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Response Inhibition Moderates the Association between Drug Use and Risky Sexual Behavior

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Abstract

Background—HIV infection is problematic among all drug users, not only injection drug users. Drug users are at risk for contracting HIV by engaging in risky sexual behaviors.

Objective—The present study sought to determine whether inhibitory processes moderate the relationship between problematic drug use and HIV-risk behaviors (unprotected sex and multiple sex partners).

Methods—One hundred ninety-six drug offenders enrolled in drug education programs were administered a battery of computer-based assessments. Measures included a cued go/no-go assessment of inhibitory processes, the Drug Abuse Screening Test (DAST) assessment of problematic drug use, and self-report assessment of condom use and multiple sex partners.

Results—Findings revealed that response inhibition assessed by the proportion of false alarms on the cued go/no-go moderated the relationship between problematic drug use and an important measure of HIV risk (condom nonuse) among drug offenders. However, response inhibition did not moderate the relationship between problematic drug use and another measure of HIV risk: multiple sex partners.

Conclusions—Among this sample of drug offenders, we have found a relationship between problematic drug use and condom nonuse, which is exacerbated by poor control of inhibition. These findings have implications for the development of HIV intervention components among high-risk populations.

Keywords

DAST; drug users; cued go/no-go; risky sex; HIV-risk; impulsivity; inhibition

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Declaration of Interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the article.

INTRODUCTION

Inhibitory Control Processes, Drug use, and HIV-risk Behaviors

HIV rates continue to rise with over 1.1 million people infected in the United States as of 2010, approximately 18% of whom are unaware that they are HIV-positive (Centers for Disease Control and Prevention, 2012). HIV infection is high among all drug users, not only injection drug users (Des Jarlais et al., 2007). In addition to sharing needles, drug users are more likely to engage in risky sexual behaviors that are known to transmit HIV (Kalichman, Cain, Zweben, & Swain, 2003; Leigh, Ames, & Stacy, 2008; Stacy, Ames, Ullman, Zogg, & Leigh, 2006).

Several studies found drug use to be associated with risky sexual behaviors, subsequently leading to increased risk of contracting sexually transmitted diseases (STDs) and higher HIV contraction rates (Des Jarlais et al., 2007; Hwang et al., 2000; Ross, Hwang, Zack, Bull, & Williams, 2002). Kirisci et al. (2006) expanded upon these studies by investigating the severity of a drug use disorder or dependence and its relationship to risky sex. Kirisci and colleagues found severity to be positively related to engaging in risky sexual behaviors. One of the most commonly used measures of problematic drug use is the self-report Drug Abuse Screening Test (DAST; Hormes, Coffey, Drobles, & Saladin, 2011; Mdege & Lang, 2011; Webster, Dickson, Duvall, & Clark, 2010; Yudko, Lozhkina, & Fouts, 2007). The DAST has been shown to be associated with risky sexual behaviors (Kalichman & Cain, 2004; Senn, Carey, Vanable, Coury-Doniger, & Urban, 2006) leading to increased risk of contracting HIV (Ellickson, Collins, Bogart, Klein, & Taylor, 2005).

Inhibitory Control Processes

Lack of inhibitory control or impulsive tendencies involves action without planning, forethought, or conscious judgment and the inclination to engage in inappropriate or maladaptive behaviors (de Wit, 2008; Kjome et al., 2010). The loss of inhibitory control with regard to rewarding or distracting stimuli (Ersche, Turton, Pradhan, Bullmore, & Robbins, 2010) also plays a role in risky sexual behaviors, such that impulsive individuals have been found to more likely engage in sex without using a condom (Abbey, Saenz, & Buck, 2005; Donohew et al., 2000; Xiao, Palmgreen, Zimmerman, & Noar, 2010) and to have more sexual partners (Donohew et al., 2000). One study found that among adolescents using alcohol before sex, those who were more impulsive were more likely to participate in risky sex (Donohew et al., 2000). The relationship found in this study is suggestive of a potential interaction effect between alcohol (or other drug use) and impulsive tendencies, though such an interaction was not formally tested.

