the VS or threat-related drives
from the amygdala occur. Therefore, young adults who use condoms consistently may plan ahead and have the condom with them, regardless of potential threatening or rewarding cues in the environment (e.g., potential partner’s risk history, etc.). However, it may also be the case that some young adults plan not to use condoms with potential partners for perceived social or personal benefits (e.g., sexual pleasure of oneself or one’s partner, concern over partner’s desire to use a condom). Research supports that contrary to popular opinion, risk taking is not necessarily always unregulated or impulsive, and instead may be planned in certain contexts (Willoughby, Good, Adachi, Hamza, & Tavernier, 2014a); condom use, among our sample in particular, may not necessarily reflect impulsive and unplanned reward seeking drives and may be more directly related to top-down PFC-driven regulation.

Finally, 39% \((n = 47)\) of our sample reported being in a committed romantic relationship at baseline data collection. It may be that many young adults in committed romantic relationships forgo condoms (with increased confidence about their partner’s sexual health) and use oral contraceptives to prevent unplanned pregnancies. Future research should examine not only longitudinal changes in sexual behavior, but also in relationship status; it is possible that participants who acquire more sexual partners over time do so in committed relationships, which could significantly alter the role of threat and reward-related actions associated with condom use decision making.
### Table 19: Summary of Baseline Self-Report Findings

<table>
<thead>
<tr>
<th>Findings</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age &amp; DSM-Diagnosis (all two-way models)</td>
<td>Older subs and subs with a mental health diagnosis = greater baseline partners</td>
</tr>
<tr>
<td>RLB x RVS</td>
<td>High RLB/low RVS = greater baseline partners</td>
</tr>
<tr>
<td>RCM x LVS</td>
<td>High RCM/low LVS = greater baseline partners</td>
</tr>
<tr>
<td>LCM x RVS</td>
<td>High on both or low on both = greater baseline partners</td>
</tr>
<tr>
<td>Gender x VS ($p = .01$) (w/in whole amygdala and whole VS model)</td>
<td>Men high in VS, but women low in VS = greater baseline partners</td>
</tr>
<tr>
<td>Gender x RVS (w/in RLB x RVS x gender model)</td>
<td>Women low in RVS = greater baseline partners</td>
</tr>
<tr>
<td>Lamy x RVS x arousal</td>
<td>High RVS + High Lamy + High Arousal = greater baseline partners</td>
</tr>
<tr>
<td>For whole amygdala and VS: Amy x VS x arousal</td>
<td>Among participants high in arousal: High VS + High Amy = greater baseline partners; Among participants low in arousal: High Amy + Low VS and Low Amy + High VS = greater baseline partners</td>
</tr>
<tr>
<td>LVS x Self Control (w/in Ramy &amp; LCM models) ($p = .03$, .04)</td>
<td>High LVS + low Self Control = greater baseline partners</td>
</tr>
<tr>
<td>Sensation Seeking (all models w/Sensation Seeking)</td>
<td>Higher Sensation Seeking = greater baseline partners</td>
</tr>
<tr>
<td>For whole amygdala and VS: Amygdala x Sensation Seeking</td>
<td>High Sensation Seeking + High Amygdala = greater baseline partners</td>
</tr>
<tr>
<td>RLB x RVS x Impulsivity</td>
<td>Low Impulsive participants: Higher RLB = greater baseline partners; for high impulsive participants: low RLB + high RVS = greater baseline partners</td>
</tr>
</tbody>
</table>

*Note. $p$ values are reported for any significant findings that did not survive Bonferroni corrections (<.006)*
6.3 Longitudinal Self-Report Findings

Longitudinal self-report findings are listed in Table 20. While specific aim 1 was not directly supported, heightened (1 SD above the mean) RLB activity significantly predicted greater increases in sexual partners over time. As discussed earlier, these findings may seem inconsistent with our original hypotheses (high VS + low Amygdala = greater risk behavior), but since the BLA mediates sensory input to the VS, it is not surprising that risk-related behaviors are associated with increased BLA reactivity.

When exploring moderating variables, many of our hypotheses for specific aim 2 were supported. First, similar to the pattern observed for baseline sexual partners, participants high in arousal with heightened (1 SD above the mean) VS and amygdala activity accumulated significantly greater sexual partners over time. Sensation seeking and impulsivity also moderated the relationship between neural function and change in sexual partners over time. Again, the results were consistent with the two-way interaction associated with baseline number of partners, such that participants high in sensation seeking with heightened (1 SD above the mean) amygdala activity and relatively decreased (1 SD below the mean) VS activity reported significantly greater increases in sexual partners over time. In contrast (but consistent with the 3-way interaction associated with baseline number of sexual partners), for participants high in impulsivity, relatively heightened (1 SD above the mean) VS activity and relatively decreased (1 SD
below the mean) amygdala activity was associated with significantly greater increases in sexual partners over time.

