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Can Cognitive Bias Modification Simultaneously Target Two Behaviors? Approach Bias Retraining for Alcohol and Condom Use

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Abstract
This study tested the effectiveness of a cognitive bias modification (CBM) intervention to simultaneously reduce approach biases toward alcohol and increase approach biases toward condoms among high-risk young adults. Participants (N = 102) were randomly assigned to either a training condition or a sham-training condition. Participants in the training condition were trained to make avoidance movements away from alcohol stimuli and approach movements toward condom stimuli over four training sessions. Approach biases and behavior were assessed at pretest, posttest, and 3-month follow-up. Approach biases changed for both stimulus categories in accordance with training condition. Condom behavior and attitudes also changed as a function of training condition such that participants in the training condition reported fewer instances of condom nonuse and more positive attitudes toward condoms at a 3-month follow-up. Participants in both conditions had significant reductions in alcohol consumption following the intervention and did not differ by training condition.

Keywords
cognitive bias modification, alcohol use, condom use, approach bias

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Cognitive bias modification (CBM) interventions are emerging as effective intervention tools for treating psychiatric disorders, reducing problematic behaviors, and changing attitudes. CBM interventions are effective because they target implicit cognitions that underlie the behavioral decision-making process. Namely, if an individual is trained to attend toward or attend away from specific information, behavioral patterns may also change. CBM interventions have been successful in reducing stress (MacLeod, Rutherford, Campbell, Ebsworthy, & Holker, 2002), anxiety (Amir et al., 2009; Beard, Weisberg, & Amir, 2011), and alcohol use (Eberl et al., 2013, 2014; R.W. Wiers, Eberl, Rinck, Becker, & Lindenmeyer, 2011; R.W. Wiers, Rinck, Kordts, Houben, & Strack, 2010) through targeting implicit automatic biases.

One approach to modifying implicit automatic biases is through targeting specific motor movements. Social psychologists have linked automatic approach and avoidance tendencies with attitudes, behaviors, and emotions (Cacioppo, Priester, & Berntson, 1993; Chen & Bargh, 1999), which dates back to William James (1884), who suggested that approach motor movements (i.e., muscle flexion) would be associated with positive emotions and evaluations and avoidance motor movements (i.e., muscle extension) would be associated with negative emotions and evaluations. Indeed, a growing amount of literature supports James's theory, finding that approach motor movements (e.g., pulling a computer joystick) are associated with increased positive

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evaluations of stimuli (e.g., words, images), whereas avoidance motor movements (e.g., pushing a computer joystick) are associated with increased negative evaluation of stimuli (Cacioppo et al., 1993; Chen & Bargh, 1999; Neumann & Strack, 2000). Cacioppo and colleagues (1993) suggested that these associations are a product of classical conditioning in which humans consistently approach (e.g., grab or reach for) preferred objects (e.g., foods, beverages) and avoid (e.g., push away) aversive stimuli. Thus, over time, humans develop learned associations between arm flexion and positive evaluations and conversely, arm extension and negative evaluations.

Recent work has applied the aforementioned approach and avoidance movement paradigm to computerized assessment and intervention approaches. Stimuli presented on a computer screen can elicit a motivational orientation and subsequent behavioral response similar to a physical object (Strack & Deutsch, 2004). The Approach-Avoidance Task (AAT; Rinck & Becker, 2007) is a computerized program in which participants push or pull a joystick in response to the format of an image presented on a computer screen (e.g., push when in portrait, pull when in landscape). The AAT features a zooming effect to simulate the sensation of approaching when pulling the joystick and avoiding when pushing the joystick such that the images increase in size when the joystick is pulled and decrease in size when the joystick is pushed. The AAT is an effective tool for measuring behavioral response to a category of stimuli via reaction time measurements of approach (i.e., pulling/arm flexion) and avoidance (i.e., pushing/arm extension) movements with a joystick in response to the stimuli.

Approach bias is the behavioral action tendency to be faster to approach rather than avoid cues for a stimulus category. The AAT is effective in assessing implicit approach biases for various stimuli, including alcohol stimuli (R.W. Wiers, Rinck, Dictus, & van den Wildenberg, 2009), cannabis (Cousijn, Goudriaan, & Wiers, 2011), gambling (Boffo et al., 2018), sexual stimuli (Hofmann, Friese, & Gschwendner, 2009; Simons, Maisto, Wray, & Emery, 2016), and condom stimuli (Simons et al., 2016). A modified version of this task is also used to retrain participants' implicit biases toward or away from stimuli by presenting the target category of stimuli predominantly in one format (e.g., push or pull; Eberl et al., 2013, 2014; R.W. Wiers et al., 2010, 2011). Given the associations between arm flexion and positive evaluations and arm extension and negative evaluations, training an individual to respond to certain stimuli with arm flexion or arm extension will subsequently change his or her approach or avoidance biases, respectively.

Generally speaking, there have been two primary approaches used to evaluate the AAT in approach bias retraining. First, proof-of-principle studies have been conducted to evaluate the hypothesized relationships between bias and behavior among participants who are not necessarily motivated to change their behavior (e.g., training one group toward alcohol and another group away from alcohol; cf. Field & Eastwood, 2005; R.W. Wiers et al., 2010). For example, R.W. Wiers and colleagues (2010) successfully modified participant action tendencies and the effects of the training generalized to subsequent drinking behavior such that individuals who were trained to avoid alcohol drank less alcohol, whereas those trained to approach alcohol showed increases in alcohol consumption. The second approach to evaluating the effects of AAT retraining is via randomized controlled trials (RCTs) among clinical samples in which participants have an objective to change behavior. RCT studies have demonstrated success in retraining participants' implicit action tendencies away from alcohol in alcohol-dependent participants at an inpatient treatment facility (Eberl et al., 2013, 2014; Manning et al., 2016; Rinck, Wiers, Becker, & Lindenmeyer, 2018; R.W. Wiers et al., 2011). Among large-scale RTCs using this methodology (e.g., four training sessions), one found a medium effect ($f^2 = 0.16$) with significant effects at 1-year follow-up (R.W. Wiers et al., 2011), and two others found 8.5% less relapse 1 year after treatment (Eberl et al., 2013; Rinck et al., 2018).

Although there have been recent proof-of-principle studies that have failed to replicate these findings (Lindgren et al., 2015; see Cristea, Kok, & Cuijpers, 2016, for meta-analysis), the aforementioned findings indicate that AAT training programs can have significant effects on subsequent behavior regardless of whether they are increasing or decreasing implicit approach tendencies. Although recent research investigated the impact of a CBM training program on decreasing maladaptive behaviors (e.g., Eberl et al., 2013, 2014; R.W. Wiers et al., 2010, 2011) and increasing adaptive behaviors (Taylor & Amir, 2012) independently, no studies have systematically examined the effect of a CBM training that simultaneously decreases maladaptive behaviors (i.e., alcohol use) and increases healthy protective behaviors (i.e., condom use). Furthermore, only one study has examined two active experimental categories in the same joystick AAT task for assessment purposes (i.e., sexual stimuli and condom stimuli; Simons et al., 2016), and no study to date has used CBM in the domain of condom use.