The other side of the same coin is response inhibition, which is the ability to control one's actions across a range of situations. Preventing acting out impulsive tendencies requires inhibitory control, often defined as the deliberate blocking of inappropriate or unwanted actions (Mostofsky & Simmonds, 2008). The go/no-go task is one of the most frequently used measures of response inhibition and impulsivity (Roberts & Garavan, 2010; Völlm et al., 2010; Weafer, Fillmore, & Milich, 2009; see Simmonds, Pekar, & Mostofsky, 2008 for meta-analysis of neural correlates of go/no-go tasks). Cocaine-dependent individuals (as

measured by the DAST) were significantly less likely to refrain from inhibiting their behavioral response to a stop-signal used in a go/no-go task than the nondrug-dependent control group (Fillmore & Rush, 2002). Fillmore and Rush (2006) found that simultaneous cocaine and alcohol users showed greater inhibition impairment and were more impulsive than those who had no history of drug abuse, as revealed on a cued go/no-go task. Research on the go/no-go task may be particularly important because it assesses performance ability, rather than relying on self-report measures of inhibitory processes or impulsive tendencies (Reynolds, Ortengren, Richards, & de Wit, 2006). Thus, the task appears to reflect a general ability that may have wide application.

Semple, Zians, Grant, and Patterson (2006) conducted a study investigating self-reported impulsivity as a moderator of effects of methamphetamine use on unprotected sex among HIV-positive men who have sex with men (MSM). Among participants with higher levels of impulsivity, the relationship between methamphetamine use intensity and unprotected sex was strongest (Semple et al., 2006). However, methamphetamine was the only type of drug investigated. Thus, it is important to determine if this finding holds across drug use problems in general.

The research, just summarized, suggests that there are a variety of concepts and measures in the domain of inhibitory control and impulsivity that relate to risky sexual behavior and drug use. Investigators have also uncovered synergistic (interactive) effects between other neurocognitive functions and spontaneous sex associations in drug users promoting risky sexual behaviors (see Ames, Grenard, & Stacy, 2012; Grenard, Ames, & Stacy, 2013) as well as inhibition/impulsivity and drug use. However, it is not yet clear whether performance measures of general inhibitory control, revealed on the go/no-go task, interact with drug problems in predicting risky sex. Investigating this possibility will expand our understanding of the generality of inhibitory effects on risky behavior.

Hypotheses

This study examined inhibitory control ability and its effect on the relationship between problematic drug use and risky sex. Specifically, we hypothesized that increased problems with drug use would be related to increased condom nonuse and this relationship would be moderated (exacerbated) by lack of inhibitory control. In addition, we hypothesized that a positive relationship between problematic drug use and sex with multiple partners would be moderated (exacerbated) by lack of inhibitory control.

METHODS

Participants

Adults enrolled in drug diversion/education programs in Southern California between 2009 and 2010 were recruited for this study. These programs provide services for convicted drug offenders in lieu of jail time. Four hundred ninety clients agreed to participate in the assessment. Eligibility criteria included having attended court-mandated outpatient drug treatment, being a minimum of 18 years, and demonstrating linguistic competence in English. During the computer-based assessment, participants were randomly assigned to

complete either a cued go/no-go task or another task not within the scope of the present article. The sample for this study included 196 drug diversion clients with a mean age of 31.18 ($SD = 11.40$), 66.84% were male, 55.10% self-described as Hispanic, and 85.57% reported high English acculturation where 63.18% communicated only in English and 23.20% communicated in English more than any other language (see Table 1).

Procedures

Administrators from drug diversion/education programs in the metropolitan Los Angeles area approved the study in advance, allowing data collectors to administer the computer-based assessments to clients in a room at the programs' facilities. Laptop computers were set up before clients arrived. Once all of the clients were seated, data collectors distributed an informed consent form, and it was dictated aloud. Clients were assured that their assessments were completely anonymous, and that a Certificate of Confidentiality from the National Institutes of Health was issued for the study so that the researchers would not be forced to disclose the data to law enforcement or other government agencies. Verbal consent was obtained from participants prior to beginning the self-administered computer-based assessments. The assessments took between 60 and 90 minutes to complete and participants were compensated \$15 for their time and effort in completing the assessments. The University's Institutional Review Board approved all procedures.

Measures

Cued Go/No-Go—The cued go/no-go task used in this study was based on the work of Fillmore, Marczinski, and Bowman (2005) and consisted of two types of stimuli trials: during “go” trials, participants were instructed to react as rapidly as possible to stimuli presented on the computer screen (e.g. press the “/” key in response to a green rectangle stimulus) and withhold a response to “no-go” trials (e.g. inhibit a response to a blue rectangle stimulus), without making mistakes (see Fillmore et al., 2005; Simmonds et al., 2008; Weafer et al., 2009). The go/no-go task taps into basic inhibitory processes or the ability to suppress a prepotent response. All subjects completed 200 trials, 80% of which were “go” trials and 20% were “no-go” trials. The outcome measure used for the present analyses was the proportion of false alarms or the failure to withhold a key-press response for a no-go stimulus (for review see Marczinski & Fillmore, 2003; Weafer et al., 2009).