Self-control did not moderate the relationship between neural function and longitudinal changes in sexual behavior. However, within the regression models including LCM and self-control, as well as LLB and self-control, RVS was significantly associated with changes in condom use consistency. Consistent with our hypotheses, participants with relatively higher (1 SD above the mean) reward-related RVS activity reported less consistent condom use over time.

Table 20: Summary of Longitudinal Self-Report Findings

<table>
<thead>
<tr>
<th>DV</th>
<th>Findings</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in Vaginal Partners</td>
<td>RLB (w/in LVS and RVS two-way models, including arousal and self-control)</td>
<td>Higher RLB activity = greater increases in partners over time</td>
</tr>
<tr>
<td></td>
<td>Lamy x LVS &amp; RVS x Arousal ((p = .03, .04))</td>
<td>Among participants high in arousal: High VS + High Amy = greatest change in partners over time; for those low in arousal no factors are associated with change in partners</td>
</tr>
<tr>
<td></td>
<td>For whole amygdala and VS: Amy x VS x arousal</td>
<td>Among participants high in arousal: High VS + High Amy = greatest change in partners over time; for those low in arousal no factors are associated with change in partners</td>
</tr>
<tr>
<td></td>
<td>For whole amygdala and VS: VS x Amygdala x Sensation Seeking</td>
<td>No factors associated with DV among low sensation seekers; among high sensation seekers: high Amy + low VS = greater change in partners over time</td>
</tr>
<tr>
<td></td>
<td>RLB x RVS x Impulsivity ((p = .04))</td>
<td>Low Impulsive participants: Higher RLB = greater increases in sexual partners over time; for high impulsive participants: low RLB + high RVS = greater increases in sexual partners over time</td>
</tr>
<tr>
<td>Change in Condom Use</td>
<td>RVS (w/in LCM &amp; LLB x Self Control models) ((p = .02, .03))</td>
<td>Higher RVS = less consistent condom use over time</td>
</tr>
</tbody>
</table>

Note. \(p\) values are reported for any significant findings that did not survive Bonferroni corrections (<.006)
6.4 Limitations

While this study is a valuable initial investigation of the role of neural function to sexual behavior and decision-making in young men and women, it is not without limitations. Foremost, there are multiple sampling concerns. Only heterosexual participants were included in the study, despite the fact that gay and bisexual men account for over half of all the HIV cases in the United States and make up approximately two thirds of new HIV infections each year (CDC, 2012). Unfortunately, the sample pool from the DNS limits our ability to collect enough data from sexual minorities to compare brain function and/or decision-making differences based on sexual orientation.

In addition, since our participants are drawn from the DNS they are representative of the Duke University student population (i.e., primarily Caucasian and Asian American young adults). Given that African American and Latino young men and women have significantly higher rates of STIs compared to White and Asian youth (CDC, 2012), future research should include more ethnically and racially diverse samples. Moreover, our sample is considerably less sexually risky compared to the average undergraduate student ($M = 2.20$, $SD = 3.63$ in the past 12 months) (American College Health Association, 2013). Students’ sexual behavior is likely to vary depending on the academic reputation of the institution, past exposure to campus-specific sexual health programs, and the perceived peer norms regarding sexual behavior on campus. In addition, we did not exclude sexually inexperienced participants to obtain a more
accurate understanding of how young adults think about and engage in sexual decision
making. The inclusion of individuals with diverse sexual experiences allows for a fuller
understanding of the potential motivating factors in individuals choosing to abstain from
sex or have protected versus unprotected sex, however the inclusion of less-risky
individuals may limit our ability to detect significant findings in a riskier sample. Finally,
the nature of the erotic stimuli used, which the participants were informed about before
consenting to the study, may have biased enrollment to a unique subset of the young adult
population that is more comfortable and liberal with sexuality compared to the average
young adult (Strassberg & Lowe, 1995). Future studies specifically targeting young
adults who engage in multiple sexual risk behaviors (e.g., poor condom use, drug and
alcohol use, sex with strangers, etc.) will more accurately capture the extent to which VS
and amygdala-related neural phenotypes could predict actual negative sexual behavior
outcomes (e.g., STIs, unplanned pregnancies).