Alcohol Consumption and Condom Nonuse

Alcohol use is very prevalent among college campuses, and the majority of college students consume alcohol, making it the most abused drug among college students;

according to the Substance Abuse and Mental Health Service Administration (2013), over 60% of college students drank alcohol in the past month, and nearly 40% are current binge drinkers. Not surprisingly, nearly one third of college students meet criteria for an alcohol use disorder (Blanco et al., 2008; Knight et al., 2002; Wechsler & Nelson, 2008). Thus, the college environment is strongly associated with extreme levels of alcohol use and related problems, one of which is sexual risk-taking (e.g., condom nonuse).

Condom nonuse is associated with many negative outcomes, including unplanned pregnancies and sexually transmitted infections (STIs). According to the American College Health Association (2013), 70% of college students in the United States engaged in oral, vaginal, or anal sex during the past year. Among college students who have engaged in vaginal sexual intercourse during the past 30 days, 50% reported not using a condom, and 44% did not use any form of contraceptive. Consequently, sexually active individuals under the age of 25 account for nearly half of all new STIs (Centers of Disease Control and Prevention, 2014; Satterwhite et al., 2013), and approximately one of every four sexually active adolescent females have an STI (Forhan et al., 2009). Consequences associated with condom nonuse are severe and costly on both individual and societal levels, with STIs costs at approximately $16 billion in direct medical costs per year (Centers of Disease Control and Prevention, 2014).

Young adults are at elevated risk for both problematic drinking and condom nonuse (American College Health Association, 2013; Certain, Harahan, Saweyc, & Fleming, 2009). Alcohol use and the disinhibition association with alcohol consumption have been identified as significant predictors of sexual risk-taking (Elifson, Klein, & Sterk, 2006; Hipwell, Stepp, Chung, Durand, & Kennan, 2012; Turchik, Garske, Probst, & Irvin, 2010). Although these outcomes can share some common psychosocial etiology, it is also possible that elevated drinking in part contributes to the observed increases in risky sexual behavior in this population. Research suggests that intoxication has a causal effect on risky sexual behavior (George et al., 2014; Maisto, Carey, Carey, Gordon, & Schum, 2004; Purdie et al., 2011). Global association studies, experimental studies, and event-level research suggest that alcohol intoxication may increase the likelihood of unsafe sex. Specifically, alcohol use is commonly associated with greater number of sexual partners and lower probability of condom and other contraceptive use (Abbey, Saenz, & Buck, 2005; Bailey, Pollock, Martin, & Lynch, 1999; Brown & Vanable, 2007; Guo et al., 2002; Hipwell et al., 2012; Patrick & Maggs, 2009; Scott-Sheldon, Carey, & Carey, 2010). However, among studies examining alcohol intoxication and risky sexual behavior, results have not been consistent and indicate a less clear event-level association (Cooper, 2002; Lewis, Kaysen, Rees, & Woods, 2010). This inconsistency suggests that the relationship between intoxication and risky sex is a complex interplay between interpersonal, intrapersonal, and contextual factors. Indeed, recent event-level research indicates that the relationship between intoxication and condom nonuse was an accelerated curve, whereas the likelihood of condom nonuse is significantly greater at higher levels of intoxication (Simons, Simons, Maisto, Hahn, & Walters, 2018). Other event-level research identified that the associations between alcohol use and sexual risk-taking are attenuated among heavy drinkers (Neal & Fromme, 2007; Simons, Wills, & Neal, 2011), indicating that less experienced drinkers may be at a greater risk for engaging in sexual risk-taking when intoxicated. These findings highlight the complexity of the relationship between alcohol and sexual behavior and underscore the need for continued investigation of these behaviors.

Alcohol use is associated with sexual risk via intoxication's impact on motivation and behavioral skills. Specifically, intoxicated individuals exhibit negative attitudes and motivation toward condom use (Gordon & Carey, 1996), especially among those with greater sexual-related alcohol expectancies (Gordon, Carey, & Carey, 1997). Young adults who are both intoxicated and aroused also have a lower implicit approach bias for condoms, thus leading to the increased risk for unprotected sex (Simons et al., 2016). Moreover, young adults who are intoxicated have diminished behavioral skills to initiate and/or negotiate condom use (Gordon et al., 1997; Maisto et al., 2004). Correspondingly, studies investigating the effectiveness of alcohol-reduction interventions also found significant subsequent reductions in sexual risk-taking (Avins et al., 1997; Carey et al., 2004), further emphasizing the complex interplay between intoxication and sexual risk. High levels of alcohol use and lack of condom use are problematic behaviors that often co-occur and can result in significant consequences. Thus, it is vital to develop innovative approaches that simultaneously target both sexual risk-taking and problematic alcohol use.

Implicit Processes in Risky Sex and Alcohol Use

Behavioral decision making is affected by a dynamic interaction between prior learning, reflective processing, and affective-motivational processes (Gladwin, Figner, Crone, & Wiers, 2011; R. W. Wiers & Gladwin, 2017). Further, time-dependent processes are theorized to play an important role in the balance between reflective processing and automatic biases (Cunningham, Zelazo, Packer, & Van Bavel, 2007; Gladwin et al., 2011; Gladwin & Figner, 2014). Specifically, automatic approach tendencies decay after delayed stimuli presentation (Gladwin, Mohr, & Wiers, 2014). This time-specific decision making may be especially relevant to risky sexual behavior because decisions about sexual behavior (e.g., using a condom) are made in the context of ongoing sexual stimuli. That is, the time a person needs to activate prior learning and evaluate potential consequences may play a key role in the decision whether or not to use a condom, particularly when other competing contextual factors also might be present (e.g., sexual arousal, intoxication). Indeed, studies investigating action tendency biases for sexual images indicate a positive association between implicit approach biases for sexual stimuli and increased risk behavior (Hofmann et al., 2009; Simons et al., 2016). Sexual risk-taking may occur when an individual's implicit approach bias toward sexual stimuli is stronger than the subsequent approach bias toward condoms, especially in situations in which sexual cues are more frequent than cues for condoms.

Correspondingly, the attentional myopia model posits that other influences, such as competing cognitive pressures, elicit a myopic effect on attention (Mann & Ward, 2007). Because of attentional myopia, an individual may inaccurately assess the costs and benefits of sexual risk-taking. Engaging in sexual risk-taking results in immediate satisfaction of sexual urges and desires. Conversely, the negative costs associated with sexual risk-taking, such as contraction of STIs and unwanted pregnancy, occur later, if at all. Thus, the immediate benefits of engaging in sexual risk-taking may overpower the costs of latent and probabilistic negative outcomes. Similarly, alcohol has a myopic effect on attention such that immediate and salient cues have a greater impact on an individual's behavior and decision making during acute alcohol intoxication (Steele & Josephs, 1990). The alcohol-myopia theory suggests that a response conflict occurs when individuals are faced with competing alternative options in a behavioral decision, especially with regard to decisions that may require further evaluation and inhibition (e.g., the decision of whether or not to use a condom with an unknown partner). Intoxication is theorized to inhibit the response conflict process, leading to more extreme behavioral responses. Individuals may be at increased risk for engaging in sexual risk-taking while intoxicated because the perceived benefits are immediate and more salient compared with the cues that may inhibit these behaviors. Thus, modifying implicit biases for both alcohol and condoms can decrease problematic alcohol use, subsequently reducing the myopic effects of alcohol while also increasing the salience of condoms.