Drug Abuse Screening Test (DAST-10)—The DAST (Skinner, 1982) measures problems related to drug abuse and dependence. The DAST-10 consists of 10 items from the original DAST measure that quantify level of problems with drugs. Participants respond “yes” or “no” to a range of items; for example, “Are you unable to stop using drugs when you want to?” Higher scores are indicative of increased problems with drug use within the past year (scores range from 0 to 10). Previous studies have found the DAST-10 to have high internal validity (alphas across studies = .86 to .94), strong criterion validity ($r = .31$ to $.39$), and strong construct validity ($r = .40$; Yudko et al., 2007). The internal consistency was very good in the current study ($\alpha = .80$).

Condom Use—A total of 14 items assessed condom use behaviors. Three items measured frequency of condom use with regular partners, casual partners, and exchange partners with

responses on a five-point Likert scale ranging from “every time” to “never” ($\alpha = .73$; Darke Hall, Heather, Ward, & Wodak, 1991; DiFranceisco, McAuliffe, & Sikkema, 1998). The next three-item scale measured how often participants used condoms during vaginal, anal, and oral sex on a five-point Likert scale ranging from “used a condom all the time” to “never used a condom” (Donenberg, Emerson, Bryant, Wilson, & Weber-Shifrin, 2001). The last scale consisting of eight items asking about condom use within the past 4 months across different situations such as “with someone you have never had sex with before” and “with someone you know had other sexual partners.” Responses were measured on a five-point Likert scale and ranged from “always” to “never” (Donenberg et al., 2001). Scores from all three scales were compiled into one single 14-item scale of condom use, with higher scores indicating not using condoms. The internal consistency across the 14 items was excellent ($\alpha = .89$).

Multiple Sex Partners—A five-item measure was used (Reilly & Woo, 2001; Richardson et al., 2004) in which participants reported the frequency of their sex partners within the past 4 months by answering the following questions: (1) “How many sexual partners have you had?” (2) “How many new sexual partners have you had?” (3) “How many casual sexual partners have you had?” (4) “How many people have you had sex with on the same day you first met them?,” and (5) “How many one-night stands have you had?.” Participants answered on a scale from 0 to 6 or more and responses were compiled for a total score ranging from 0 to 30. The internal consistency was excellent ($\alpha = .88$).

Acculturation—A four-item language-based proxy was used to measure acculturation (Marin, Sabogal, Marin, Otero-Sabogal, & Perez-Stable, 1987). The questions asked about use of the English language in general, at home, with friends, and selected media. For acculturation, the items were reverse coded and scored on a five-point Likert scale ranging from “only English” to “only another language (not English).” Higher scores indicate more use of English. The internal consistency was excellent ($\alpha = .88$).

Data Analysis

Analytic procedures consisted of general linear regression models using SAS[®] software Version 9.3 (SAS Institute Inc., 2011) to evaluate main and interaction effects. All models evaluated included the following covariates: gender, ethnicity, acculturation, and age. Continuous variables were centered on their means before the regression models were analyzed. Consistent with recommendations for continuous variable interactions (Cohen, Cohen, West, & Aiken, 2003), the interaction term in the analysis consisted of the product of the centered mean scores on the DAST and the centered mean proportion of failed inhibitory responses (false alarms on the go/no-go task). The dependent variables, condom nonuse, and multiple sex partners were regressed on main effects predictors first and then the interaction term. Missing data were handled using multiple imputation ($n = 40$) under the normal model to avoid variance lost (Graham, 2009).

RESULTS

Participant Characteristics

See Table 1 for participant characteristics. The mean DAST score for participants was 4.83 ($SD = 2.89$) and the mean proportion of failed inhibited responses or false alarms to the cued go/no-go task was .06 ($SD = .08$).