Another limitation of the study is that data was collected via self-report, such that
recall and selection bias may have occurred. With regard to the SDMT, it is unclear
whether the arousal induced by the video manipulation and the hypothetical sexual
decisions will translate from our laboratory setting to naturalistic sexual encounters or to
populations outside of our sample. Despite using a sexually charged protocol, it is likely
that the levels of arousal experienced in the lab still under-represent those experienced in
real-life. Another methodological limitation is that although the online experimental
format can be seen as particularly ecologically valid, it limited our ability to control the
situation in which the participants completed the study. For instance, while participants were instructed to complete the study in a quiet room alone, they may have completed the study in the presence of others or with other background noises (e.g., television, music).

In addition, due to the limits of available recording equipment, sexual arousal and disgust were measured by self-report, compared to more direct assays of physiologic arousal, such as genital responsiveness using a vaginal photoplethysmograph or penile strain gauge. Future research should include both genital response measures to better capture overall differences in physiologic arousal elicited by erotic videos. However, given that a recent meta-analysis found no significant correlations between BOLD signal and vaginal photoplethysmography measures (Stoleru et al., 2012) and given that some of our hypotheses (especially including self-report sexual arousal) were significant despite engaging in fMRI tasks with no sexual content and not having physiologic measures of arousal, it is likely that future neuroimaging tasks involving sexual stimuli will illicit even more robust findings.

Finally, we recognize that impulse control related to threat avoidance and reward seeking are only two potential aspects of risky sexual decision-making and behavior among young adults. We recognize and acknowledge the importance of environmental (situational), familial and individual value/religious factors, pubertal, and genetic factors on sexual decision-making and risk behavior in adolescence and emerging adulthood. For instance, while sexual behaviors are likely not occurring in the presence of one’s peers, self-report data underscores how peer norms impact individual sexual behavior
over time (e.g., Coley, Lombardi, Lynch, Mahalik, & Sims, 2013; Huebner, Neilands, Rebchook, & Kregels, 2011; Romer et al., 1994; Sieving, Eisenberg, Pettingell, & Skay, 2006). For instance, cross-sectional and longitudinal studies have reported a filtering effect that may be especially relevant for samples of college students similar to ours. This filtering effect is such that adolescents more likely to go to colleges and universities are differentiated by their peers in high school by reporting lower levels of impulsivity and risk taking and greater academic achievement; however, these students go on to surpass the drinking behaviors of their non-university/college classmates in emerging adulthood (Johnston, O’Malley, Bachman, & Schulenberg, 2009; O’Malley & Johnston, 2002; Schulenberg & Parick, 2012; Slutske, 2005; Stanford, Greve, Boudreaux, Mathias, & Brumbelow, 1996). Willoughby et al. (2014a) argue that this discrepancy underscores the role of one’s environment/social context in facilitating or constraining risk taking behavior.

In this same vein, experimental studies using alcohol have highlighted it’s importance as a contributor to “in the moment” states and processes that directly precede sexual decisions (see reviews by George & Stoner, 2000; Hendershot & George, 2007; meta-analysis by Rehm, Shield, Joharchi, & Shuper, 2011). In particular, Rehm et al. (2011) found that across 12 experimental studies, an increase in blood alcohol content of 0.1 mg/ml resulted in an increase of 2.9% (95% CI: 2.0-3.9%) of the indicated likelihood of engaging in unprotected sex. Moreover, research has provided support that alcohol impacts one’s ability to correctly identify potential partners as high risk and alter decision
making strategies (Abbey, Saenz, Buck, Parkhill, & Hayman, 2006; Zawacki, 2011). Given George et al. (2009)’s and Prause et al.’s (2011) findings that alcohol affects risky sexual decision making through subjective, not genital, arousal, it would be important for future research to tease out how alcohol and drugs affect not only unconscious physiological processes involved in sexual decision making, but also more subjective higher-order cognitive appraisals of sexual arousal that may impact sexual decision making. Ultimately, continued research is necessary to ascertain how various social environments and contexts may moderate the associations between adolescent and emerging adult brain development and risk behavior (Willoughby et al., 2014a, b).

While it is beyond the scope of this paper, the role of pubertal hormones on brain developmental and function is likely intimately tied to individual differences in sexual risk behavior and should also be further investigated in future research on the role of neural function in sexual risk (see Sisk & Zehr, 2005 for a more detailed review; also see reviews by Blakemore et al., 2010; Crone & Dahl, 2012; Eisenegger, Haushofer, & Fehr, 2010; Peper & Dahl, 2013). Forbes et al. (2010) found decreased ventral striatum and increased PFC activity in response to reward outcome in adolescents with more advanced pubertal maturation compared to their same-aged peers with less advanced pubertal maturation. Vermeersch et al. (2008a,b; 2009) found that acute increases in gonadal hormones in adolescent boys and girls was positively correlated with greater affiliation with risk-taking peers and higher social dominance. Further research should help clarify
whether and to what extent onset and changes across pubertal development impact threat
and reward-related neural pathways related to sexual decision making and behavior.

