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Translation of basic research in cognitive science to HIV-risk: a randomized controlled trial

Alan W. Stacy[1] · **Liesl A. Nydegger**[2] · **Yusuke Shono**[3]

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Abstract Many people enrolled in drug diversion programs are not receiving evidence-based prevention for HIV or hepatitis. This study translated basic research from cognitive science to increase screening for infection and condom use in this population. A parallel three-condition randomized trial was conducted in a drug diversion sample (N = 358), comparing a memory practice condition with two active control conditions. Outcomes were condom use frequency and testing for infection (hepatitis B/C, HIV). At 3-month follow-up, participants in the memory practice condition were at least twice as likely (OR = 2.10 or greater, $p < .01$) to self-report testing compared to those in the control conditions and also reported more frequent condom use compared to a health education condition [B = .37, $t(1) = 2.02$, $p = .02$]. Basic research on memory can be effectively translated to brief interventions on infection screening and risk prevention in existing drug diversion programs.

Keywords Cognitive science · HIV/AIDS · Hepatitis · Screening · Condom use

✉ Alan W. Stacy
alan.stacy@cgu.edu

[1] School of Community and Global Health, Claremont Graduate University, 675 West Foothill Boulevard, Suite 310, Claremont, CA 91711-3475, USA

[2] Department of Kinesiology and Health Education, University of Texas, 2109 San Jacinto Blvd., Stop D3700, Austin, TX 78712, USA

[3] Department of Psychiatry and Behavioral Sciences, University of Washington, 1100 NE 45th Street, Suite 300, Box 354944, Seattle, WA 98195-4944, USA

A widespread population in need of evidence based intervention

People who use noninjection drugs are frequently a neglected population, at sufficient risk for HIV and other infections to warrant intervention (Crawford & Vlahov, 2010). They are characterized by low or inconsistent condom use and regularly exhibit other risky behaviors, such as sex with multiple partners, engagement in sex with people who use injection drugs, and sex work (Castor et al., 2010). A principal route for the transmission of HIV/AIDS is through these risky sexual practices (Zuckerman & Boyer, 2012); unprotected anal sex greatly exacerbates risk. Although injection drug use is also a well-established hazard, in 2015 less than 10% of HIV infections were transmitted through the injection route (CDC, 2018). Yet, relative risk regarding sexual practices and lack of condom use is quite similar between people who use injection drugs and those who only use noninjection drugs (Des Jarlais et al., 2007; Shoptaw et al., 2013). Although many interventions have been designed to address these risks (for reviews, see Aletraris & Roman, 2015; Underhill, Dumont, & Operario, 2014), some widespread settings and populations have not been a focus of evidence-based intervention or intervention development.

One of the widespread and nationally available sites for intervention in people who use noninjection drugs is through existing court-referred drug education programs (Longshore et al., 2005), where substantial numbers of individuals with infection risks can be found. Individuals in drug diversion programs are convicted of non-violent drug offences such as low-level drug possession and being under the influence. They commonly use alcohol, cocaine or crack cocaine, and less frequently amphetamines and heroin (Hser et al., 2003). Diversion participants tend to be

male and self-report primarily as heterosexual, though a minority report sex with the same sex (Nydegger, Ames, & Stacy, 2017). Although heterosexuals are not usually considered the priority for HIV prevention interventions, several findings suggest that intervention research in the diversion population is important (Castor et al., 2010; Festinger, Dugosh, Kurth, & Metzger, 2016). For example, there is a strong association between drug use and HIV risk behaviors (Des Jarlais et al., 2007), a higher than expected prevalence of infection risk behaviors among drug court participants (Festinger, Dugosh, Metzger, & Marlowe, 2012), and high rates of HIV in some areas in which such participants live (Festinger et al., 2012). When opportunities for intervention exist, then programs for drug diversion clients could help promote infection screening and condom use.

In California and many other states, these drug diversion programs occur in classroom settings amenable to rigorous preventive interventions. However, *evidence-based* HIV risk programs are not typically provided in these settings. This may appear inconsistent with a recent major review that reported that some research on HIV risk prevention has been conducted in drug offender samples (Underhill et al., 2014). However, these rare studies were not conducted in drug court or diversion settings and only a small minority of participants in the several studies were recruited from drug court/diversion programs (less than 22% in any single study). Despite the absence of evidence-based infection prevention in such settings, drug diversion programs commonly provide HIV education since some county-level contracts require one or two sessions on the topic. Even if people in drug diversion programs are not considered the highest risk priority, availability of evidence-based programs tested in this setting would fulfill an unmet need. Thus, one major goal of the present study was to test a new intervention designed to increase infection screening and reduce infection risk in diversion participants in actual drug diversion classroom settings. Although many fairly lengthy educational approaches to HIV risk could be relevant in diversion settings (Underhill et al., 2014), the study was designed to test a very short, and hence potentially useable, intervention tailored to the setting.

Translation of compelling basic research

A second major goal of the present article is to expand the scope of basic research translated to this research area. Although there are many existing, lengthy infection prevention interventions (listed in Underhill et al., 2014) that might be suitable for drug diversion programs if time allowed, none have applied some compelling areas of basic research to the topic. Yet, there are reasons to believe basic research can be harnessed to investigate normally untapped intervention avenues suitable for short interventions.