Interaction Models

Residuals were normally distributed for the interaction effect on condom nonuse. The interaction term was significant in the regression model for condom nonuse ($B = 9.63, p = .004$). Residuals were not normally distributed on number of sex partners. Because of the assumption violation, robust regression employing least trimmed squares estimation (Cohen et al., 2003) was used for the interaction effect on number of sex partners. In this model, the interaction term was nonsignificant for number of sex partners ($B = .61, p = .76$). Both model parameters are described below and are shown in Table 2.¹

Covariates and Main Effects

Gender, ethnicity, acculturation, and age were not significant predictors of condom nonuse (all $ps > .05$). Response inhibition as measured by the cued go/no-go trended toward significance in the prediction of condom nonuse ($B = -16.07, p = .0528$). Both the DAST ($B = .98, p < .0001$) and the interaction term ($B = 9.63, p = .004$) were significant predictors of condom nonuse. The overall model accounted for 14.31% of the variance and the interaction term accounted for 3.57% of the variance in condom nonuse. The relationship between the DAST (x -axis) and condom nonuse (y -axis) moderated by response inhibition is shown in Figure 1. The slopes increase with increasing response disinhibition scores showing the relationship to be stronger between substance abuse and condom nonuse among those participants with more false alarms or greater inhibition errors than among those with more inhibitory control.

Gender, ethnicity, acculturation, DAST, response inhibition as measured by the cued go/no-go, and the interaction term were not significant predictors of multiple sex partners. The only significant predictors were gender and language acculturation (both $ps < .05$). The overall model accounted for 10.53% of the variance.

DISCUSSION

This study evaluated the relationship between problematic drug use and risky sexual behaviors as moderated by inhibitory control or impulsive tendencies. As hypothesized, the relationship between problematic drug use and condom nonuse was stronger among those drug offenders with less inhibitory control. Both first order and interaction terms were significant (see Figure 1). The model evaluated here explained 14.31% of the variance for condom nonuse. Although the variance explained by the interaction term was small, this is

¹Supplemental analyses evaluated gender by DAST scores, gender by go/no-go false alarms, and a three-way interaction analysis evaluated gender by DAST score by go/no-go false alarms. Results of these analyses were similar to the two-way interaction models and no interactions by gender were significant.

not unusual in moderated relationships in field studies (Grenard et al., 2008; McClelland & Judd, 1993). Field studies often provide nonoptimal distributions influencing the residual variance leading to lower power. In addition, key predictor variables (e.g. DAST and go/no-go) are already entered in the model to evaluate first-order effects, thus influencing the effect size (McClelland & Judd, 1993). The interaction effect found in this study is consistent with one study in which impulsivity was found to moderate the relationship between methamphetamine use and unprotected sex among HIV-positive MSM (Semple et al., 2006). Contrary to our hypothesis, impulsive tendencies did not moderate the relationship between drug abuse problems and multiple sex partners.

There are several implications of these findings. Although drug users with higher levels of drug abuse are at risk for failure to use condoms, this risk from drug abuse is elevated even further for those with poorer inhibitory control. Response inhibition was not a significant predictor by itself, though it showed a trend toward significance. Its relevance only appeared in its interaction effect with drug problems. In other words, drug problems and poorer response inhibition acted in concert to enhance each other's effects. On the basis of the analytic strategy and pattern of findings, it is reasonable to consider either response inhibition or drug problems as a moderator of the first-order effect of the other variable in the interaction: drug problems and inhibitory control appear to operate synergistically.

Future research needs to replicate these findings due to the lack of studies conducted in this area, and prospective studies are particularly needed to see if these relationships replicate longitudinally. However, the present study was a reasonable first step in exploring the interactions between inhibitory control ability and drug abuse. Clearly, intervention in this population should take both problematic drug use and disinhibition into account. Those most at risk for engaging in unprotected sex have more problematic drug use and are highly impulsive. Future research might consider addressing problematic drug use and impulsivity to potentially improve the prevention of HIV transmission among drug users. Timely intervention on problematic drug use is particularly important because of its exacerbating effect on impulsive tendencies. One should consider screening drug users for impulsivity, and interventions may need to be specifically tailored for highly impulsive individuals. By definition, impulsive individuals often do not use forethought or consider consequences; therefore interventions emphasizing those elements may not be successful for these individuals. Instead, interventionists should identify safe activities that can be incorporated into sexual situations that are novel and exciting to the individual, and ones which could become habitual enough to avoid reliance on forethought or deliberation. Tailoring interventions to personality traits such as impulsivity has been successful in reducing drug and alcohol use in other populations (Conrod, Castellanos-Ryan, & Mackie, 2011; Conrod, Castellanos-Ryan, & Strang, 2010; O'Leary-Barrett, Mackie, Castellanos-Ryan, Al-Khudhairy, & Conrod, 2010).