Finally, without an executive-control specific fMRI task in the DNS, we are
unable to determine to what extent the VS and amygdala drives are biased by the absence
of effective PFC functioning (Ernst & Fudge, 2009). Future research including a PFC-
related task could serve to support the Triadic model where significant PFC-Amygdala-
VS interactions would predict sexual risk behavior, such that individuals low in PFC and
amygdala function, but high in VS function will engage in significantly greater sexual
risk behavior compared to individuals with greater PFC top-down regulation of the VS
and amygdala.

Nevertheless, the proposed study has several strengths, including multiple
measures of sexual behavior combining both self-reports of one’s sexual history and an
experimental within-subject design wherein sexual arousal is induced pre and post sexual
decision making. This combined cross-sectional self-report, experimental, and
longitudinal approach presents unique insights in the role of the association between
individual differences in neural response to threat and reward and subsequent sexual
decision-making and risk behavior over time. Findings from this study have the potential
to advance the understanding of this important, but largely understudied topic, and will
hopefully set the stage for future research on the association between brain development
and function and sexual decision making and behavior among young adults. Given that
this developmental period has the greatest rates of STIs and unplanned pregnancies, this
research has the potential to inform clinical prevention and intervention efforts and thus, potentially improve STI and HIV-related outcomes.
7. Implications and Future Directions

Farris et al. (2013) call for translational research that integrates neuroscience, ecological systems theory, and decision science to create sexual health interventions that better account for the salience of social rewards, reward-driven decision-making, and sensitivity to peer or social context among adolescents and emerging adults. One promising approach to integrating these areas of research in understanding sexual behavior is the “brain-as-predictor” approach, wherein brain measures of activation, structure, and connectivity are used as independent variables in models that predict longitudinal behavioral outcomes as dependent variables (Berkman & Falk, 2013). The current study attempted to address both Farris et al.’s (2013) and Berkman and Faulk’s (2013) points by using the brain-as-predictor approach (VS and amygdala function as independent variables) for both real-world self-reported sexual risk behavior and experimentally controlled real-time sexual decision-making. While all our hypotheses were not supported, studies incorporating multiple aspects of sexual decision making (e.g., individual differences related to trait level personality variables, neural response, physiologic arousal, and potential partner characteristics) have the potential to generate valuable knowledge regarding sexual decision making and how brain function differentially affects these decisions among emerging adults.

The findings suggest important, yet complex, interactions between arousal, personality, and brain response to both threat and reward. The observed relationship between risk-related neural phenotypes and sexual behavior, and the extent to which trait-
level personality variables moderated these relationships, underscores the potential for
unique intervention strategies. For instance, based on an individuals’ physiologic and
neural response to threat and reward, interventions could be targeted toward specific
groups of individuals (e.g., decreasing relatively high limbic drive versus increasing
relatively low PFC regulation). Prevention programs could capitalize on inhibitory
control reinforcement efforts that focus on upregulation of the immature PFC inhibitory
regions to facilitate safer health choices (Eldreth, Hardin, Pavletic, & Ernst, 2013),
especially among participants high in sensation seeking and impulsivity and low in self-
control.

Recent neuroimaging research underscores how increased striatal response during
reward-related preparation for inhibition in adolescents could serve a protective role
against health risk behavior in the future (Geier, Terwilliger, Teslovich, Velanova, &
Luna, 2010; Hardin et al., 2009). Currently, the Good Behavior Game (GBG), a universal
school-based intervention which teaches children to inhibit impulses and regulate
emotions to obtain rewards, is as an example of how a self-regulatory skills-based
program could help to reduce high risk behaviors, like substance abuse (e.g., Kellam et
al., 2008; Poduska et al., 2008).

Suleiman and Brindis (2014) have begun to outline how previous developmental
affective neuroscience research could inform sex education, based largely on adolescent
risk-related neuroscience concepts that have not specifically been investigated in the
context of sexual risk behavior (see Suleiman & Brindis, 2014 for examples of potential
sex education innovations integrating neuroscience concepts). However, with continued research in this understudied area, a clearer relationship between brain function and risky sexual decision-making and behavior could be established, and more innovative and individually tailored sexual health efforts could be created. For instance, sexual health promotion and prevention programs could utilize risk awareness and goal setting strategies for taking the time to evaluate the rewards and punishments of different scenarios with adolescents and young adults high in sensation seeking, impulsivity and/or reward-related drives; while individuals driven by negative mood states could be taught emotion awareness skills and emotion regulation exercises (e.g., effective relaxation and coping techniques). Specific to individuals who experience significantly greater increases in arousal to sexual cues, prevention strategies could teach youth how to better understand and recognize physiological reactivity and misattribution of these cues (e.g., When I feel my heart racing, I must be attracted to a person).