Current Study

The current study was a proof-of-principle investigation that tested a CBM intervention that aimed to simultaneously target alcohol-approach/condom-avoidance implicit processes. To date, no studies have systematically examined the effect of a combined CBM training to simultaneously decrease one behavior and increase another, and only one previous study (Simons et al., 2016) examined the AAT as an assessment tool with two active stimulus categories in the same joystick AAT task. The hypotheses for the current study were as follows: (a) The CBM training would be associated with changes in implicit approach and avoidance tendencies to alcohol and condoms such that individuals in the training group would have reductions in approach bias for alcohol stimuli and an increased approach bias for condom stimuli. (b) The CBM training would decrease alcohol use and condom nonuse at the 3-month follow-up. (c) Cognitive biases would mediate postintervention changes in corresponding behavior at 3-month follow-up. (d) Changes in alcohol use would mediate changes in condom nonuse.

Method

Design

This study employed a 2 (training: training, sham) × 3 (time: pretest, posttest, 3-month follow-up) mixed design. Participants were randomized to a training (i.e., experimental) or sham (i.e., control) condition. Following R.W. Wiers and colleagues' (2011) procedure, the intervention and sham-intervention (i.e., control) occurred over the course of four training sessions. Repeated measures of the implicit approach assessments as well as self-report assessments of drinking and sexual risk behavior were conducted at baseline, at 1-week postintervention, and at 3-month follow-up.

A priori power analyses were conducted using G*Power 3.1 (Faul, Erdfelder, Buchner, & Lang, 2009). Previous research investigating the effectiveness of CBM trainings using similar methodology found a moderate to large effect size (f^2 = 0.16; R.W. Wiers et al., 2011). However, because of the novel nature of simultaneously training participants to avoid and approach different stimuli, a power analysis was conducted for a 2 (training: experimental, sham) × 3 (time: pretest, posttest, 3-month follow-up) repeated measures analysis of variance (ANOVA) to detect a small to moderate effect (f^2 = 0.08, α = .05) with a power of .80. Results indicated that 70 participants would be needed.

Participants

Participants were 102 students between the ages of 18 and 24 years (*M* = 19.98, *SD* = 1.46) from a public university. Participants completed a brief telephone screen to determine eligibility and an online baseline questionnaire that assessed demographic information, alcohol use history, and sexual behavior history. The inclusion criteria for study was consuming alcohol at least moderately (e.g., at least seven drinks per week for women and at least 14 drinks per week for men; National Institute on Alcohol Abuse and Alcoholism, 2017) or engaging in binge drinking episodes more than three times during the 3 months preceding data collection and had unprotected sexual intercourse with a casual partner during the 3 months preceding data collection.

A total of 1,507 participants were formally screened online, and approximately 500 participants were informally screened via telephone to recruit the full experimental sample. One hundred and two participants were randomized. Eleven people participated in some aspect of the study but were removed from the final analyses. Two participants, one from each condition, attended the first session but did not complete the training or follow-up sessions and thus were excluded from the final sample. Nine additional participants were initially screened via telephone and provided verbal responses that fit within the inclusion criteria. However, after completing the baseline assessments, these participants did not meet the inclusion criteria (e.g., 8 participants did not engage in sexual intercourse with a casual partner prior to data collection, and 1 participant did not meet the inclusion criteria for alcohol use). Of the 9 participants who did not meet criteria, 4 were from the training condition, and 5 were from the control condition. Thus, the data from the 11 aforementioned participants were not included in the analyses, and 91 participants (46 in the training condition, 45 in the control condition) were included in the final sample. The final sample comprised 31 men (34%) and 60 women (66%). The majority of the participants were White (93%), 2% were Native American, 2% were Asian, and 2% were multiracial. Four percent of the sample was Hispanic. Of the 91 participants included in the final analysis, 85 completed the 3-month follow-up, and 6 participants were unable to be contacted for follow-up (2 in the training condition, 4 in the control condition). Thus, there was a 93% retention rate for participants in this study.

Measures

Daily Drinking Questionnaire. The Daily Drinking Questionnaire–Modified (DDQ-M; Dimeff et al., 1999) was used to assess participants' daily alcohol use during an average week. The DDQ-M provides participants with a 7-day grid in which participants record the average amount of drinks consumed over the past 3 months. The DDQ-M has been shown to be a valid measure of alcohol consumption with multiple samples of college students (Baer, Kivlahan, Blume, McKnight, & Marlatt, 2001; Larimer et al., 2001; Marlatt et al., 1998). Total drinks per average week were used in the analyses.

Alcohol Use Disorders Identification Test. The Alcohol Use Disorders Identification Test (AUDIT; Saunders, Aasland, Babor, de la Fuente, & Grant, 1993) is a 10-item self-report measure that is used to identify problematic drinking. The AUDIT is a widely used alcohol screening assessment that has been validated among both college students (Fleming, Barry, & MacDonald, 1991) and the general population (Saunders et al., 1993). The Cronbach's α was .82 for both the baseline assessment and the 3-month follow-up.

HIV Risk Measure. The HIV Risk Measure (HRM; National Institute of Drug Abuse [NIDA], 2013) is a measure included in the "harmonized" instruments used for the Seek, Test, Treat, and Retain initiative sponsored by the NIDA. The HRM is a self-report measure of sexual risk behaviors that is based on the Women's Health CoOp Baseline Questionnaire (Wechsberg, 1998). For the current study, the HRM assessed sexual risk behavior during the 3 months preceding the questionnaire administration. The HRM measures sexual behavior with a main partner, sexual behavior with casual partners, and sexual behavior under the influence of drugs and/or alcohol. Moreover, this measure allows for the assessment of number of sexual partners, number of times engaging in sexual intercourse, instances of condom use, and percentage of condom use. The HRM has been used extensively within NIDA-funded research and has been demonstrated to be a reliable measure of risk behavior (e.g., test-retest reliability > .75; Wechsberg, 1998; Wechsberg et al., 2003). Condom nonuse was calculated by subtracting instances of condom use from total number of times engaging in sexual intercourse. Percentage of condom use was calculated by dividing instances of condom use by total instances of sexual intercourse. Only participants who reported engaging in condom nonuse with a casual partner qualified for the study. Moreover, if a participant did not have sexual intercourse with a casual partner during the follow-up period, they were coded as missing on condom use variables.