There are several limitations to this study. Due to the sensitive nature of drug use and sexual behavior, there is the possibility that some participants underestimated the number of sexual partners they have had or overestimated condom use. Even though the interaction of impulsivity and drug use problems on condom nonuse was significant, the effect could have been attenuated if these inaccuracies occurred. Attenuation is the most likely bias of

inaccuracies because of concomitant decreased variation in responses. Furthermore, this study was cross-sectional and our inferences are suggestive rather than causal. Therefore, caution is necessary when drawing conclusions from cross-sectional data. While the literature supports these inferences, a carefully controlled longitudinal study should be conducted to confirm our findings.

Although the current study focused on a central hypothesis, other pathways from drug use to unsafe sexual behavior are possible. These include, but are not limited to, transactional sex (Jenness et al., 2011) and impairment under the influence of alcohol or various types of drugs (Leigh, 2002; Leigh et al., 2008). Further, it is likely that condom nonuse can frequently be a deliberate choice due to having a long-term main partner rather than an effect of impulsivity. Future studies might investigate the relationship between other possible pathways, the role of monogamous-relationship status, and additional effects of the role of impulsivity on unsafe sexual behavior.

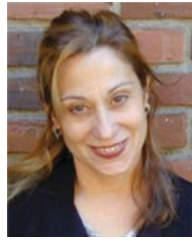
CONCLUSIONS

In conclusion, we have documented a relationship between problematic drug use and condom nonuse, which is exacerbated by poor control of inhibition. These findings are the first to identify this relationship among drug users and are important for the development of HIV interventions among this high-risk population.

Biographies



Liesl A. Nydegger received her M.P.H. in 2011 and is a doctoral student at Claremont Graduate University in the School of Community and Global Health. Her current research interests include HIV prevention among vulnerable populations including adolescent and adult substance users, abuse survivors, rural South African adolescents, and other international populations. In addition, her work has focused on the development of web-based interventions and intimate partner violence prevention. She has published several peer-reviewed articles related to this research and has led several intervention and epidemiologic projects on HIV risk.



Dr. Susan L. Ames received her Ph.D. in Preventive Medicine from the Keck School of Medicine at the University of Southern California. She has conducted a variety of studies that focus on associative (habit-based) memory processes and dual process models of appetitive behaviors among adolescents and other at-risk populations. She has been influential in linking basic neurocognitive findings to cognitive assessment in addiction and contributed to methodological developments in neurocognitive assessment, including increasing understanding of neural processes underlying automatic implicit associations and control mechanisms in substance use and eating-related behaviors in adolescents and emerging adults.



Dr. Alan W. Stacy's research translates compelling but rarely applied basic research in cognitive neuroscience and memory systems for use in preventive medicine and allied areas. He was one of the first to apply basic research on memory systems and implicit (automatic) cognition to appetitive habits relevant to addiction, HIV risk behavior, and diet. He has published major reviews of this literature (e.g., *Annual Review of Clinical Psychology*, Stacy & Wiers, 2010; *Current Directions in Psychological Science*, Wiers & Stacy, 2006) that help explain why some people engage in nonoptimal, risky appetitive behavior even when they have sufficient knowledge of the risks.



Dr. Jerry L. Grenard received his Ph.D. in Preventive Medicine from the Keck School of Medicine at the University of Southern California. Although recently retired, his research examined dual cognitive processes that influence behavior related to chronic diseases such as substance use, HIV, and diabetes.