The next steps in this field are to not only continue to explore the relationship between brain function and sexual behavior with larger and greater at-risk sample sizes, but also to explore how functional genetic polymorphisms may predict observed variability in neural responsiveness to threats and rewards that could further inform the developmental of biomarkers for sexual risk behavior (Hariri, 2009). If such biomarkers could be identified, prevention and interventions targeting specific intermediate phenotypes in adolescents and young adults could be implemented.
8. Conclusion

The transition from adolescence to adulthood is characterized as a critical period in brain development, reward sensitivity, and risk-taking, but it remains unclear whether and to what extent the interaction of threat-related amygdala and reward-related VS activation drive individual differences in sexual decision making and risk behavior. Therefore, the goal of the current study was to examine the association between neural function and individual differences in self-reported sexual behavior (cross-sectional and longitudinal) and experimentally-based hypothetical sexual decision making under arousal among emerging adults. We first examined the relation between threat-related amygdala activity and reward-related VS activity on sexual risk behavior and decision making. Second, we examined whether gender, sexual arousal, or stable personality traits (impulsivity, sensation seeking, and self control) moderate the relationship between neural function and sexual risk behavior/decision making. The results indicate that specific neural risk phenotypes (largely heightened reward-related VS response coupled with decreased threat-related amgydala response) are associated with increased sexual behavior and riskier sexual decision making, however these associations are more strongly related to self-reported number of sexual partners, rather than condom use. While the proposed moderating variables did not consistently moderate brain-behavior relationships across self-report and decision making outcomes, these variables did not significantly moderate one or more associations between neural function and sexual behavior. Finally, significant gender differences were observed, such that men but not
women, with relatively increased reward-related VS activity engaged in significantly greater sexual risk behaviors, while women with relatively decreased VS activity reported greater sexual risk behavior. These findings suggest that the neural patterns we observe, especially in the context of individual differences in trait-level personality variables and sexual arousal, may be useful in identifying individuals at particularly high risk for engaging in sexual risk behavior. Continued research focused on identifying additional factors that predict the observed variability in neural responsiveness to threat and reward could be used to inform the development of key biomarkers for sexual risk and interventions for targeting these intermediate phenotypes. Finally, future challenges lie in unraveling how individual differences in threat and reward-related brain activation are related to changes in sexual risk behavior across adolescence and young adulthood and in creating experimental paradigms that are sensitive to individual and developmental differences in sexual decision making and behavior.
Appendix A

Measures taken from DNS Day 2 Visit

Barratt Impulsivity Scale

Directions: Please use the scale provided to answer the following questions.

<table>
<thead>
<tr>
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<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rarely/Never</td>
<td>Occasionally</td>
<td>Often</td>
<td>Almost always/Always</td>
</tr>
</tbody>
</table>

1. I plan tasks carefully.
2. I do things without thinking.
3. I am happy-go-lucky.
4. I have “racing” thoughts.
5. I plan trips well ahead of time.
6. I am self-controlled.
7. I concentrate easily.
8. I save regularly.
9. I find it hard to sit still for long periods of time.
10. I am a careful thinker.
11. I plan for job security.
12. I say things without thinking.
13. I like to think about complex problems.
15. I act “on impulse.”
16. I get easily bored when solving thought problems.
17. I have regular medical/dental check ups.
18. I act on the spur of the moment.
19. I am a steady thinker.
20. I change where I live.
21. I buy things on impulse.
22. I finish what I start.
23. I walk and move fast.
24. I solve problems by trial and error.
25. I spend or charge more than I earn.
26. I talk fast.
27. I have outside thoughts when thinking.
28. I am more interested in the present than the future.
29. I am restless at lectures or talks.
30. I plan for the future.
Appendix B

Part 1 Online Survey Measures

Directions:
You are being asked to participate in a study conducted in the Department of Psychology and Neuroscience at Duke University. The purpose of this research is to study how people make decisions about whether or not to have sex with someone. In this online survey, you will be asked your age, gender, and race/ethnicity, and your parents’ occupations and education. There will also be questions about how you see yourself, your religious beliefs, and your past sexual behavior and partners.