Multi-Factor Attitudes Towards Condoms Scale. The Multi-Factor Attitudes Towards Condoms Scale (MFACS; Reece, Herbenick, Hollub, Hensel, & Middlestadt, 2010) is a 14-item scale that was used to assess participants' attitudes toward condoms. The scale consists of three factors, affective, perceived effectiveness, and manageability. Each item is scored on a 7-point semantic differential scale using polar adjectives in assessing condom attitudes. Each item has the prompt, "I would describe condoms as:." Example adjectives phrases include "effective at preventing sexually transmitted infections" versus "not effective at preventing sexually transmitted infections" and "comfortable" versus "uncomfortable." Total scores were calculated, and higher scores indicate a more negative attitude toward condoms. The Cronbach's α was .78 for the baseline assessment and .80 at the 3-month follow-up. The MFACS has been validated for assessment of condom attitudes among college students (Hollub, Reece, Herbenick, Hensel, & Middlestadt, 2011).

Implicit approach avoidance task

The approach avoidance task utilized the Alcohol Approach Avoidance Task in the Inquisit programming environment, which was based on the task developed and modified by R.W. Wiers et al. (2009, 2010, 2011). For the current study, 20 alcohol-related images and 20 condom-related images were used as stimuli. The instructions for completing the AAT were automated.

The assessment AAT consisted of 80 trials of a computerized task in which participants push or pull a joystick in response to the orientation (landscape or portrait) of a picture presented on a computerized screen. The pictures consisted of alcohol images (e.g., beer, liquor, and/or wine) and condom images (e.g., condoms, condom packaging). Research using joystick tasks indicates that positive and negative stimuli elicit pulling and pushing motions, respectively (Cacioppo et al., 1993). Thus, the automated instructions stated that when pushing or pulling the joystick, participants should imagine pulling the image toward them and pushing the image away. The task featured a zooming effect to simulate the sensation of approaching when pulling the joystick and avoiding when pushing the joystick. The image zoomed in and increased in size when the joystick was pulled, and the image decreased in size when the joystick was pushed. During the assessment, AAT images were presented in landscape and portrait format such that participants approached and avoided equally for both alcohol and condom stimuli.

The CBM training task for this study followed that of R.W. Wiers et al. (2011). However, all of the alcohol pictures were in landscape (avoid) format, and all of the condom stimuli were in portrait (approach) format. The task was designed to pair alcohol with an avoidance movement and the condom stimuli with an approach movement. The training task included 200 trials and took approximately 10 min with a brief break in between. Individuals in the sham (control) condition also completed 200 trials. However, for the sham condition, half of each stimulus category (e.g., condoms and alcohol) was presented in portrait and 50% in landscape format. Thus, the sham-training task did not attempt to modify response tendencies through manipulating the pairings, and alcohol and condom images were pushed and pulled an equal number of times. The sham-training condition controls for exposure effects of the task. Participants completed four training sessions, or sham-training sessions, depending on group randomization (R.W. Wiers et al., 2011). Spearman-Brown split-half reliabilities for reaction times at pretest, posttest, and 3-month follow-up were .90, .96, and .96, respectively; reliabilities after D score calculations were .62, .33, and .52.

Procedure

Participants completed a telephone screen and an online screening questionnaire to determine eligibility for the study. The experimental portion of the study consisted of six appointments. Participants were told that they were participating in a study about reaction time and were unaware that this study was examining behavior modification. The first four appointments were attempted to be scheduled on consecutive days. However, there was occasionally a 1- or 2-day gap between training sessions if a participant started the protocol midweek and could not present to the laboratory on Saturday and/or Sunday. During the initial appointment, participants completed a baseline assessment AAT and, depending on their group assignment, either the sham-training or CBM-training AAT. The first appointment lasted approximately 15 min. The second through fourth appointments consisted only of the sham-training or CBM-training AAT and lasted approximately 10 min. The fifth appointment (1-week follow up) and the sixth appointment (3-month follow up) lasted approximately 10 min. During the follow-up appointments, participants completed the assessment AAT and an online outcome questionnaire. All appointments took place in a private research room and were conducted by two trained graduate student members of the research team. Participants were compensated $50 for participating.

Results

Statistical approach

The AAT data were examined for potential outliers or incorrect responses. Response latencies on the AAT

Table 1. Descriptive Statistics Across Time by Group

	Baseline		Posttest		3-Month follow-up	
	Training n = 46	Control n = 45	Training n = 45	Control n = 44	Training n = 44	Control n = 41
Alcohol use	21.45 (15.40)	18.50 (10.90)			12.28 (9.38)	10.85 (7.78)
Binge	6.27 (3.67)	7.09 (4.58)			3.87 (2.94)	3.49 (3.07)
AUD-C	7.45 (2.21)	6.90 (2.07)			6.33 (2.22)	5.80 (2.16)
Frequency of intercourse	12.81 (14.82)	12.45 (13.57)			12.52 (11.75)	13.94 (15.33)
Condom use	3.62 (7.65)	2.52 (3.20)			**5.00 (7.66)**	**1.68 (3.45)**
Condom nonuse	9.19 (12.79)	9.93 (13.52)			7.52 (11.22)	12.26 (15.63)
Condom use (%)	25.73 (31.05)	29.27 (29.97)			**43.39 (41.59)**	**26.07 (38.09)**
Negative condom attitudes	45.64 (13.81)	46.36 (13.14)			**43.43 (11.58)**	**50.67 (9.92)**
Alcohol bias	0.18 (0.43)	0.09 (0.46)	**–0.21 (0.42)**	**–0.01 (0.40)**	0.11 (0.40)	0.04 (0.49)
Condom bias	0.07 (0.33)	0.10 (0.40)	**0.39 (0.40)**	**–0.01 (0.34)**	**0.16 (0.35)**	**–0.08 (0.39)**

Note: Values are means with standard deviations in parentheses. Boldface type represents significant group differences at given time point at $p < .05$. *n*s differ as a result of missing data. Alcohol use = Daily Drinking Questionnaire–Modified (i.e., self-report of drink consumed during a typical week over the prior 3 months). Binge drinking = number of days over past 30 days that participant engaged in binge drinking (e.g., ≥ 4 standard drinks for women; ≥ 5 standard drinks for men). AUD-C = Consumption subscale of Alcohol Use Disorders Identification Test. Frequency of intercourse = number of instances of vaginal or anal intercourse during prior 3 months. Condom use = frequency of condom use during instances of vaginal or anal intercourse over prior 3 months. Condom nonuse = frequency of vaginal or anal intercourse instances without using a condom. Condom use = percentage of times using a condom during vaginal or anal intercourse instances. Alcohol and condom bias = *D* scores on the alcohol and condom Approach-Avoidance Task. Positive values indicate approach bias, and negative value indicates avoidance bias.

assessments that were faster than 300 ms or slower than 2,000 ms were removed. The proportion of correct responses for each participant was examined. Three participants, 2 from the training group and 1 from the control group, responded correctly less than 75% of the time and were omitted from the analysis. Mean response latencies were calculated for each subblock of responses (i.e., approach alcohol, avoid alcohol, approach condoms, avoid condoms) using only correct responses for each subblock. Next, penalties were applied for incorrect responses such that incorrect responses were coded as the mean reaction time for each subblock plus two standard deviations (6.54% of responses; Barkby, Dickson, Roper, & Field, 2012). The number of incorrect responses did not vary as a function of condition ($t = -0.160$, $p = .873$ in two-sample t test). Finally, *D* scores were calculated for each participant according to the procedures of Greenwald, Nosek, and Banaji (2003). Participants' mean reaction times during the approach alcohol trials were subtracted from the mean reaction times during the avoid alcohol trials. These scores were then divided by the participant standard deviation across all alcohol trials (i.e., [Mean Alcohol Approach – Mean Alcohol Avoid]/*SD* across all alcohol trials). This was repeated for the condom trials. Positive *D* scores indicate an approach bias, and negative scores indicate an avoidance bias. The advantage of using *D* scores (compared with simple differences scores or median reaction times) is that they are less vulnerable to biases that occur as a result of differences in average reaction time (Sriram, Greenwald, & Nosek, 2010).

Descriptive statistics

Table 1 presents descriptive statistics across time by treatment condition. Two-sample *t* tests were analyzed, and there were no significant differences between group on any baseline variables or percentage of correct trials. Figure 1 presents biases, alcohol use, and condom use by group across time. Associations between the implicit approach-avoidance biases and drinking and condom-related behaviors at baseline and 3-month follow-up were also tested (see Table 2).

Effect of intervention on implicit biases

The effect of the training on implicit approach and avoidance biases for alcohol and condom stimuli was tested with 2 (condition: experimental, sham) × 3 (time: pretest, posttest, 3-month follow-up) repeated-measures ANOVAs. First, the effect of the training on alcohol bias was tested. The overall model was significant, $F(89, 243) = 2.39$, $p < .001$. There were significant main effects

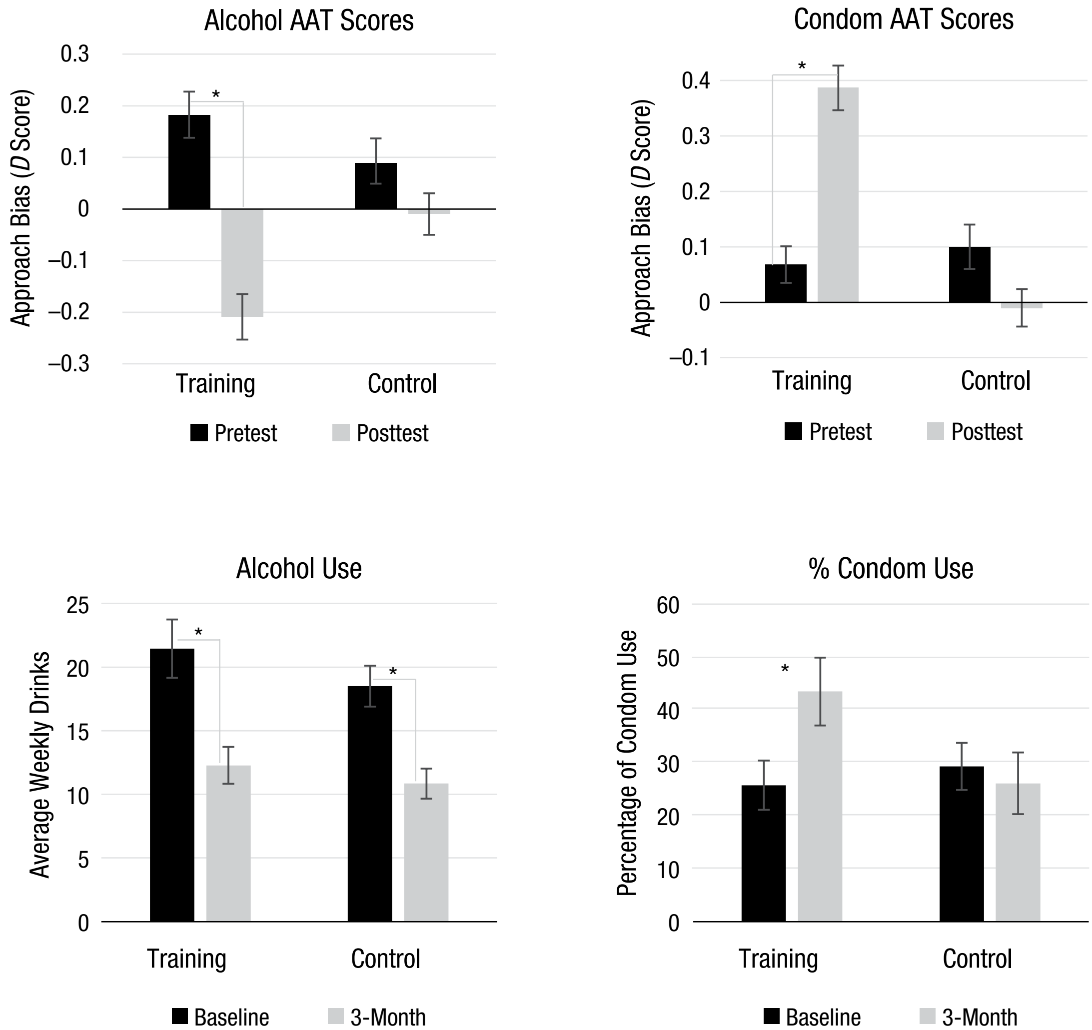

Fig. 1. *D* scores on the alcohol and condom AAT for participants in training and control groups at baseline and follow-up. *D* scores were derived at pretest and posttest. Positive values indicate approach bias, negative value indicates avoidance bias. Error bars indicate ±1 *SE*. Paired *t* tests were conducted to examine mean differences within groups from pretest to posttest (or from baseline to 3-month follow-up). Asterisks indicate significant differences (*$p < .05$).

of condition, $F(1, 243) = 9.52$, $p = .002$, $\eta^2 = .06$, and time, $F(2, 243) = 10.52$, $p = .001$, $\eta^2 = .12$. Moreover, the Time × Condition interaction was also significant, $F(2, 243) = 3.95$, $p = .021$, $\eta^2 = .05$. Contrast analyses indicated that the only significant simple effect was for the treatment condition between pretest and posttest, $F(1, 242) = 16.61$, $p < .001$, and no significant simple effects for the control condition. These results indicated a reduction in approach bias for alcohol stimuli among participants in the training condition. The effect size for the mean differences in alcohol bias was a medium to large effect from pretest to posttest between groups ($d_{pp2} = –0.65$) and very small effect between pretest and 3-month follow-up ($d_{pp2} = –0.05$).

For condom biases, the overall model was significant, $F(89, 243) = 1.61$, $p = .005$. There was a significant main effect of time, $F(2, 243) = 3.82$, $p = .020$, $\eta^2 = .05$, but the main effect of condition was not significant, $F(1, 243) = 2.05$, $p = .154$. The Time × Condition interaction was also significant, $F(2, 243) = 7.55$, $p = .001$, $\eta^2 = .09$. These results indicated an increase in approach bias among participants in the training condition. Contrast analysis indicated a significant simple effect for the treatment condition between pretest and posttest, $F(1, 243) = 15.30$, $p < .001$. Hence, for both alcohol and condom biases, there were expected treatment effects at posttest that diminished at the 3-month follow-up. Unexpectedly, there was also a simple effect in the control condition between pretest and follow-up, $F(1, 243) = 4.86$, $p = .028$, such that participants in the control condition had an approach bias for condoms at pretest and an avoidance bias for condoms at 3-month follow-up. The effect size for the mean differences in condom bias was a large effect from pretest to posttest between groups ($d_{pp2} =$

Table 2. Correlations Between Observed Variables at Baseline and 3-Month Follow-Up

	Sex	Alcohol use	AUDIT	Condom nonuse	Condom use	Condom attitudes	Alcohol bias	Condom bias
Sex	—	.26*	.11	.20	–.21	.24*	–.00	.11
Alcohol use	.30**	—	.63***	.17	–.17	.10	–.07	.16
AUDIT	.15	.38***	—	–.06	–.13	.21	.01	.08
Condom nonuse	.19	.01	.12	—	–.37***	–.00	–-.13	.07
Condom use	–.24*	–.27*	–.14	–.47***	—	–.26*	.18	–.13
Condom attitudes	.17	.17	.09	.16	–.31*	—	–.01	.19
Alcohol bias	–.07	–.04	.14	.20	.05	.13	—	.38***
Condom bias	.03	.02	.05	–.05	.12	–.01	–.15	—
Treatment condition	–.03	.08	.13	–.15	.23*	–.29**	–.24*	.47***

Note: Baseline correlations are above the diagonal, and follow-up values are below the diagonal. Sex (men = 1, women = 0). Alcohol use = self-report of drink consumed during a typical week over the past 3 months. AUDIT = Alcohol Use Disorders Identification Test. Condom nonuse = frequency of intercourse without the use of a condom over the 3 months prior to data collection. Condom use = percentage of times a condom was used during intercourse. Condom attitudes = participant attitudes toward condoms; higher scores indicate a negative attitude toward condoms. Alcohol and condom bias = *D* scores on the alcohol and condom Approach-Avoidance Task. Positive values indicate approach bias, and negative value indicates avoidance bias. Treatment condition (training = 1, control = 0). *p < .05. **p < .01. ***p < .001.

1.17) and medium to large effect between pretest and 3-month follow up (d_{pp2} = 0.74).

Effect of intervention on alcohol use

The effect of the intervention on alcohol use was tested using 2 (condition: training, sham) × 2 (time: pretest, 3-month follow-up) repeated-measures ANOVAs. For average weekly drinking, the overall model was significant, $F(87, 166) = 2.18$, $p < .001$, and there was a significant effect of time, $F(1, 166) = 29.78$, $p < .001$, η^2 = .28. However the main effect of condition was not significant $F(1, 166) = 0.01$, $p = .916$, $\eta^2 = .00$. The Time × Condition effect was also not significant, $F(1, 166)$ = 0.13, $p < .718$, $\eta^2 = .00$. These findings indicate that both groups had significant reductions in alcohol use between baseline and 3-month follow-up assessments. The effect size for the mean differences in alcohol use between baseline and 3-month follow-up was a small effect (d_{pp2} = –0.11).

Effect of intervention on condom-related outcomes

Condom outcomes were also tested using 2 (condition: training, sham) × 2 (time: pretest, 3-month follow-up) ANOVAs. First the effect of the intervention on percentage of condom use (i.e., proportion of times using a condom/times not using a condom) was tested. The independent effects of condition, $F(1, 155) = 1.83$, p = .178, and time, $F(1, 155) = 1.34$, $p = .249$, were not significant. The Time × Condition interaction was significant, $F(2, 155) = 3.93$, $p = .049$, $\eta^2 = .03$. However, the overall model was not significant, $F(3, 155) = 2.05$, $p = .109$, $\eta^2 = .04$. Thus, the interaction effect should be interpreted with caution. The effect size for the mean differences in condom use percentage from baseline to 3-month follow-up between groups was a significant medium to large effect (d_{pp2} = 0.68). The effect of condition on condom attitudes was also assessed using a 2 × 2 repeated measures ANOVA. The overall model was significant, $F(87, 157) = 4.65$, $p < .001$, $\eta^2 = .83$. The main effect of condition on condom attitudes was not significant, $F(1, 157) = 3.68$, $p = .059$, $\eta^2 = .05$, nor was the main effect of time, $F(1, 157) = 0.00$, $p = .950$, $\eta^2 = .00$. However, the Time × Condition interaction was significant, $F(1, 157) = 7.39$, $p = .008$, $\eta^2 = .10$. Moreover, there was a medium to large effect for the mean differences in condom attitudes from baseline to 3-month follow-up between conditions (d_{pp2} = –0.48).

Path model of bias on condom nonuse

The remaining hypotheses were tested with an autoregressive path model in Mplus 7.4 (Muthén & Muthén, 2015). Pretest implicit approach biases, alcohol use, and condom nonuse (i.e., number of instances of condom nonuse at baseline) were included as covariates with autoregressive paths to the respective follow-up variables. Frequency of intercourse during the follow-up period was controlled for in the path analysis as an exposure variable. Direct paths were specified from the intervention indicator (i.e., training condition) to both posttest bias scores and condom nonuse at follow-up. Finally, direct paths were specified from both posttest approach bias scores and alcohol use at 3-month

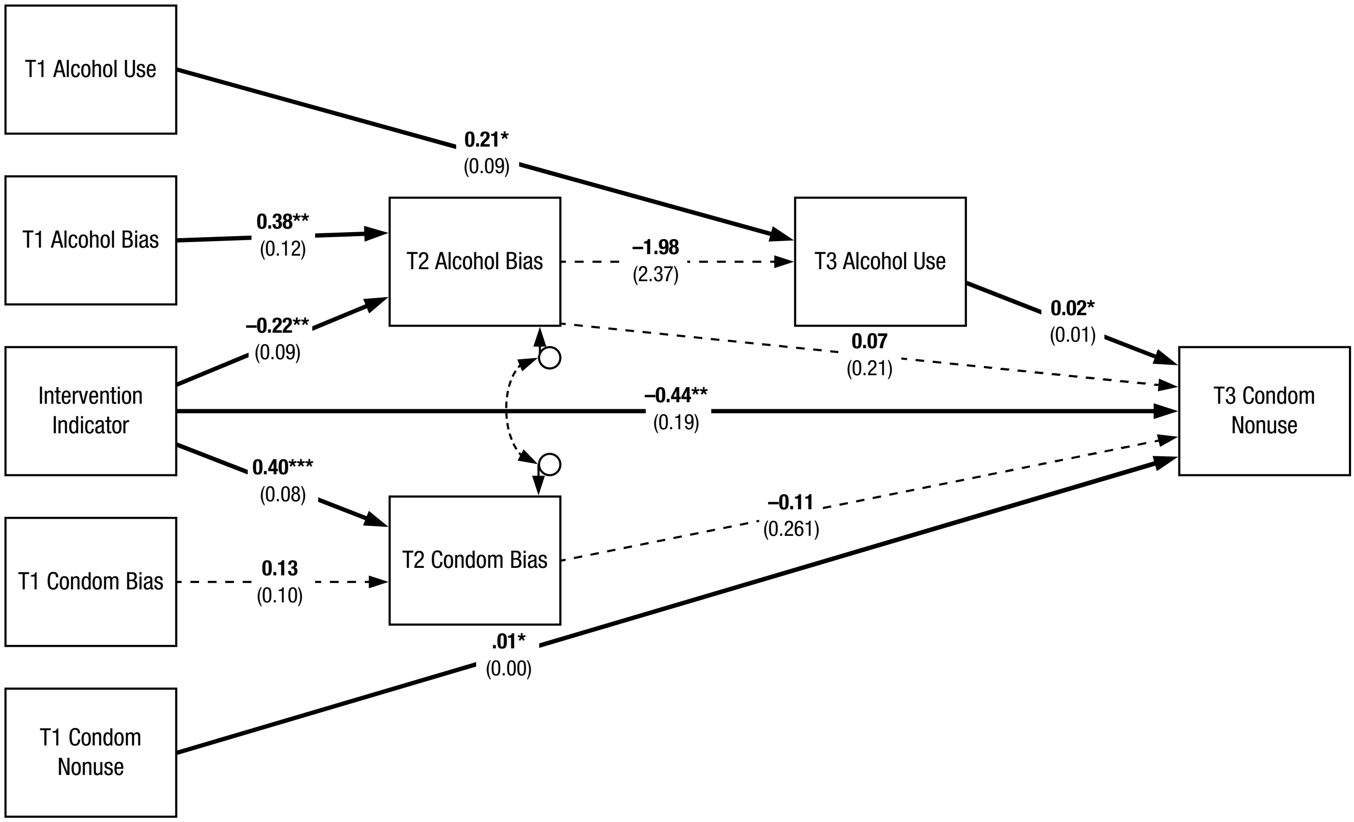

Fig. 2. Path model. Values are nonstandardized effects, standard error in parentheses. Solid lines indicate significant effects. Dashed lines indicate nonsignificant effects. Sex was originally included as a covariate to all exogenous variables but had no significant effects and was thus removed. T1 = pretest scores; T2 = posttest scores; T3 = 3-month follow-up scores. Alcohol use is the number of standard alcoholic drinks during average week over past 3 months. Frequency of intercourse was included as an exposure variable.

follow-up to condom nonuse at 3-month follow-up. Additionally, to examine whether participant sex moderated treatment outcomes, we included a Condition × Sex interaction term with paths to posttest biases and condom nonuse at follow-up. However, the interaction term did not have a significant effect on any of the endogenous variables and thus was excluded from the model to reduce the number of parameters. The path model was tested with the maximum likelihood robust estimator using full-information maximum likelihood estimation and Monte Carlo integration. Because of the count outcome (i.e., condom nonuse), traditional fit statistics could not be calculated for the model. As hypothesized, the training condition was significantly associated with posttest biases for both condom and alcohol stimuli. Moreover, condition had a significant effect on condom nonuse at the 3-month follow-up. However, posttest biases were not significantly related to condom outcomes, but the relationships were in the anticipated direction (i.e., negative association between condom approach and condom nonuse; positive association between alcohol approach and condom nonuse). Thus, contrary to hypotheses, posttest biases did not mediate changes in alcohol or condom use.[1] There were no significant indirect effects in the model (i.e., p values range = .143–.747). See Figure 2.

Discussion

The overall objective of the current study was to examine the efficacy of a cognitive bias modification intervention to simultaneously retrain approach biases for two stimulus categories, alcohol and condoms. Specifically, the effect of the intervention on automatic approach tendencies for alcohol- and condom-related behavior was tested as well as the effect of the intervention on subsequent behavior at 3-month follow-up. It was hypothesized that the intervention would significantly decrease participants' automatic approach tendencies for alcohol-related stimuli and increase participants' automatic approach tendencies for condom-related stimuli. Moreover, it was hypothesized that the intervention would significantly improve participants' attitudes regarding condoms. The intervention was also predicted to significantly decrease alcohol use and instances of condom nonuse during the 3 months following the intervention. Finally, it was hypothesized that automatic approach biases would mediate post-intervention changes in corresponding behavior at 3-month follow-up and that changes in alcohol use would mediate changes in condom nonuse.

The intervention was successful in modifying automatic approach tendencies for both alcohol- and condom-related stimuli. Specifically, individuals in the training condition had significant reductions in alcohol approach bias and significant increases in condom approach bias. This finding is consistent with previous proof-of-principle research with undergraduates that have aimed to modify implicit approach/avoidance tendencies (e.g., R.W. Wiers et al., 2010) as well as RCTs with clinical samples (Eberl et al., 2013, 2014; R.W. Wiers et al., 2011). However, the current study was the first to simultaneously modify implicit approach/avoidance biases for two stimulus categories using the same task.

There was also a significant effect of the training on condom use and condom attitudes at the 3-month follow-up, indicating that the intervention was successful in modifying both behavior and attitudes related to condom use. In contrast, consistent with some recent findings, there was not a significant effect of the training on alcohol-related outcomes (see Cristea et al., 2016; Lindgren et al., 2015). This lack of effect could be due to a number of factors. First, the participants in this study were not treatment seeking, nor were the participants informed that they were participating in an intervention. Although the CBM targets implicit associations, participants with a motivation to reduce their alcohol use may be more likely to benefit from this type of intervention. Moreover, although college students consume alcohol at high levels, the high levels of consumption could be due to environmental factors rather than a strong implicit bias.

Finally, there were no significant associations between changes in biases and subsequent behavior at follow-up. In other words, the intervention was successful in modifying implicit biases and partially successful in modifying behavior and attitudes (i.e., accounted for change in condom behavior and attitudes but not alcohol behavior), but postintervention biases were not associated with corresponding behavior at the follow-up.

Automatic approach/avoidance tendencies

At baseline, all participants exhibited implicit approach biases for both alcohol and condom stimuli. However, at posttest, individuals in the training condition had mean scores indicating an avoidance bias for alcohol stimuli and a stronger approach bias for condom stimuli. The mean scores for the control condition indicated neither approach nor avoidance bias at the posttest assessment, likely because of practice effects of the task. Interestingly, implicit biases for alcohol and condoms were not significantly associated with respective baseline behavior. In fact, only the combined bias (i.e., approach alcohol/avoid condoms) had a significant positive association with condom use, which is in the opposite direction as one would suspect. Similarly, the posttest implicit biases were also not significantly associated with behavior at the 3-month follow-up appointment. The lack of relationship between implicit biases and baseline behavior could be due to the inclusion criteria such that all individuals in the sample consumed relatively high levels of alcohol and engaged in unprotected sexual intercourse. Thus, detecting an association among this particular sample could be more difficult than among a heterogenous population-based sample.

Consistent with previous research on the modification of implicit alcohol biases (R.W. Wiers et al., 2010, 2011), the intervention significantly reduced alcohol approach bias, with a large effect between pretest and posttest (Cohen's d = 0.86) and a small effect size between pretest and follow-up (Cohen's d = 0.15). Similarly, the intervention had a large effect on the training group's condom approach bias between pretest and posttest (Cohen's d = 0.69) and a small effect on condom approach bias between pretest and follow-up (Cohen's d = 0.22). These findings are consistent with hypotheses such that the intervention was successful in reducing approach bias for alcohol stimuli and increasing approach bias for condom stimuli. However, the decreased effect at follow-up indicates that the treatment effects eroded during that time period.