The particular focus here is on translation of basic research in cognitive science, because this research has addressed memory strategies that help people access and use newly learned information of all types—an issue relevant to drug diversion and other risk reduction programs. This is important, because it is difficult to imagine how information or skills learned in a program are used by individuals if the information is not eventually retrieved or accessed from memory in some form. One of the most compelling and efficient strategies uncovered in this research is *retrieval practice*. Across many studies, retrieval practice of newly learned information has been shown to have powerful effects on subsequent memory for newly learned material (Karpicke, 2012). Retrieval practice procedures use a variety of "memory prompting or testing" strategies that help most anyone more readily access and use previously learned information, and the utility of the strategies is validated by criteria that match responses to "correct" (target or preventive) responses (Roediger & Butler, 2011). A recent meta-analysis demonstrated robust, strong effects of retrieval practice across one hundred and fifty-nine effect sizes reported since 1975 (Rowland, 2014), and the most recent studies continue to document the increasingly recognized importance and generality of the effect (Abel & Roediger, 2017). Retrieval practice essentially makes newly learned information much more accessible (top of mind) in memory when needed. In complex everyday situations relevant to HIV risk, preventive steps that are easily retrieved or accessed have a chance to compete with the many everyday activities that do not normally prompt top of mind preventive thoughts and actions.

Although some forms of memory testing (such as a test of knowledge of health facts) are superficially similar to retrieval practice, retrieval practice derived from basic research has not been previously used as a systematic *intervention tool* in infection risk interventions or prevention research. As an intervention tool, retrieval practice is different from traditional knowledge tests that can often inadvertently enhance memory for the wrong or inappropriate answer (Roediger & Butler, 2011). Although the approach potentially could be integrated with well-known health behavior frameworks, memory approaches from basic research focus on cognitive assumptions that are entirely different from those characterizing most health behavior theories. As just one example from basic memory research, memory retrieval assessed through well-controlled performance tests is fundamental to the effects of learning and is of paramount concern. Retrieval governs whether, when or where, and how easily learned information is accessed and used. In some traditional health

behavior theories, retrieval may be listed as a cognitive barrier with other barriers, which are typically assessed through self-reported thoughts or beliefs, or it may not be mentioned at all. Yet, the goal here is only to introduce differences in assumptions relevant to memory retrieval, not to debate the merits of alternative paradigms. Theoretically, retrieval practice is likely to have effects through neural circuits that engage multiple neural systems (Henke, 2010) and a cascade of different memory processes (Roediger & Butler, 2011), revealing another paradigmatic difference.

Retrieval practice procedures can harness additional findings uncovered in basic memory research, such as the power of image processing, that is, the use of systematic imagery techniques. These procedures may be particularly important to help diversion clients practice memory retrieval by integrating new information with situational prompts or cues they are likely to face—cues that can be used as reminders that may be essential for preventive plans that reduce infection risks. Basic research on imagery has long been used to effectively integrate new information (Graf & Schacter, 1989), and the research area has evolved into a rigorous and active area of cognitive neuroscience (Kaplan et al., 2017; Kosslyn, Ganis, & Thompson, 2001). Further, specific forms of imagery have been found to engage the motor system, revealing benefits of motor imagery for improving motor preparation and performance in other research areas (Caligiore et al., 2017; Hovington & Brouwer, 2010; Robin et al., 2007). Motor preparation and performance is quite relevant to preparation and actions for preventive steps, including those that reduce infection risks.

Overview

In the present study, integrative visual and motor imagery, coupled with systematic manipulation checks, are used in concert with retrieval practice to link cues to preventive actions in memory. Such procedures were tailored to the drug diversion population and the infection risk topic through user friendly procedures that acknowledge cues of relevance as well as reasonable, simple action plans. The authors vary the procedures in different memory retrieval tasks to help make cues for action plans relevant to individual situations and salient (McDaniel & Scullin, 2010). Application and evaluation of this research is potentially important for the diversion population, which is in need of short evidence-based programs evaluated with real-world constraints in the specific setting, and for promotion of Type I and II translational research (Fishbein, Ridenour, Stahl, & Sussman, 2016), designed to harness and test untapped but compelling basic research.

The dependent variables in the study are screening (testing for HIV, other sexually transmitted infections, and hepatitis B/C) and a preventive behavior (condom use). Two self-contained intervention sessions were delivered, with each session the focus of one of the two dependent variables. The trial randomized three different experimental conditions in a cumulative, parallel design in which retrieval practice was compared to two active control groups. Participant assignment was yoked across intervention session. The design provides a test of whether the procedures translated from cognitive science and delivered in drug diversion settings increased screening and preventive behavior at 3-month follow-up.

Methods

Participants and recruitment

The study took place between October 2013 and March 2016. Drug diversion programs serving clients diverted from the criminal justice system (under Penal Code 1000, PC 1000) throughout the greater Los Angeles region were eligible to participate. Some programs welcomed an intervention study on infection risks, but others had a policy not to participate in research. Programs were reimbursed $50 per study session to help coordinate the scheduling of the study with their staff. Participants were sampled from the pool of these available programs. The planned overall sample size (N = 375) was determined on the basis of power analysis, anticipating small to medium effect sizes from each of the two interventions delivered. The randomized sample (N = 358) was somewhat smaller than planned and data collection was stopped when enrollment at available diversion programs subsided and precluded reaching the target sample size with time for follow-up during the project period. Drug diversion sites were chosen on the basis of availability in the area, and each served a wide mix of ethnic groups reflective of the Los Angeles region. All participants attending available diversion classes were at least 18 years old and were eligible to participate if they spoke English and were not intoxicated. There was not sufficient availability of Spanish speaking diversion classes to propose, develop, and test a Spanish language version of the intervention. Consent materials emphasized the completely voluntary nature of the study, independence from the diversion program, and confidentiality. Some participants declined to participate (10.6%), which has been fairly typical in previous studies in court-referred programs in this region and numerically reveals that participants were free to decline. A trained data collector not affiliated with the diversion program read and distributed a recruitment flyer in a regular diversion class

either 1 week prior to the first intervention session or on the days of the intervention sessions. The flyer described that the study was testing different ways to help people reduce infection risks for HIV and hepatitis. The flyer also emphasized the confidential and completely voluntary nature of the study and all other characteristics of the study such as independence from diversion program, risks and benefits, security of data protected by a Federal Certificate of Confidentiality, and other details. At the request of diversion programs, participants were invited to enroll and were consented during either of the intervention sessions. Participants who did not consent were nonetheless invited to attend the sessions if they chose, which allowed them to blend in with participants, receive education, but not provide data. The study allowed attendance at either or both sessions and variation in the timing of consent before the study, because program attendees often miss sessions in diversion programs, some intervention may be better than none, and the authors wanted to enhance the ecological validity or generalizability in accord with the nature of the diversion setting. Further, each intervention session was self-contained, with a distinct outcome, and did not depend on the other session. Potential participants were asked to follow-along while the flyer was read. They were given an IRB approved consent form to read and complete if they wanted to participate. Participants were compensated in a cumulative manner for participation, depending on the number of study sessions they attended (from 1 to 3), with a minimum of $15 and maximum of $60. Participants were compensated more for follow-up sessions than initial sessions. A university IRB approved the research.

Experimental design and procedure

Because of the ability of participants to consent during either intervention session covering distinct issues, the trial was effectively separated into two sub-trials that focused on a different intervention and outcome variable of focus at the two different sessions in the study: Session 1 (S1) focused on condom use; Session 2 (S2) focused on infection testing. The basic procedure of the intervention was identical across sessions, but the health-related content of the activities was entirely different. Some participants only consented and attended during one of the sessions, while some attended both sessions; this variation was accounted for in the data analysis. Within the two sub-trials, the concept of intention to treat (ITT) was maintained in the analysis. The experimental parallel group design within each session manipulated three conditions: Health Education only (HE), Action Plans (AP), and Memory Practice (MP). A randomized (true experimental) design was used with pretests for preventive behaviors that were assessed on the same day as the intervention sessions. The conditions were equated for intervention time, on the basis of several pilot studies. All participants in both sessions first received live health education, which was conducted in a small group, classroom-like setting, delivered in-person (live) by a health educator. Following live health education, each participant was assigned a laptop in the same classroom. An algorithm programmed into the laptop then automatically randomly assigned participants to one of the three conditions within each diversion classroom. Instructions and intervention procedures were automatically presented to participants on their laptop screen as well as over noise cancelling headphones. Participants from all conditions received the intervention and assessments together (maximum of 17) in the same large room but were well isolated from one another, and each laptop included a privacy screen protector that maintained masking of assignment to condition to other participants as well as to program and project staff, who were also blind to the specific hypothesis. The investigators had no contact with participants and were thus blind to condition. Although no participants were excluded from the analysis (ITT was maintained), a few participants included in the analysis did not provide sufficient valid data because they began but did not complete the intervention session (n = 6), did not have sufficient knowledge of English (n = 2), were intoxicated during baseline assessment (n = 1), had invalid contact information (n = 2), or were distributed the wrong laptop (n = 1). The ITT analysis effectively handled these cases by treating them as missing and using a well validated missing data estimation procedure outlined below in the article.

The pretests assessed target behaviors (e.g., HIV testing, condom use) covering a time frame before the intervention session (e.g., past year condom use). However, because of diversion program logistics and feasibility, these measures were assessed immediately following the intervention sessions and after assessment of several other measures described below. Importantly, the participants could not possibly have engaged in the target behaviors between the intervention procedures and these nearly simultaneous assessments. Nevertheless, it is best to classify these measures as *proxy pretests*. A pretest could not be assessed before the day of the intervention sessions because diversion programs would only allow three sessions for this study.

The interventions and assessments requested participation at up to three different times; each session was a maximum of 1½ h. The first two sessions (separated by 1 week) were devoted to the intervention, proxy pretests, and other assessments. The final session (S3; 3 months following S2) was devoted entirely to follow-up assessment. Each of the three conditions received the same duration of intervention exposure and number of sessions. The intensity of exposure was controlled across condition

by including interactive questions during later phases of HE and AP conditions while subjects in the MP condition engaged in specific steps outlined below.

Intervention procedures for condom use (S1)

Condom use was the focus of the first intervention session (S1). The three conditions first received live health education on HIV/AIDS following recommendations of the CDC and evidence-based research (Calsyn et al., 2009), including well-documented HIV risks, barriers to preventive behavior, preventive steps such as condom use, monogamy, and using new needles (for the rare injection drug users in the diversion population), a condom demonstration, and an introduction and group discussion of action plans using mental imagery. The education delivery was similar to what participants normally receive from diversion programs and involved presentation mixed with active discussion.

In the *Health Education (HE) Condition (at S1)*, participants received the live health education just described followed by two supplementary but informative videos (AIDSvideos.org) presented on individually-assigned laptops on HIV risk, condom use, and safe sex. These widely used videos (Global Life Works, 2012) are more relevant for the heterogeneous drug user population than a variety of alternative videos. Two additional supplementary videos created by the CDC were also presented so that participants would finish the procedure at approximately the same time as participants in other conditions. The HIV videos were interspersed with 30 multiple-choice and yes–no computerized questions requiring a response, designed to encourage active attention and more intensive processing than viewing alone. An analysis of these questions from previous pilot studies revealed that control participants' mean proportion correct was 82% (*SD* = .14); coupled with strong internal consistency (α = .91; low random error), this suggests good attention to the material and assessments. The HE condition was essentially a "standard care" active control.

In the *Action Plan (AP) Condition (at S1)*, participants received the same live heath education followed by instructions on laptops in the following two steps:

1. On the first laptop screen, participants were introduced to linking particular situational cues to a condom-related behavior by selecting a situation for the behavior among a list of five situations relevant to this population. To help diversion participants understand these procedures, the situations and behavior were listed in an if–then structure guided by, and similar to, research on implementation intentions (Gollwitzer, 1999). The five situations in the list varied so that at least one situation could be relevant to any participant, regardless of their current partnership situation (e.g., *When I am getting ready to go out to party or to a bar*; *When I am getting ready to go out with my new partner; When I am walking toward the door to leave my place*). The first behavior presented was, *I will put condoms in my pocket or purse*. Participants were asked to select one situation, with mouse click, from the list.
2. After a situation was selected for the behavior on the first screen, participants were asked on a second screen to type a statement that repeats the linkage they have chosen (e.g., *When I am going out, I will put a condom in my pocket or purse*). After this screen, a new condom behavior, *I will stop on the way to buy condoms,* was presented and participants were again asked to select a cue from a list of five different situations (e.g., *When I have left home without condoms*) engaging in the two steps just outlined. Two additional sets of condom behaviors were provided to participants in these same two steps. Subsequently, participants in the AP condition observed the same HIV videos as in the HE condition, as well as one of the other health related videos to equate for completion time across conditions; they received identical interactive questions during the identical HIV videos.

In the *Memory Practice (MP) Condition (at S1),* four computerized procedures were added following all procedures from the AP condition up through the cue-selection phase. No videos were presented.

1. *Associative recognition and initial semantic task*. For each of the behaviors outlined in the AP condition, participants were asked to select the situational cue (e.g., when I am going out) they previously chose in an extremely easy multiple-choice format with three alternatives and automated feedback.
2. *Visual and motor imagery*. Tasks fostering visual and motor imagery were completed for each of the four cue-action pairs from the cue-selection phase (e.g., When I am going out, I will put a condom in my pocket or purse). The next steps requested the participants to imagine and type their location and a part of their body moving in their mental picture. A final screen for each pair asked participants to rate on a four-point scale (very clearly to not at all) how clearly their mental picture was (Baddeley & Andrade, 2000).
3. *Situation-behavior matching*. Following the imagery procedures, all four chosen situations were listed in one column adjacent to a second column that listed the condom behaviors on a single screen. Participants were asked to choose with a mouse click the preventive behavior that he or she originally linked to each situation. Automated feedback was provided.

4. *Cued-recall.* This active retrieval task presented each of the four chosen situations one by one (on separate screens). Participants were instructed to remember and type in the action, in their own words, that they linked previously to the situation. Immediately after each of the responses, the next screen presented the situation again followed by the correct (previously chosen) action. Participants were asked to code their response as correct or incorrect and were shown the situation with the correct answer one more time. Next, two intervening screens assessed demographic questions and provided a short delay. The final task in this series provided a final cued-recall test instructing participants to type the action they previously linked to each of the four situations. No self-correction or feedback was provided at this stage.

Intervention procedures for HIV/HBV/HCV testing (S2)

The second session (S2) focused on testing for HIV and hepatitis infections. All steps and sequences were identical to those in S1 (not reiterated here) and only varied in content (situations and behaviors). For those who attended S1 as well, the assignment to conditions was yoked to initial random assignment at S1. The outcome analysis below fully accounts for the allocation pattern across session. The live health education for all conditions at S2 was based on CDC, Los Angeles County Commission on HIV, and other recommendations (Tross et al., 2008; Workowski et al., 2010). In each condition this content focused on the need for testing for HIV and hepatitis B and C viruses (HBV, HCV) and testing/counseling locations. It also included basic information about the viruses, testing procedures, confidentiality/anonymity of testing, and introduction and discussion of action plans about testing for infection and using mental imagery for action plans. The videos (AIDSvidoes.org) focused on infection testing, following guidelines from the CDC (Branson et al., 2006).

In AP and MP conditions, participants choose situations as in S1 but the situations were linked to four important testing-related behaviors: calling a clinic for testing hours, jotting down a reminder and specific time to get tested, talking with partner or friend for support, and going to the clinic for test results. Example cues are: *If I am afraid to get tested* (I will talk with my partner or friend to help me get tested); *When I return home tomorrow* (I will call a clinic for testing hours); *When I get the clinic hours* (I will jot down a reminder and time to get tested); *When my test results are ready* (I will go to the clinic for my test results).

Measures

Dependent variables

Infection testing and condom use outcome variables were assessed at S3. *Past 3-month HIV, HBV, HCV, and other sexually transmitted disease testing* were assessed with items adapted from the AIDS Risk Behavior Assessment (Donenberg et al., 2001). The four items assessed on a 5-point scale the number of times participants were tested in the past 3 months from zero to four or more times. Because local testing centers usually help clients decide which infection test they need, and if additional tests are necessary, it was considered preventive if any infection testing was reported. Thus, the a priori primary outcome variable used the preceding three scales to derive a binary score of any infection testing in past 3 months (yes or no). *Past 3-month general condom use* was assessed with three condom use frequency items based on the HIV Risk-taking Behavior Scale (Darke et al., 1991). The questions asked how often participants used condoms in the past 3 months when having sex with a casual partner, multiple partners, or someone "you had never had sex with before," on five point scales from "never" to "always."

Other assessments

Demographic measures included age, gender, ethnicity, and employment status. Various behavioral and health status variables were assessed. *Past 12-month condom use* and *Past 12-month and lifetime infection testing (HIV, HBV, HCV, other STIs)* were measured as previously described for 3-month outcome variables. These variables were assessed at S1 or S2 yoked to the intervention target at that session and served as proxy pretests for condom use and testing. Other assessments were also distributed across the intervention sessions because of the focus of the two sub-trials and time constraints imposed by the diversion programs. They included past 12-month alcohol and other drug use (Graham et al., 1984), relationship status, and multiple sexual partners (Richardson et al., 2004).

Data analysis

To assess the adequacy of randomization at each session, comparability across intervention conditions was evaluated using Pearson's Chi square tests for categorical variables and analysis of variance (ANOVA) or multivariate analysis of variance (MANOVA) for continuous variables. Attrition analyses were conducted separately for condom use and infection testing interventions since the current outcome

analyses for each intervention included only those who participated in the intervention of focus.

Outcome analyses testing for the intervention effects were conducted on the basis of ITT principles. That is, all the participants who had been randomized at each intervention session were included in the outcome analyses regardless of their availability at 3-month follow-up (S3). Missing data were handled with multiple imputation (MI) methods to minimize potential bias of estimating intervention effects. Briefly, missing values were imputed by the multivariate imputation by chained equations (MICE) under SAS PROC MI, which generated 20 multiple imputed data sets to which regression models were applied (logistic regression for infection testing and linear regression for condom use). Subsequently, the parameter estimates and standard errors were pooled using PROC MIANALYZE. The MI models included the outcome variable and several auxiliary variables (e.g., demographics) to increase the likelihood that the assumption of missing at random (MAR) could be held. Due to a priori directional hypotheses (see introduction above), one-tailed tests were used where appropriate.

Logistic regression analyses were performed evaluating infection testing intervention effects and linear regression analyses were conducted to test for condom use intervention effects. To account for the clustering of the data in which participants were nested within intervention sites, cluster robust standard errors were estimated (Williams, 2000). Supplementary analyses were also undertaken to assess potential intervention dose effects on infection testing and condom use. Intervention dosage was defined as the number of intervention sessions individuals participated in (testing intervention only or both condom use and testing interventions).

Results

Session and condition sample sizes

Participants (N = 358) were present at either both interventions (n = 241), only Session 1 (S1, n = 53), or only Session 2 (S2, n = 64). This variation is an inevitable product of research within existing drug diversion programs in the field, and entire diversion classes were recruited and assessed in existing classes at the request of diversion programs. It is common for clients to miss consecutive classes. Nevertheless, the data analysis fully accounted for this variation, and the two interventions were not only self-contained but focused on different dependent variables (infection testing or condom use). Since a pure form of randomization was employed in the automatic randomization algorithm, as expected sample sizes were not equal across condition. Of 294 total participants at S1, 110 were allocated to the MP condition, 94 to the AP condition, and 90 to the HE condition. Of 305 total participants at S2, 117 were allocated to the MP condition, 101 to the AP condition and 87 to the HE condition. A flow chart of participation and the ITT analysis is depicted in Fig. 1.

Randomization and attrition check

Randomization

No significant group differences were found in demographic and previous behavior variables relevant to condom use or infection testing outcome variables with one exception: Lifetime infection testing measured at S2 was significantly different among intervention conditions, χ^2 (2) = 10.11, $p < .01$ (Table 1). Supplementary outcome analyses reported below were conducted to take into account this and other possible effects of potential confounding variables selected according to substantive relevance.

Attrition

Among the 294 individuals at S1, 81% of those in the MP condition, 77% of the AP condition, and 84% of the HE condition remained at S3. No significant association was found between attrition status and intervention condition at this session, χ^2 (2) = 1.82, $p > .40$, suggesting that participants' attrition from the study before S3 was not associated with condom use intervention conditions. Of the 305 individuals at S2, 83% of those in the MP condition, 73% of those in the AP condition, and 87% of those in the HE condition were retained at S3. The association between attrition status and infection testing intervention condition was statistically significant, χ^2 (2) = 6.48, $p = .04$. Follow-up multiple comparisons with adjustment of Type-1 error revealed that attrition rates were higher for the AP condition than the HE condition ($p < .02$). The most common reason for attrition was failure of participant to respond to repeated requests to complete the assessment (HE = 8; AP = 22; MP = 21). The ITT analysis included all participants regardless of attrition status.

Intervention effects

Infection testing intervention

Results indicated that participants in the MP condition were twice as likely to self-report an infection test compared to participants in both the HE (OR = 2.10, B = .74, $p < .01$) and AP (OR = 2.12, B = .75, $p < .01$) conditions

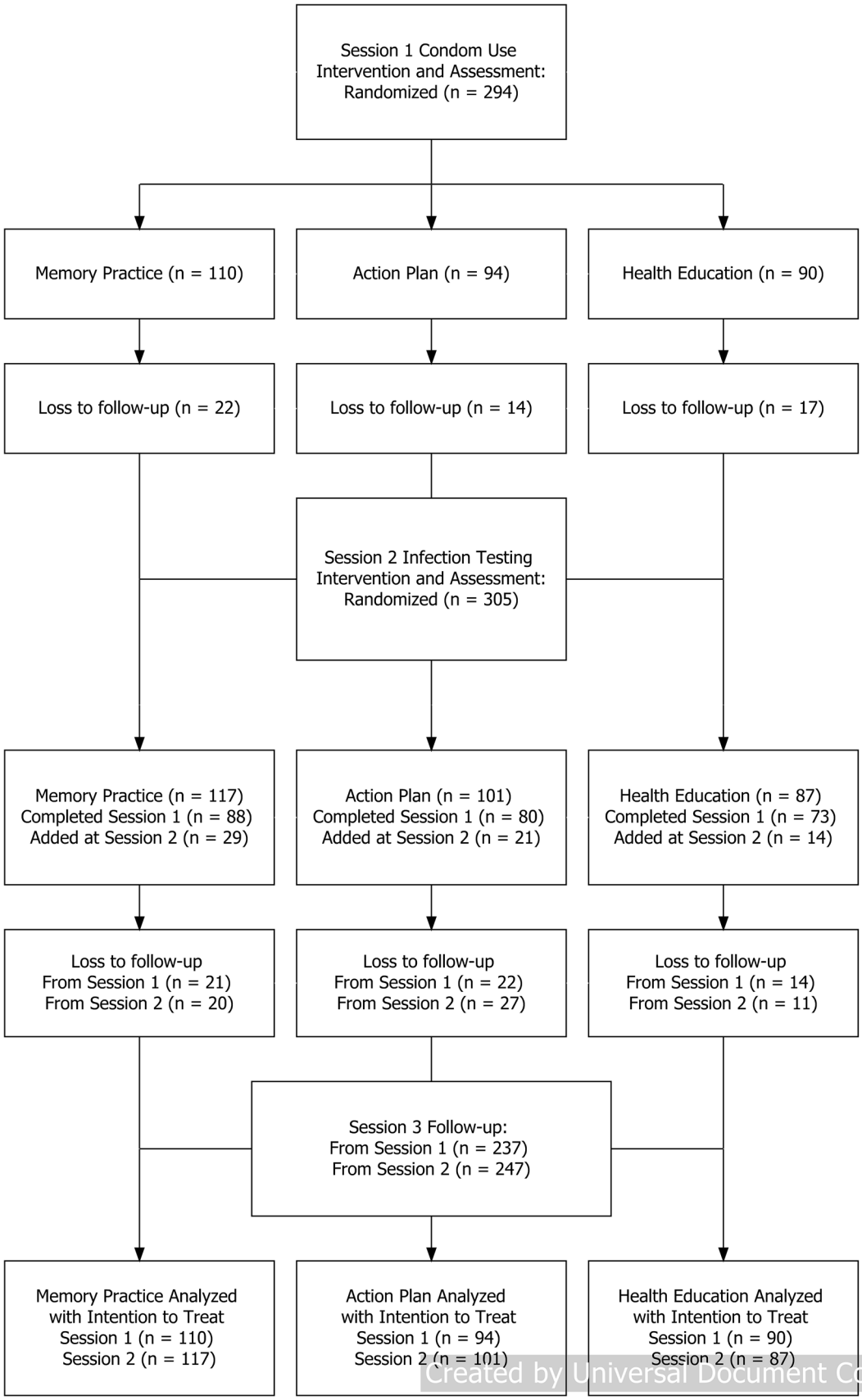

Fig. 1 Flow chart of participation and analysis

Table 1 Demographics and behavior measures by intervention condition

Variable	Condom use intervention (S1)			p^d	Infection testing intervention (S2)			p^d
	MP	AP	HE		MP	AP	HE	
Age (SD)	30.5 (10.5)	29.7 (10.2)	31.8 (12.1)	.46	29.7 (9.5)	30.2 (10.5)	31.4 (12.4)	.57
Female %	32.7	27.2	28.1	.65	26.8	28.3	25.6	.92
Hispanic %	64.8	70.0	57.8	.60	61.9	59.5	50.7	.68
Race-white %	65.2	62.3	65.0	.93	35.0	40.6	43.7	.44
Employment rate %	71.3	62.3	60.3	.26	72.0[e]	60.9[e]	58.6[e]	.20[e]
Exclusive relationship %	37.3	28.4	30.6	.4	80.0	76.5	79.0	.89
Mean condom use past 12 months[a]								
Casual partners (SD)	2.81 (1.32)	2.71 (1.34)	2.58 (1.39)	.78[f]	2.82 (2.31)[e]	2.60 (1.37)[e]	2.51 (1.40)[e]	.62[f]
Main partners (SD)	2.12 (1.35)	2.09 (1.37)	2.06 (1.36)	.78[f]	2.10 (1.38)[e]	2.04 (1.41)[e]	1.97 (1.36)[e]	.62[ef]
Mean multiple partners 12 months[b]								
Casual partners (SD)	6.39 (6.90)	6.46 (6.98)	6.04 (6.78)	.92	6.11 (6.42)[e]	6.54 (7.08)[e]	5.98 (6.48)[e]	.88[e]
Mean drug use past 12 months[c]								
Alcohol (SD)	4.39 (3.33)	4.71 (3.69)	3.90 (3.24)	.35[f]	4.28 (3.27)[e]	4.42 (3.58)[e]	4.02 (3.27)[e]	.75[f]
Other drugs (SD)	1.72 (1.50)	1.81 (1.85)	1.95 (1.72)	.35[f]	1.69 (1.52)[e]	1.84 (1.92)[e]	1.96 (1.72)[e]	.75[ef]
STD testing—lifetime %	80.5[e]	82.7[e]	67.1[e]	.06[e]	82.5	82.8	65.5	.01
STD testing—12 months %	51.7[e]	54.7[e]	42.9[e]	.34[e]	53.5	52.7	39.3	.10

S1 Session 1, *S2* Session 2, *MP* memory practice, *AP* action plan, *HE* health education

[a]Condom use past 12 months was assessed with a 5-point rating scale (4 = always, 0 = never); higher scores indicate less risk

[b]Multiple partners were assessed by the sum of four items with 7-point rating scale [0 = 0, 6 = 6 or more, range (0, 24)]; higher scores indicate more risk

[c]Drug use was assessed with an 11-point rating scale (0 = none, 1 = 1–10 times … 10 = 91 + times); higher scores indicate more risk

[d]*p* values for the tests of difference across intervention conditions

[e]Values represent responses by participants assessed at both S1 and S2

[f]Identical adjacent *p* values are from a MANOVA with two dependent variables

(Table 2). The risk difference (RD) for self-report of an infection test between the MP condition and the HE or AP condition was .17 (95% CI [.03–.31]), indicating that there were about 17 additional cases of self-report of infection testing per 100 participants in the MP condition, compared to the AP or HE condition. Comparable intervention effects were obtained while controlling for potential confounders including age, gender, Hispanic ethnicity, relationship status, and lifetime testing status as a proxy pretest (Table 2). Adjusting for these potential confounding vari-

Table 2 Summary of outcome analyses for condom use and infection testing interventions

	Condom use intervention (S1)			Infection testing intervention (S2)						
	B	*SE*[a]	*p*[b]	*B*	*SE*[a]	*p*[b]	*OR*	95% CI	RD	95% CI
Unadjusted model										
MP versus HE	.37	.18	.02	.74	.32	.01	2.10	[1.12, 3.91]	.17	[.03, .31]
MP versus AP	.26	.22	.12	.75	.31	.01	2.12	[1.15, 3.93]	.17	[.04, .31]
Adjusted model[c]										
MP versus HE	.42	.23	.04	.74	.33	.01	2.10	[1.10, 3.99]	.15	[.004, .30]
MP versus AP	.18	.24	.22	.88	.34	.01	2.41	[1.25, 4.69]	.16	[.03, .29]

S1 Session 1, *S2* Session 2, *MP* memory practice, *AP* action plan, *HE* health education, *OR* odds ratio, *RD* risk difference

[a]Robust standard errors

[b]One-tailed *p* values

[c]Potential confounding variables included in the adjusted model for condom use (S1) were: age, gender, hispanic ethnicity, race, relationship status, baseline drug use and condom use. Potential confounding variables included in the adjusted model for infection testing (S2) were: age, gender, hispanic ethnicity, relationship status, and lifetime testing

ables, participants in the MP condition were 2.10 times (B = .74, $p < .001$) and 2.41 times (B = .88, $p = .01$) as likely to self-report an infection test compared to participants in the HE and AP conditions, respectively. The RD was .15 (95% CI [.004, .30]) and .16 (95% CI [.03, .29]) between MP and HE and between MP and AP, respectively. When lifetime testing was replaced with 12-month testing in this adjusted model, similar MP intervention effects were again observed relative to HE (OR = 2.22) and AP (OR = 2.14) conditions. A logistic regression analysis examining the effects of intervention dose on infection testing showed no dose effect ($p > .18$), indicating that the condom use intervention did not augment the effects of testing intervention on reported infection testing behavior.

Condom use intervention

Planned comparisons of the mean condom use scores revealed that participants in the MP condition ($M = 2.80$, $SD = 1.25$) reported using condoms statistically significantly more often than those in the HE condition ($M = 2.35$, $SD = 1.46$) during the past 3 months, B = .37, $t(1) = 2.02$, $p = .02$. No significant difference was found between the MP and AP ($M = 2.50$, $SD = 1.52$) conditions, B = .26, $t(1) = 1.18$, $p = .12$. The effect size of the mean difference was small (Cohen's d = .33). Adjusting for potential confounders including age, gender, hispanic ethnicity, race, relationship status, drug use, and previous condom use as a proxy pretest, participants in the MP condition reported greater condom use at posttest than those in the HE condition, B = .42, $t(1) = 1.80$, $p < .04$. Participants in the MP and AP conditions did not differ significantly in reported condom use at S3, B = .18, $t(1) = .77$, $p = .22$. No evidence of intervention dosage effects (S1 only or S1 and S2) was obtained on condom use reports ($p = .38$), suggesting that there was no additional effect of testing intervention on condom use.

In supplementary analyses available on request, intervention effects on infection testing and condom use were analyzed using the full sample assuming that all participants consented before S1 and thus had the chance to participate in both sessions. In these findings, the pattern of significance across conditions was identical, and the odds ratios and effect sizes were comparable.

Discussion

This study has shown that diverse procedures from cognitive science, not often applied to health issues, can be readily applied to HIV interventions. The computerized protocol was designed to help participants easily accomplish intervention tasks; yet the procedures applied several key concepts showing strong support in basic research. Importantly, participants assigned to the memory practice condition were approximately twice as likely to self-report getting tested for infection as those in the comparison groups. The procedures also showed some promise for condom use, though the effect on this outcome was small. The memory practice condition led to only slightly more frequent self-reported condom use in comparison with the health education condition. It did not reveal a statistically significant difference when compared to the action plan condition, though the means across condition were in the expected direction.

The additional intervention procedures in the memory practice condition focused on retrieval practice through associative recognition and cued-recall of cue-action pairs, in line with numerous but largely untapped findings from basic research documenting strong effects of retrieval practice (Karpicke, 2012; Rowland, 2014). The procedures were further buttressed by applying research on additional areas of basic cognitive research. Further, the procedures virtually ensured adequate processing, as confirmed by an analysis of critical responses and objective criteria such as cued-recall and recognition tests available from the authors. In traditional classroom education in the drug diversion setting and similar settings, intervention is typically focused on group education and discussion where individualized feedback of processing is difficult. Group procedures can be effective and some individuals may be quite actively engaged. However, similar to a college classroom, such engagement does not usually ensure adequate active processing among all individuals. Indeed, tests may later reveal some quite interactive students did not master the material. The present study combined an initial group educational procedure, as an introduction, with an individualized strategy, still within a classroom setting, that engaged nearly all participants in active processing. The response checks throughout the procedure informed the investigators whether or not such processing occurred.

The study has several limitations. First, the follow up period was 3 months instead of 1 year or more. Although it is important to evaluate effects in the short term, additional research needs to determine if effects are longer lasting. Second, the findings are applicable to people in drug diversion programs in the Los Angeles region but may not generalize to all diversion populations. Yet, the present study is the first to translate procedures from several mostly untapped areas of cognitive science to this important area. In addition, there was a statistically significant association between attrition and the two control conditions during Session 2, with somewhat more attrition in the action plan (AP) versus health education (HE) condition. The reason

for this difference, coupled with no statistically significant difference in attrition with the memory practice condition, is not clear. Yet, the superiority of reported infection testing effects of the memory practice condition replicated in comparison with both AP and HE. Another issue is that the study may have been slightly underpowered for some of the comparisons. Finally, the study relied on self-reports, though the experimental design limits the potential of demand characteristics as an explanation of effects. Each condition focused on the need for infection testing and condom use, and differential effects on the two outcomes argue against a demand characteristic unique to memory practice that might strongly bias each outcome in the study.

Conclusion

Although replication and attempts at improvements are warranted, the results showed that the set of procedures, focusing on retrieval practice and integrative processing, shows promise and is feasible to combine with more traditional health education on HIV and other infection risks. In the first study of its kind, promising effects of retrieval practice were revealed under *real world* conditions in existing drug diversion settings in need of empirically evaluated, short interventions on these risks. More attempts at translation of untapped but compelling findings from basic research are warranted.

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Compliance with ethical standards

Conflict of interest Alan W. Stacy, Liesl A. Nydegger and Yusuke Shono declare that they have no conflict of interest.

Human and animal rights and Informed consent 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 was obtained from all individual participants included in the study.

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