You must be at least 18 years old to participate. Please take your time and consider each question thoughtfully. The entire questionnaire should take no more than 20 minutes to complete and it is recommended that you set aside this time to focus solely on the questionnaire. There are no right or wrong answers. In general, the first things that come to mind are the best answers. We are relying on your honestly in responding to each question to have a better and also “true” understanding of identity development and sexual behavior in late adolescence/early adulthood. This survey will remain completely anonymous and your name will never be associated with your answers. You will be asked to provide an ID to link your responses from today's survey to your responses in the research center session.

The survey is made up of 3 sections. In the first section you are asked to provide information about your age, gender, race/ethnicity, and highest level of education. In the second section you are asked to respond to questions about your beliefs, characteristics, and behaviors and to various social situations. In the third section you are asked to respond to questions about your past and current sexual behaviors and relationships.

Section 1: Demographic Questions (subjects will not be shown section headings)
1. Please indicate your subject ID (which should be your one of your parent’s middle name and his or her birthday (i.e., if my father’s middle name is Lee and his birthday is May 26th, then my unique ID is Lee26). _______________

2. What is your birthdate (include month, day, and year)? ______

3. What is your age? _____

4. What is your gender?
   - Male
   - Female

5. What is your race/ethnicity?
   - Caucasian/White
   - African American
   - Asian/Asian-American
- Indian/Native American
- Other (please write in: _______)

6. Are you Latino/Hispanic? YES NO

7. What year are you in school?
- Freshman
- Sophomore
- Junior
- Senior
- I am not a college student

Section 2: Personality Measures – Self Control & Sexual Sensation Seeking
13-item Brief Self-Control Scale (BSCS; Tangney, Baumeister, & Boone, 2004)
10-item Sexual Compulsivity Scale (Kalichman et al., 1994)

A. Using the scale provided, please list how much each of the following statements reflects how you typically are.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not at all</td>
<td>Like me</td>
<td>Very much</td>
<td>Like me</td>
<td></td>
</tr>
</tbody>
</table>

1. I am good at resisting temptation
2. I have a hard time breaking bad habits
3. I am lazy
4. I say inappropriate things
5. I do certain things that are bad for me, if they are fun.
6. I refuse things that are bad for me
7. I wish I had more self-discipline
8. People would say I have iron self-discipline
9. Pleasure and fun sometimes keep me from getting work done
10. I have trouble concentrating
11. I am able to work effectively toward long term goals
12. Sometimes I can’t stop myself from doing something, even if I know it is wrong
13. I often act without thinking through all the alternatives
15. The physical sensations are the most important thing about having sex.
16. My sexual partners probably think I am a “risk taker.”
17. When it comes to sex, physical attraction is more important to me than how well I know the person.
18. I enjoy the company of sensual people.
19. I enjoy watching “X-rated” videos.
20. I am interested in trying out new sexual experiences.
21. I feel like exploring my sexuality.
22. I like to have new and exciting sexual experiences and sensations.
23. I enjoy the sensations of intercourse without a condom.

Section 3: Past and Current Sexual Behaviors
Directions: The following section will ask you questions that concern sexual identity and behavior you have engaged in over your lifetime. These questions relate to consensual (voluntary) sexual behaviors. Please do not refer to behaviors that involved coercion or force. Please note that some of these questions might feel particularly intimate and/or sensitive. Remember: your answers are completely anonymous and this information will greatly help us to better understand sexual decisions and behavior for young adults today.

1. I consider my sexual orientation to be:
   - Heterosexual
   - Homosexual
   - Bisexual

2. Currently,
   - I am single (not in a casual or committed romantic relationship or married)
   - I am currently in a casual romantic relationship
   - I am currently in a committed romantic relationship, but not married.
   - I am married

3. Are you currently taking a birth control pill regularly? YES NO N/A
4. Have you engaged in oral sex at least once in your lifetime? YES NO
   *If no, skips to question #10*

5. At what age were you when you first engaged in oral sex? ____

6. How many different partners have you engaged in oral sex with in your lifetime? ____

7. Thinking of all the times you have had oral sex, about what proportion of the time have you/has your partner used a condom? (1=never (0% of the time), 2=rarely (25% of the time) 3= about half the time (50% of the time) 4= most times (75% of the time) 5= always (100% of the time))
8. Have you engaged in vaginal intercourse at least once in your lifetime? YES or NO. If no, skips to #21.

