J Behav Med (2020) 43:666–671
https://doi.org/10.1007/s10865-019-00090-9

BRIEF REPORT

Working memory moderates the association between condom use intentions and behavior among moderate-to-heavy drinking men who have sex with men

K. D. Tahaney[1] · T. P. Palfai[1] · P. Luehring-Jones[1] · S. A. Maisto[2] · J. S. Simons[3]

Received: February 25, 2019 / Accepted: July 30, 2019 / Published online: August 14, 2019

Abstract Men who have sex with men (MSM) are a high-risk population for HIV infection and this risk is increased for those who consume alcohol. Condomless anal intercourse (CAI) is the central transmission risk factor for this population. This study examined whether individual differences in working memory moderated the association between intentions to use condoms and the frequency of CAI among MSM who engaged in anal intercourse over a subsequent 6-week period. Moderate- and heavy-drinking MSM (n = 207) completed questionnaires regarding alcohol use and condom use intentions and an operation span task to assess working memory at baseline. Participants then completed 6 weeks of morning surveys via a mobile phone app to assess anal intercourse frequency with and without condoms. Negative binomial regression analyses showed that the association between intentions to use condoms and episodes of CAI during the monitoring period was moderated by working memory such that intentions predicted CAI for those high in working memory but not those low in working memory. These results support the view that self-reported intentions may be less-likely to translate into health behaviors among those with poorer executive functioning skills.

✉ K. D. Tahaney
ktahaney@bu.edu

[1] Department of Psychological and Brain Sciences, Boston University, 900 Commonwealth Avenue, 2nd Floor, Boston, MA 02215, USA

[2] Department of Psychology, Syracuse University, Syracuse, USA

[3] Department of Psychology, University of South Dakota, Vermillion, USA

Introduction

Men who have sex with men (MSM) are at increased risk for contracting HIV, with CAI being a primary transmission route for infection (Koblin et al., 2006; McFarland et al., 2012). Efforts to develop approaches to reduce this risk behavior have sought to understand the processes through which individual difference and contextual variables may influence CAI in this population (Cooper, 2010; Maisto & Simons, 2016). Investigators have adapted theories of health behavior to provide insight into the processes through which decisions to use condoms may occur in order to identify potential targets for change (Fisher et al., 2002). Despite the value of these theories, there is growing evidence to show that the predictive value of intentions for health behavior may vary with individual differences in self-regulatory abilities (Sheeran & Webb, 2016). The purpose of this study was to examine whether working memory moderates the association between intentions to use condoms and the frequency of CAI, in a sample of MSM.

Intentions are central to a number of behavior change theories that have been applied to condom-related behavior. For example, the theory of planned behavior (Ajzen & Madden, 1986) and the information-motivation-behavioral skills (IMB) model of behavior change (Fisher & Fisher, 2002), hold that successful condom use is influenced by the strength of intentions to engage in that behavior. These and other theories have emphasized the value of targeting and measuring changes in intentions related to condom use behavior and have utilized such changes as proximal indicators of intervention efficacy (Fisher et al., 2002). Similarly, researchers who have sought to experimentally examine the causal effects of contextual risk factors, such

as alcohol, on CAI-related decision making in the lab have frequently used intentions as a key outcome (Maisto et al., 2012; Shuper et al., 2017; Wray et al., 2019).

Although intentions have been shown to predict a variety of health behaviors, including condom use/safer sex (McEachan et al., 2011; Montanaro & Bryan, 2014), they typically explain a relatively small percentage of the variance in behavioral outcomes (Sheeran & Webb, 2016). Among MSM, for example, intentions may account for as low as 10–15% of the variance in predicting condom use behavior (Andrew et al., 2016). Moreover, while meta-analyses have shown that HIV-prevention interventions appear to regularly produce changes in intentions, they have been considerably less efficacious in changing actual behavior (Albarracín et al., 2006; Andrew et al., 2016). This discrepancy may be associated with the relative importance of other elements outlined in health behavior models (e.g., behavioral skills) for producing behavior change (Fisher et al., 2002), as well as other unmeasured variables that may influence whether intentions are translated into behavior (Gollwitzer & Sheeran, 2006; Sheeran & Webb, 2016).