The AAT is being used at an increasing rate since first implemented to examine automatic action tendencies for spider stimuli by Rinck and Becker (2007). However, nearly all studies using this intervention included one active stimulus category that is paired with an inactive, or control, stimulus category. To date, only one published study has utilized the AAT as an assessment with two active target categories (Simons et al., 2016). This study successfully assessed approach biases for two conditions (erotic and condom stimuli). The current study extended these findings by using not only two active categories (i.e., alcohol and condoms) in the assessment of approach biases but also in the modification of biases. Moreover, these findings highlight the ability to simultaneously modify implicit approach biases for two active stimulus categories without reducing the effect sizes that have been found in previous AAT CBM studies that used only one active condition. Having two active conditions, however, is not without its own limitations. Specifically, studies that utilize only one active condition provide an unambiguous means to interpret approach and avoidance biases. The use of two active conditions in the current study does not allow for the differentiation between actual approach biases for the stimulus categories versus a faster approach reaction irrespective of the category.

Alcohol outcomes

Both the training and the control groups had significant decreases in alcohol use from baseline to 3-month follow-up on all measures of alcohol use (i.e., DDQ-M, AUDIT, and binge drinking). These significant reductions did not differ by treatment condition. Thus, the decreases in alcohol consumption cannot be attributed to the intervention. However, it is important to note that all participants demonstrated an approach bias for alcohol stimuli at baseline regardless of treatment condition. Because of the effect of the intervention, the mean bias for the training condition changed from an approach bias for alcohol to an avoidance bias for alcohol (i.e., D score = –0.21). Similarly, because of repeated exposure to the sham training, the control group exhibited practice effects such that the mean alcohol bias changed from an approach bias for alcohol to no bias for alcohol (i.e., D score = –0.01). The repeated exposure to the alcohol stimuli in half of the sham trials and subsequent decrease in approach bias in the control condition could be a potential explanation for the significant decrease in alcohol consumption across both the training and control conditions. Indeed, the decrease in alcohol use is consistent with a recent meta-analysis of CBM RTCs, which found that sham-controlled conditions might exhibit larger effects than training conditions (Boffo et al., 2019). Altogether, these findings underscore the pitfalls associated with sham training as a control condition and highlight the need for alternative techniques for comparing against the CBM treatment.

It is also important to note that neither pretest alcohol bias nor posttest alcohol bias was significantly associated with drinking behavior. This finding is consistent with previous studies using the Alcohol AAT in which there were no significant associations between changes in approach biases and subsequent follow-up behavior (C. E. Wiers et al., 2017; R. W. Wiers et al., 2010, 2011). Although the aforementioned studies did not find significant associations between postintervention alcohol bias and drinking behavior, those studies did find significant differences between treatment conditions in drinking behavior at follow-up.

Condom outcomes

The most promising findings from this study were those associated with condom-related outcomes. Specifically, the Time × Condition interaction was significant for both condom attitudes and the percentage of condom use, indicating that the intervention was significant in not only increasing participants' condom use but also in improving their explicit attitudes with regard to condoms. The significant effect of condition on condom behavior and condom attitudes supports the theory that physical motor movement can influence motivation and behavior (Strack & Deutsch, 2004).

The path analysis examined the effect of the treatment condition on implicit biases and behavior and also examined the mediating effect of posttest biases on follow-up behavior. There was a significant effect of condition on condom nonuse at the 3-month follow-up over and above the effects of posttest biases, alcohol use, baseline condom nonuse, and frequency of intercourse. However, the effect of alcohol use was not significant in the path model. The significant effect of condition on condom nonuse indicates that the training did significantly decrease rate of condom nonuse. However, the lack of indirect effect from condition to condom nonuse via condom approach biases does not support the hypothesized mechanism of action (i.e., increasing approach bias for condoms would decrease instances of condom nonuse). This finding is consistent with previous CBM studies using the AAT (C. E. Wiers et al., 2017; R. W. Wiers et al., 2010, 2011) such that the training was associated with postintervention biases and follow-up behavior without significant associations between biases and behavior. However, mediation was found in a larger study (Eberl et al., 2013) and reanalysis of R. W. Wiers et al. (2011), with estimates of associations and control parameters (Gladwin et al., 2015). The findings of the current study accentuate a need for further investigation to understand and measure better how the AAT changes behavioral outcomes.

Although this study has many important strengths, it is not without limitations. First, motivation to change and participant awareness were not assessed. Participants may have been more motivated to engage in safe sex than change alcohol-related behavior, which could explain the significant effects on condom behavior but not alcohol. Second, two thirds of the sample was female, and the sample lacked racial and ethnic diversity, thus limiting generalizability. Moreover, an undergraduate sample was used. Although problematic alcohol consumption and risky sexual behavior are prevalent among college students (American College Health Association, 2013; Certain et al., 2009), the effects that were demonstrated in the current study may not generalize to other populations. In addition, because participants were trained with condom and alcohol stimuli at the same time, it was not feasible to detect a causal relationship between drinking behavior and condom behavior. Future studies would benefit from using a more rigorous design that includes more treatment conditions. An additional limitation was that the same AAT stimuli were used during the assessment and training phases of the study. Therefore, we were unable to discern if participants learned the task with the specific stimuli or if there was an overall shift in evaluations for the target stimulus category. Finally, the relatively small sample size limited the statistical approaches. Future investigations using a larger sample size could be able to detect effects that were less clear with the current sample.

The present findings raise a number of questions in this line of research that could address unresolved issues and improve clinical applications. First, although the present findings are promising, it remains to be established whether the combined training (i.e., approach condoms/avoid alcohol) outperforms modifications targeting each independently. A second question is, to what extent does motivation affect the treatment effect, and relatedly, should participants be informed about the intended purpose of the training? The inconsistency between proof-of-principle studies and RCTs with clinical samples has been attributed to motivation to change or lack thereof (R. W. Wiers, Boffo, & Field, 2018). Systematically examining the roles of motivation and awareness could be fruitful. Finally, given the positive effect on condom outcomes, it would be interesting to explore retraining procedures for increasing other positive health behaviors. In conclusion, this brief intervention can simultaneously modify implicit biases for two target categories in the same task while improving health behavior outcomes.

Action Editor

Stefan G. Hofmann served as action editor for this article.

Author Contributions

A. M. Hahn, R. M. Simons, and J. S. Simons developed the study concept. R. W. Wiers contributed to study design. Testing and data collection were performed by A. M. Hahn and L. E. Welker. A. M. Hahn performed the data analysis and interpretation under the supervision of J. S. Simons. All the authors approved the final manuscript for submission

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Declaration of Conflicting Interests

The author(s) declared that there were no conflicts of interest with respect to the authorship or the publication of this article.

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Note

1. In addition to the reported analyses, an exploratory post hoc analysis was conducted to examine if changes in condom attitudes mediated changes in condom nonuse. Relationships were in the expected direction but were not significant. Future research applying this same methodology with a larger sample that engaged in greater rates of condom nonuse may be able to detect a mediating effect.

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