9. At what age were you when you first engaged in vaginal intercourse? ____

10. How many different partners have you engaged in vaginal sex with in your lifetime? ____

11. Thinking of all the times you have had vaginal sex, about what proportion of the time have you/has your partner used a condom? (1=never (0% of the time), 2=rarely (25% of the time) 3=about half the time (50% of the time) 4=most times (75% of the time) 5=always (100% of the time))

12. Have you ever had an unplanned pregnancy or impregnated someone unintentionally? YES NO if no, skip to #21
   a. At what age where you when this unplanned pregnancy occurred? _____
   b. How many unplanned pregnancies have you had in your lifetime? ____

13. Has a doctor/nurse ever told you that you have contracted a sexually transmitted disease (STD) (including HPV, genital herpes, gonorrhea, syphilis, chlamydia, genital warts, and HIV)? YES or NO if no, skip to #22
   a. Which STD specifically? (HPV, genital herpes, gonorrhea, syphilis, chlamydia, genital warts, trichomoniasis, hepatitis B, and HIV)
   b. At what age did you contract an STD? _____

14. Outside of this study, have you ever watched pornography or erotic/sexual films by yourself or with a partner? YES NO
   a. If yes, how often have you watched pornography or erotic/sexual films in the last month?
      - I have not watched pornography in the past month
      - 1 time in the entire month
      - 1-3 times in the month
      - Once a week during the month
      - More than once a week, but not everyday during the month
      - Everyday during the month
Appendix C

Part 2 Online Experimental Measures

Measures before video task:

Please indicate your subject ID given to you by the study investigators______________

The Positive and Negative Affect Schedule (PANAS, Watson, Clark, & Tellegen, 1988)

Directions: Please use the following scale to rate a number of words that describe different feelings and emotions. Indicate to what extent you CURRENTLY feel this way. Please be sure to provide an answer for each item.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Very slightly/Not at all</td>
<td>A little</td>
<td>Moderately</td>
<td>Quite a bit</td>
<td>Extremely</td>
</tr>
</tbody>
</table>

1. Interested
2. Distressed
3. Excited
4. Upset
5. Strong
6. Guilty
7. Irritable
8. Alert
9. Ashamed
10. Inspired
11. Nervous
12. Determined
13. Scared
14. Hostile
15. Enthusiastic
16. Proud
17. Attentive
18. Jittery
19. Active
20. Afraid
21. Surprised
22. Amused
23. Sexually aroused
24. Sad
25. Disgusted
26. Angry

Immediately following these measures, subjects will receive the following directions for the first task:

For the next task, please imagine that even if you are in a sexual relationship you are open to having sex with another person. You will see a number of pictures of people of the opposite sex. Based on the images and information presented, please answer the following questions for each face you see using the keyboard numbers 1 through 5. For each face that you see you will be provided with three sources of information about the person’s past sexual experiences. You will be told how many people the person in the picture has had oral sex with in the past and how many people the person in the picture has had vaginal sex. You will also be told how often they have used a condom when they had vaginal sex in the past. This information will be presented in the top right hand corner of the picture. Please note that you should assume all of the people in the pictures have used condoms rarely or never when they have had oral sex in the past. Please base your decisions on how attractive you found the person and the also on that person’s previous sexual history (the number of people they have had oral and vaginal sex with in the past) and condom use.

Participants will then be presented with 22 pictures of attractive faces of the opposite sex (face pictures will be taken from Heather Rupp’s Stimulus Set (see Rupp et al., 2009a,b). This sexual decision making task is identical to Rupp’s (2009a, b) task, except an additional 3 questions were added for each picture (e.g. oral sex questions and condom use). While pictures are presented, participants will answer five questions. Each face picture will have in the upper right hand corner three sources of risk information: number of oral and vaginal sexual partners this person has had and consistency of his or her condom use with vaginal sex in the past (low risk = 2-5 oral and vaginal sexual partners, usually/always used condoms; high risk= 10-13 oral and vaginal sexual partners, rarely/never used condoms). This information will be provided as two numbers with oral or vaginal and a single word for condom use (e.g. 3 Oral, 2 Vaginal, Usually). As each image appears, the subject will be asked to answer the following four questions using the numerical pad on the keyboard:

1) How sexually attractive is this person to you?
   1= Very Unattractive
   2= Unattractive
   3= Attractive
   4= Very Attractive
2) How likely would you be to have oral sex with this person?
   1 = Very unlikely
   2 = Unlikely
   3 = Likely
   4 = Very Likely

3) How likely would you be to have vaginal sex with this person?
   1 = Very unlikely
   2 = Unlikely
   3 = Likely
   4 = Very Likely

4) How likely would you be to use a condom if you had vaginal sex with this person?
   1 = Very unlikely
   2 = Unlikely
   3 = Likely
   4 = Very Likely

Participants will be given the following directions for the two sexually arousing 120-second video clips.