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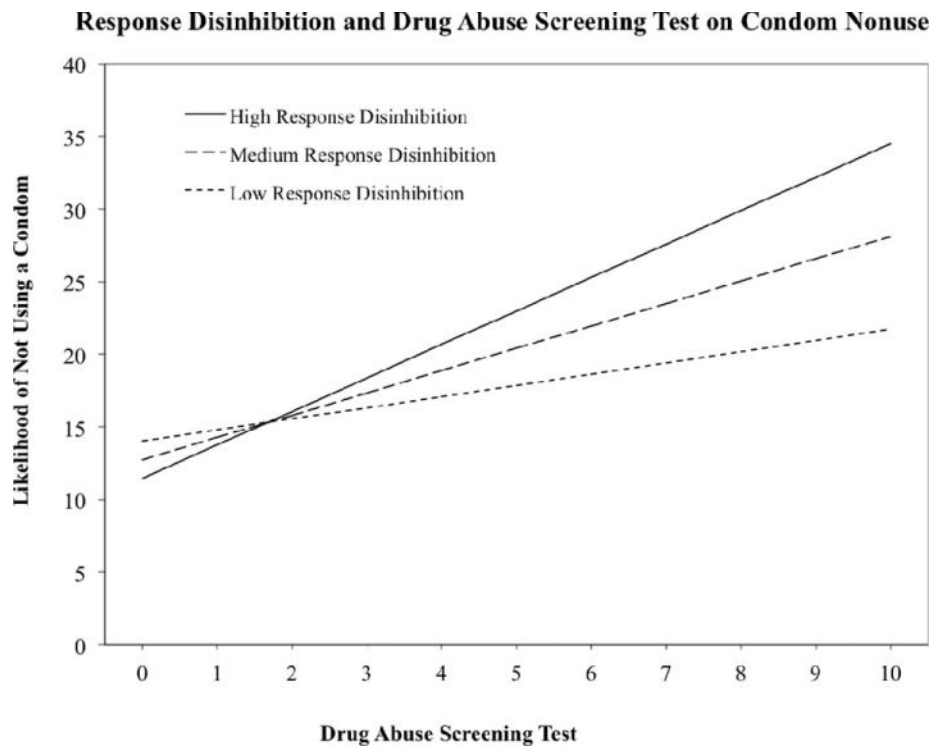


FIGURE 1.

Plot of the interactions between cued go/no-go and DAST in the prediction of the likelihood of not using a condom. The cued go/no-go is plotted at the mean (medium response disinhibition), the mean plus 1 *SD* (high response disinhibition), and the mean minus 1 *SD* (low response disinhibition).

TABLE 1Descriptive statistics ($n = 196$)

Item	<i>M</i>	<i>SD</i>
Age in years	31.26	11.60
Sex, <i>n</i> (%)		
Male	131 (66.84%)	
Female	63 (32.14%)	
Missing	2 (1.2%)	
Ethnicity, <i>n</i> (%)		
Hispanic	108 (55.10%)	
Non-Hispanic	82 (41.84%)	
Missing	6 (3.06%)	
Acculturation, weighted% ^a	85.57%	
English only	63.18%	
English more than another language	23.20%	
Go/No-Go	.06	.08
DAST	4.83	2.90
Condom nonuse	14.96	8.20
Multiple sex partners	12.78	9.72

^aFour acculturation questions were compiled and the weighted percentages for all questions is presented.

TABLE 2

Regression models

Variable	B	95% CI	t	P	Cumulative R ²
Condom nonuse model					
Intercept	13.664	11.18–16.15	10.78	<.001	
Sex (1 = <i>female</i> , 0 = <i>male</i>)	-.954	-3.31–1.340	-.79	.427	
Ethnicity (1 = <i>Hispanic</i> , 0 = <i>other</i>)	2.214	-.29–4.72	1.73	.083	
Language acculturation	.138	-.24–.51	.72	.472	
Age	.097	-.01–.20	1.82	.069	.0241
DAST	.978	.57–1.38	4.72	<.001	.1072
Go/No-Go	-16.071	-32.34–-.19	-1.94	.053	.1074
DAST X Go/No-Go	9.626	3.07–16.19	2.88	<.001	.1431
Multiple sex partners model (Robust LTS estimation)					
Intercept	9.291	6.063–12.519	5.64	<.001	
Sex (1 = <i>female</i> , 0 = <i>male</i>)	3.980	.877–7.084	2.51	.012	
Ethnicity (1 = <i>Hispanic</i> , 0 = <i>other</i>)	-1.074	-2.208–4.356	.64	.521	
Language acculturation	.690	.207–1.172	2.80	.005	
Age	-.064	-.202–.074	-0.91	.363	.0922
DAST	.279	-.252–.811	1.03	.303	.0992
Go/No-Go	7.026	-14.352–28.404	.64	.520	.1015
DAST X Go/No-Go	-.052	-8.547–8.651	.01	.991	.1053

Note. Continuous predictor variables were centered on their means to obtain the (nonstandardized) parameter estimates (B); LTS = Least Trimmed Squares. Supplemental analyses evaluated gender by DAST scores, gender by go/no-go false alarms, and a three-way interaction analysis evaluated gender by DAST score by go/no-go false alarms. Results of these analyses were similar to the two-way interaction models and no interactions by gender were significant.