Recent research has focused on enhancing our understanding of this "gap" between intentions and behavior by identifying potential moderators of the intentions-behavior relationship (Gollwitzer & Sheeran, 2006; Sheeran & Webb, 2016). The likelihood that an individual will behave in a manner consistent with his or her intentions is impacted by a variety of individual difference factors. Executive functioning skills in particular impact the association between intentions and behavior in that they allow individuals to avoid, discern and overcome distractions and temptations that conflict with goals (Allan et al., 2011; Hofmann et al., 2012; Sheeran & Webb, 2016). Successful behavior change requires the ability to represent a behavioral goal standard (e.g., more frequent condom use), identify and monitor discrepancies between the goal and one's present behavior, and regulate affect and behavior in order to reach the goal. Being able to do so depends on the strength of executive functions (Hofmann et al., 2012).

One component of executive functioning—working memory—is specifically associated with the ability to maintain representation of goals and goal-relevant information in memory while directing attention toward goal-relevant information and away from distractors. These abilities are essential for successful self-regulation efforts (Hofmann et al., 2012), including translating behavioral goals into action (Hofmann et al., 2012). In fact, working memory has been shown to moderate explicit goal-directed cognitions for a variety of health behaviors, including alcohol use and sexual behavior (Hofmann et al., 2008). Previous work suggests that individuals higher in working memory may be more successful at translating intentions into behavior (Hofmann et al., 2008) and be less susceptible to competing automatic cognitive processes that are incongruent with goals (Barrett et al., 2004). Although previous work has shown that stronger condom use intentions are associated with reduced incidence of CAI among MSM (Teng & Mak, 2011; Montanaro & Bryan, 2014; Andrew et al., 2016), no study has yet examined the role of working memory in this association. Identification of individual difference factors that may impact this association would expand our understanding of intervention mechanisms, suggest ways in which they may be improved, and help determine the individuals for whom they may be most effective.

The current study sought to investigate whether the association between condom use intentions and CAI is moderated by working memory capacity. Based on previous research that has shown an association between greater working memory and more adaptive behavioral outcomes, it was hypothesized that individuals with more working memory would exhibit a stronger negative association between condom use intentions and frequency of CAI.

Methods

Participants

Two hundred and seven moderate to heavy-drinking MSM were recruited for this study though social media and posted flyers. Eligible participants were between the ages of 21 and 50, and were currently single or in a non-monogamous relationship. Of this sample, 157 were included in the analysis for this paper as they met the additional eligibility study criterion of having completed the 6-week monitoring period, reporting at least one episode of anal intercourse during that period, and providing data within measurement ranges.[1]

Measures

Drinking status (i.e., moderate or heavy) was assessed by the QFV Index, which measures the typical quantity and frequency of beer, wine, and hard liquor consumption during the past month (Cahalan et al., 1969). The computerized operation span task (OSPAN; Turner & Engle, 1989) was used to assess working memory capacity. The task requires participants to memorize strings of letters of varying lengths while also solving math problems. The OSPAN score was derived from the total number of letters correctly recalled across sets. The question "Do you intend to use a condom each time that you have sex?", along with a 5-point Likert scale ("No" to "Definitely") was used as measure of condom use intentions at baseline. Finally, frequency of anal intercourse and CAI specifically was measured daily during a 6-week experience sampling method (ESM) period with app-based morning sur-

[1] Three participants had morning survey scores that exceeded the maximum range (due to data or procedural irregularities) and were therefore not included in analyses.

veys. ESM is an assessment strategy that involves surveying participants on things such as behaviors, feelings, and environment in real time over a set period of time. The 6-week period was broken into two separate "bursts" of 3 weeks each that were separated by a 3-week break. During each burst, participants were presented with up to 23 morning surveys for a maximum number of 46 for the study. Participants were compensated at the end of each burst period based on the number of surveys completed. Frequency of days of anal intercourse and frequency of days of CAI were assessed based on data from the morning surveys.

Procedure

Participants were recruited through advertisements on social media platforms (i.e., Grindr, Scruff, Craigslist) and flyers posted at local community health centers and bars that cater to an LGBT clientele. Prospective participants were screened by phone to assess eligibility before being enrolled into the study. Because this study also included an alcohol administration component (discussed elsewhere) additional exclusions criteria were employed including: history of alcohol treatment during the past 3 years, any lifetime history of treatment for bipolar disorder or schizophrenia, any substance use disorder or mental health treatment in the past 3 months, medical conditions that contraindicate alcohol use (including HIV), and use of medication or supplements that interact negatively with alcohol. Because the intention question referred to intentions to use condoms during sex, only participants who completed the 6-week ESM period and reported one or more instances of sexual intercourse with a man over that period were included in the analyses for this study.

Analyses

A negative binomial regression analysis was used to determine whether working memory moderated the association between condom use intentions and frequency of CAI. Analyses controlled for number of days on which anal intercourse questions were completed (which served as the offset variable) and total intercourse days with male partners. The interaction was probed at ± 1 SD from the mean working memory score to examine this association at different levels of working memory.

Results

The sample was predominantly White (65%) and highly educated (92% with some college education). See Table 1 for baseline characteristics of the sample. Regarding ESM completion rates, the mean number of ESM days completed was 45.45 of a possible 46 survey days (*SD* =2.33), mean morning survey completion percentage was 91.04 (*SD* = 11.34), and mean intercourse days with male partners was 5.31 (*SD* = 5.37). Finally mean CAI days with male partners was 3.60 (*SD* = 4.64). Partial correlations, controlling for number of assessments completed, showed that intentions to use condoms was negatively associated with frequency of CAI for the sample as a whole ($pr = -0.25$, $P \leq 0.01$), while working memory was not ($pr = 0.02$, P = n.s.)

Table 1 Baseline characteristics (n = 157)

Variable		(%)
Race/ethnicity	White	65.0
	Black	11.5
	Asian	8.9
	Native American or Alaskan native	1.3
	Other	7.0
	Mixed	4.5
	Hispanic	16.6
Highest level of education*	High school	8.1
	Some college	56.8
	Post-bachelors	35.1
Drinking status (QFV)	Moderate	12.7
	Heavy	86.6
	M	*S.D.*
Age	27.88	6.67
Working memory (total correct letters)	19.01	5.04
Intent	2.49	1.40

*These data are based on a subset of the sample (n = 74) for which level of education information was obtained

See Table 2 for the results of the negative binomial regression. The negative binomial regression analysis revealed a significant interaction between condom use intentions and working memory in predicting frequency of CAI over the 6-week ESM monitoring period (aIRR = 0.982; 95% CI: 0.966, 0.999, $P < 0.05$), adjusting for frequency of intercourse days and diary reports. A simple slopes analysis (probed at ± 1 *SD* of working memory) revealed that condom use intentions predicted number of condomless sex episodes for those high in working memory ($b = -1.626$, $P < 0.01$), but not for those low in working memory ($b = -0.511$ $P = 0.216$). (See Fig. 1.)

Discussion

The results of this study suggest that the association between the strength of intentions to use condoms and CAI may depend on working memory capacity among moderate- and

Table 2 Negative binomial regression results

Variable	Model 1			Model 2			Model 3			Model 4		
	IRR	95% CI for IRR	*P*	IRR	95% CI for IRR	*P*	IRR	95% CI for IRR	*P*	IRR	95% CI for IRR	*P*
Intercourse days	1.176	1.144, 1.211	< .001	1.164	1.134, 1.196	< .001	1.164	1.134, 1.196	< .001	1.160	1.131, 1.191	< .001
Intent				0.848	0.773, 0.931	< .001	0.848	0.773, 0.931	< .001	1.189	0.860, 1.649	0.329
Working memory							1.005	0.979, 1.032	0.701	1.059	1.003, 1.120	0.052
Intent X working memory										0.982	0.966, 0.999	0.045

As described in the text, an offset variable was used in all four models to account for differences in the number of completed morning surveys received from each participant

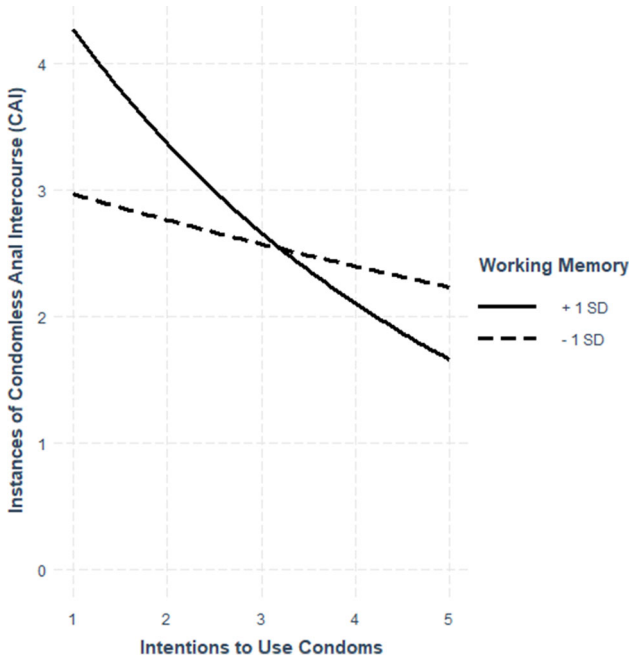

Fig. 1 Simple slopes analysis of impact of working memory capacity on the relationship between condom-use intentions and instances of CAI

heavy-drinking MSM. For individuals with greater working memory capacity, intentions were significant predictors of subsequent behavior. On the other hand, individuals with lower levels of working memory exhibited no significant association between intentions and rates of CAI.

The results of this study are consistent with research that has shown working memory to be a moderator of explicit goal-directed processes and subsequent behavior (Hofmann et al., 2008; Hofmann et al., 2008). Behavioral intentions can be seen as a reflection of an individual's behavioral goals, therefore this study is consistent with past research showing the process of translating such goals into behavior is at least partially moderated by individual differences in working memory (and other executive functions associated with self-regulation; Hofmann et al., 2012).

These findings also suggest that, for individuals with lower working memory capacity, intentions related to condom use behavior may be less likely to guide behavior. It should be noted that stronger working memory does not lead to increased condom use but rather increases the likelihood that individuals act on their intentions. Situational factors that impair working memory capacity, such as alcohol consumption, may also interact with working memory capacity to interfere with goal-directed behavior (Hogarth et al., 2012; Finn et al., 1999). There are a variety of additional processes through which dispositionally lower working memory may impact self-regulatory effort such as those relating to sexual risk behavior. Lower working memory may decrease the ability to identify response conflict and consequently reduce the activation of behavioral inhibition systems (Gray, 1982) in highly tempting contexts (Hirsh et al., 2011). This behavioral disinhibition effect may be exacerbated under situational conditions that further impact working memory such as alcohol intoxication (Finn et al., 1999) leading to heightened risk behavior.

Results suggest that future efforts to increase condom use among MSM may benefit from consideration of individual differences in working memory capacities. In addition to efforts to modify behavioral intentions, those with lower levels of executive functioning abilities may benefit from interventions designed to increase their executive functioning (Klingberg, 2010). This approach has been shown to be helpful in intervention efforts targeting behavior change and self-regulation (Bickel et al., 2011; Houben et al., 2016; Houben et al., 2011). In addition, interventions/prevention efforts may benefit from adjunctive elements that address factors that can interfere with executive functioning, such as alcohol use (Marteau et al., 2012).

There are limitations to note with regard to this study. First, all participants in this sample were recruited from two urban areas in the northeastern region of the United States, which may limit the generalizability of these findings to MSM in other areas of the country. Most partici-

pants were recruited through social media websites/smart phone applications, which resulted in a sample that over-represented MSM with access to these online services. Additional research is needed in order to determine whether these findings apply to more diverse samples. Another limitation is the intention variable used in this study. The gap between the predictive validity of intentions and behavior may be, in part, due to the qualities of behavioral intention measures (Webb & Sheeran, 2006; Sheeran & Webb, 2016). For example, the intention measured in the current study referred generally to one's intention to use condoms and thus does not refer to any specific timeframe or consider variations on a person's intention based on extenuating factors such as partner type. Although we may not expect the impact of working memory to change based on such factors, this will be important to consider in future work.

Overall, these findings show that individuals high in working memory exhibit a stronger association between condom use intentions and CAI, such that higher intentions to use condoms predict greater condom use during sexual behavior. Given that intentions are often an important target of behavior change interventions, these findings suggest that it would be beneficial to address executive functioning in intervention efforts to reduce risky sexual behavior among moderate to heavy drinking MSM for those with low levels of working memory capacity.

Funding This study was supported by the National Institute on Alcohol Abuse and Alcoholism of the National Institute of Health under the award number R01AA022301.

Compliance with ethical standards

Conflict of interest Kelli Tahaney, Tibor Palfai, Peter Luehring-Jones, Stephen Maisto, and Jeffrey Simons declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all patients for being included in the study.

References

Ajzen, I., & Madden, T. J. (1986). Prediction of goal-directed behavior: Attitudes, intentions, and perceived behavioral control. *Journal of Experimental Social Psychology, 22,* 453–474.

Albarracín, D., Durantini, M. R., & Earl, A. (2006). Empirical and theoretical conclusions of an analysis of outcomes of HIV-prevention interventions. *Current Directions in Psychological Science, 15,* 73–78.

Allan, J. L., Johnston, M., & Campbell, N. (2011). Missed by an inch or a mile? Predicting the size of intention—behavior gap from measures of executive control. *Psychology & Health, 26,* 635–650.

Andrew, B. J., Mullan, B. A., de Wit, J. B., Monds, L. A., Todd, J., & Kothe, E. J. (2016). Does the theory of planned behaviour explain condom use behaviour among men who have sex with men? A meta-analytic review of the literature. *AIDS and Behavior, 20,* 2834–2844.

Barrett, L. F., Tugade, M. M., & Engle, R. W. (2004). Individual differences in working memory capacity and dual-process theories of the mind. *Psychological Bulletin, 130,* 553573.

Bickel, W. K., Yi, R., Landes, R. D., Hill, P. F., & Baxter, C. (2011). Remember the future: Working memory training decreases delay discounting among stimulant addicts. *Biological Psychiatry, 69,* 260–265.

Cahalan, D., Cisin, I. H., & Crossley, H. M. (1969). American drinking practices: A national study of drinking behavior and attitudes. *Monographs of the Rutgers Center of Alcohol Studies, 6*, 260.

Cooper, M. L. (2010). Toward a person × situation model of sexual risk-taking behaviors: Illuminating the conditional effects of traits across sexual situations and relationship contexts. *Journal of Personality and Social Psychology, 98,* 319.

Finn, P. R., Justus, A., Mazas, C., & Steinmetz, J. E. (1999). Working memory, executive processes and the effects of alcohol on Go/No-Go learning: Testing a model of behavioral regulation and impulsivity. *Psychopharmacology (Berl), 146,* 465–472.

Fisher, J. D., & Fisher, W. A. (2002). The information-motivation-behavioral skills model. *Emerging theories in health promotion practice and research: Strategies for improving public health, 1,* 40–70.

Fisher, J. D., Fisher, W. A., Bryan, A. D., & Misovich, S. J. (2002). Information-motivation-behavioral skills model-based HIV risk behavior change intervention for inner-city high school youth. *Health Psychology, 21,* 177.

Gollwitzer, P. M., & Sheeran, P. (2006). Implementation intentions and goal achievement: A metaanalysis of effects and processes. In M. P. Zanna (Ed.), *Advances in experimental social psychology* (Vol. 38, pp. 69–119). San Diego: Elsevier.

Gray, J. A. (1982). Précis of The neuropsychology of anxiety: An enquiry into the functions of the septo-hippocampal system. *Behavioral and Brain Sciences, 5,* 469–484.

Hirsh, J. B., Galinsky, A. D., & Zhong, C. B. (2011). Drunk, powerful, and in the dark: How general processes of disinhibition produce both prosocial and antisocial behavior. *Perspectives on Psychological Science, 6,* 415–427.

Hofmann, W., Baumeister, R. F., Förster, G., & Vohs, K. D. (2012a). Everyday temptations: An experience sampling study of desire, conflict, and self-control. *Journal of Personality and Social Psychology, 102,* 1318.

Hofmann, W., Friese, M., & Wiers, R. W. (2008a). Impulsive versus reflective influences on health behavior: A theoretical framework and empirical review. *Health Psychology Review, 2,* 111–137.

Hofmann, W., Gschwendner, T., Friese, M., Wiers, R. W., & Schmitt, M. (2008b). Working memory capacity and self-regulatory behavior: Toward an individual differences perspective on behavior determination by automatic versus controlled processes. *Journal of Personality and Social Psychology, 95,* 962.

Hofmann, W., Schmeichel, B. J., & Baddeley, A. D. (2012b). Executive functions and self-regulation. *Trends in Cognitive Sciences, 16,* 174–180.

Hogarth, L., Attwood, A. S., Bate, H. A., & Munafò, M. R. (2012). Acute alcohol impairs human goal-directed action. *Biological Psychology, 90,* 154–160.

Houben, K., Dassen, F. C., & Jansen, A. (2016). Taking control: Working memory training in overweight individuals increases self-regulation of food intake. *Appetite, 105,* 567–574.

Houben, K., Wiers, R. W., & Jansen, A. (2011). Getting a grip on drinking behavior: Training working memory to reduce alcohol abuse. *Psychological Science, 22,* 968–975.

Klingberg, T. (2010). Training and plasticity of working memory. *Trends in cognitive sciences, 14,* 317–324.

Koblin, B. A., Husnik, M. J., Colfax, G., Huang, Y., Madison, M., Mayer, K., et al. (2006). Risk factors for HIV infection among men who have sex with men. *Aids, 20,* 731–739.

Maisto, S. A., Palfai, T., Vanable, P. A., Heath, J., & Woolf-King, S. E. (2012). The effects of alcohol and sexual arousal on determinants of sexual risk in men who have sex with men. *Archives of Sexual Behavior, 41,* 971–986.

Maisto, S. A., & Simons, J. S. (2016). Research on the effects of alcohol and sexual arousal on sexual risk in men who have sex with men: Implications for HIV prevention interventions. *AIDS and Behavior, 20,* 158–172.

Marteau, T. M., Hollands, G. J., & Fletcher, P. C. (2012). Changing human behavior to prevent disease: The importance of targeting automatic processes. *Science, 337,* 1492–1495.

McEachan, R. R. C., Conner, M., Taylor, N. J., & Lawton, R. J. (2011). Prospective prediction of health-related behaviours with the theory of planned behaviour: A meta-analysis. *Health Psychology Review, 5,* 97–144.

McFarland, W., Chen, Y. H., Nguyen, B., Grasso, M., Levine, D., Stall, R., et al. (2012). Behavior, intention or chance? A longitudinal study of HIV seroadaptive behaviors, abstinence and condom use. *AIDS and Behavior, 16,* 121–131.

Montanaro, E. A., & Bryan, A. D. (2014). Comparing theory-based condom interventions: Health belief model versus theory of planned behavior. *Health Psychology, 33,* 1251.

Sheeran, P., & Webb, T. L. (2016). The intention–behavior gap. *Social and Personality Psychology Compass, 10,* 503–518.

Shuper, P. A., Joharchi, N., Monti, P. M., Loutfy, M., & Rehm, J. (2017). Acute alcohol consumption directly increases HIV transmission risk: A randomized controlled experiment. *Journal of Acquired Immune Deficiency Syndromes, 76*(5), 493–500.

Teng, Y., & Mak, W. W. (2011). The role of planning and self-efficacy in condom use among men who have sex with men: An application of the health action process approach model. *Health Psychology, 30,* 119.

Turner, M. L., & Engle, R. W. (1989). Is working memory capacity task dependent? *Journal of Memory and Language, 28,* 127–154.

Webb, T. L., & Sheeran, P. (2006). Does changing behavioral intentions engender behavior change? A meta-analysis of the experimental evidence. *Psychological Bulletin, 132,* 249.

Wray, T. B., Celio, M. A., Pérez, A. E., DiGuiseppi, G. T., Carr, D. J., Woods, L. A., & Monti, P. M. (2019). Causal effects of alcohol intoxication on sexual risk intentions and condom negotiation skills among high-risk men who have sex with men (MSM). *AIDS and Behavior, 23*(1), 161–174.