“For the next part of the study, you will watch two short video clips and answer questions about each of the clips after you watch them. Please make sure your volume is turned on. As we outlined in the consent form, these clips will include nudity and sexual intercourse. You don’t need to do anything but pay attention to the videos. Please try your best to look at the screen through the entire video clip. After each video there will be some questions asking you to rate on a 1 (not at all) to 5 (extremely) scale how much the video elicited certain feelings. You will also be asked to indicate how much of the video clip you saw. After rating each video clip, we will ask you to engage in the two tasks again that you just completed. At any point in time, if you are uncomfortable with the video clips and would not like to proceed with the study, please exit the study browser and send the study coordinator an email (Liz Victor, Elizabeth.victor@duke.edu) letting her know that you were not comfortable watching the videos and ended the study short.”

The following questions will be completed after each 120-second video clip

1. How much of the video clip did you just watch? (A sliding scale will be provided from 0 (none of the video clip) to 100 (all of the video clip, the entire 120
seconds); 50 will also be marked as (half or about 60 seconds of the video clip).

2. During the video, a letter flashed on the screen. What letter flashed on the screen?

Directions: Now we would like to know how you feel about the video you just watched or how it may have affected your mood. Please use the following scale to rate a number of words that describe different feelings and emotions. Indicate to what extent you feel the video YOU JUST SAW elicited the emotion or feeling. Please be sure to provide an answer for each item.

[ Participants will complete the PANAS again ]
Appendix D

Online Follow Up Survey Items

1. With how many partners have you had vaginal intercourse in your lifetime, even if only once? _____ (if zero, subject is “skipped” to question 5)
2. With how many partners have you had vaginal intercourse with in the past 3 months? _____
3. On how many of these occasions did you use a condom? _____
4. Have you ever had an unintended/unplanned pregnancy? (Please select YES or NO) If male: Have you ever unintentionally impregnated a female sexual partner? (Please select YES or NO) (if NO, subject is “skipped” to question 11)
   a. If YES, approximately how many unplanned pregnancies have you (or your partner) had? ___
   b. If YES, approximately what month and year did the most recent unplanned pregnancy occur? (MM/YYYY)
5. Has a doctor or nurse ever told you that you had a sexually transmitted disease (STD), such as HPV, Herpes, Gonorrhea, Chlamydia, etc.? (Please select YES or NO) (if NO, subject is “skipped” to question #12)
   a. If YES, approximately how many STDs have you had? ___
   b. If YES, approximately what month and year were you diagnosed with the most recent STD? (MM/YYYY)
   c. If YES, Please select all the STDs you have been diagnosed with.
      i. HPV
      ii. Genital Herpes
      iii. Gonorrhea
      iv. Syphilis
      v. Chlamydia
      vi. Genital Warts
      vii. HIV
      viii. Trichomoniasis
      ix. Hepatitis B
      x. Other (Please write in) ___________
6. Please indicate your subject ID number to confirm your participation. This is the number given to you in an email from the study coordinator. _____
7. We appreciate the time you have taken to complete this follow up survey. Please indicate how you would like to be compensated for this study:
   - I would like to be emailed a $10.00 amazon gift card at the email address I was contacted on to participate in this follow up survey.
- I would like to be entered in the raffle to win $100 cash. If you choose this option please be aware that drawings will be made every six months, with approximately two drawings each year. If you are chosen as a winner you will need to provide your name, social security number, and address for IRS tax purposes before receiving your cash compensation.


References


New York University.


Biology of Mood and Anxiety Disorders, 2(19), 1-3.


of college students’ spontaneous and anonymous sexual experiences. *Journal of Sex Research, 37, 76–88.*


Somerville, L.H., Jones, R.M., & Casey, B.J. (2010). A time of change: Behavioral and


146
Biography

Elizabeth Christine Victor was born in Lexington, Kentucky, on November 4th, 1986. She received a Bachelor of Arts in psychology from Duke University in May 2009. She received a Master of Arts in clinical psychology from Columbia University, Teachers College in December 2010. She entered the Clinical Psychology doctoral program at Duke in 2011. She will attend Harvard Medical School/Boston Children’s Hospital for her clinical pre-doctoral internship in September 2015. During her time in graduate school, she has received a National Institute on Drug Abuse Young Scientist Pilot Grant and a summer research fellowship from Duke University, as well as research funding through Duke’s Interdisciplinary Initiative in Social Psychology and Duke’s Kenan Institute for Ethics. For two consecutive academic years (2013-2015), she received the E. Bayard Halsted Scholarship. In addition, she has authored or co-authored the following publications:


Finally, she has authored or co-authored the following papers under review:
