Moving Beyond Role-Play: Evaluating the Use of Virtual Reality to Teach Emotion Regulation for the Prevention of Adolescent Risk Behavior Within a Randomized Pilot Trial

Wendy Hadley,¹ PhD, Christopher Houck,¹ PhD, Larry K. Brown,¹ MD, Josh S. Spitalnick,² PhD, Mirtha Ferrer,³ MS, and David Barker,¹ PhD

¹Bradley/Hasbro Children's Research Center/Rhode Island Hospital and the Warren Alpert Medical School of Brown University, ²Spitalnick and Associates, and ³Virtually Better, Inc.

All correspondence concerning this article should be addressed to Wendy Hadley, PhD, Staff Psychologist and Associate Professor, Bradley/Hasbro Children's Research Center, One Hoppin Street, Suite 204, Providence, RI 02903, USA. E-mail: whadley@lifespan.org

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Abstract

Objective The purpose of the current pilot study was to evaluate the acceptability and preliminary impact of using immersive virtual reality environments (IVREs) paired with a brief emotion regulation and risk reduction intervention (ER + IVRE) relative to this same intervention content paired with role-plays (ER + RP). **Methods** Eighty-five adolescents attending middle school (grades 6th–8th; ages 12–15 years) in an urban northeast city were recruited and randomized to ER + IVRE ($n = 44$) or ER + RP ($n = 41$) and had complete data. Data examining acceptability, feasibility, sexual knowledge and attitudes, and ER were collected at baseline and 3 months after intervention completion. Analyses of covariance controlling for baseline scores were used to evaluate study outcomes. Within and between intervention effect sizes were calculated with effect sizes $\geq .20$ considered meaningful. **Results** At the 3-month follow-up assessment, several within intervention condition effect sizes were found to exceed $d = 0.20$ across the measured sexual attitudes and ER outcomes. Between intervention analyses found that adolescents randomized to ER + IVRE attended more intervention sessions, reported less difficulty accessing ER strategies ($d = 0.46$), and reported higher emotional self-efficacy ($d = 0.20$) at the 3-month follow-up relative to adolescents randomized to the ER + RP intervention. **Conclusions** This study provides preliminary evidence that using virtual reality environments to enhance ER skill building in risk situations was acceptable, feasible to deliver, and positively impacted ER abilities.

Key words: adolescent; emotion regulation; risk prevention; technology.

Adolescence is a time of exploration and emerging risk behaviors, as demonstrated by Youth Risk Behavior Surveillance (CDC, 2013) data, which indicate that by high school, 35% of adolescents report drinking in the past 30 days and 45% report using marijuana (CDC, 2011). Substance use and abuse during adolescence is predictive of early mortality (Clark, Martin, &

Cornelius, 2008) and problematic use in early adulthood (Piehler, Véronneau, & Dishion, 2012; Winters & Lee, 2008). Likewise, 41% of high school students have had sex, and adolescents who engage in risky sexual behaviors continue to exhibit greater sexual risk (more sex partners and less condom use) as they grow older (Sandfort, Orr, Hirsch, & Santelli, 2008), resulting in

more unintended pregnancies (Magnusson, Masho, & Lapane, 2011) and sexual transmitted diseases (STDs; Kaestle, Halpern, Miller, & Ford, 2005).

Many of the most effective interventions targeting sexual and substance use risk prevention (Baumann & Sayette, 2006; Bordnick et al., 2008; Cho et al., 2008) are time intensive, face-to-face, group interventions (>15 hr) that are based on Social Learning Theory (Bandura, 1977) and target individual skills, such as knowledge and assertive communication. There is increasing awareness that most risk decisions are motivated by emotion rather than an analysis of facts (Steinberg, 2007). Furthermore, neurobehavioral studies indicate that neurobiological circuitry (e.g., motivational circuitry involving prefrontal cortex and ventral striatum) is undergoing significant changes during adolescence (Mills, Goddings, Clasen, Giedd, & Blakemore, 2014), and neurochemical processes that underlie this circuitry are also significantly impacted by adolescent hormonal changes (Chambers, Taylor, & Potenza, 2003). Studies have begun to demonstrate that less coordination between the brain circuitry responsible for emotion regulation (ER) and planful decision-making are related to increased adolescent risk taking across a number of health domains (Caouette, Hudson, Bryan, & Feldstein Ewing, 2018; Davidson, Putnam, & Larson, 2000). These difficulties in emotion processing likely impact teens' abilities to recognize and regulate emotions in emotion-laden situations, such as those involving substance use and sexual risk, and to implement learned safer behaviors.

ER has been conceptualized as the set of processes used to manage feelings and their expression to achieve goals (Gross, 2011). ER is thought to include the use of both effortful and automatic processes that serve to reduce the intensity or frequency of emotional states (e.g., lability) as well as the ability to generate and sustain an emotional state. It emphasizes the regulation of both positive and negative momentary emotional states (such as curious or pressured), which are associated with increased substance use and sexual risk behaviors (Bhushan, Blood, & Shrier, 2013; Zapolski Cyders & Smith, 2009).

Poor ER in adolescence has been related to frequency of substance use (Hessler, & Katz, 2010; Wills et al., 2013) and sexual risk-taking (Raffaelli & Crockett, 2003). These relationships likely exist because of adolescents' difficulties with ER that increase the likelihood that they will engage in self-soothing behaviors, such as substance use or risky sex. Additionally, difficulties with ER likely decrease their ability to access knowledge and skills when in emotionally charged environments (Steinberg, 2007). Without ER skills training, behavioral skills training alone may be unlikely to influence the ways in which adolescents respond to risk situations.

ER skills can be learned via teaching and modeling, making them an excellent target for intervention (O'Connell, Boat, & Warner, 2009). Our team has developed and empirically validated several theoretically based ER interventions that teach adolescents to better recognize their emotions, to understand how intense emotions (both positive and negative) can influence risk behavior, and to use a variety of developmentally tailored strategies (e.g., walk away from the trigger, expressing emotions) to manage their emotions (Brown et al., 2011; Houck et al., 2016). Furthermore, our interventions highlight that the intensity of the emotion, rather than the specific state, can impair decision-making. For example, overwhelming sadness associated with interpersonal rejection and the excitement associated with a sexually arousing situation could both lead to sexual risk. The focus of ER interventions is to regulate the underlying emotion so that one can use protective behavioral strategies (e.g., assertive communication and condom use skills).

Interventions typically approach these concepts through role-playing; yet, this technique may be limited by developmental abilities in perspective taking and imagination (Riva & Waterworth, 2014). Teens often have difficulty recreating the emotional tone of risk situations, thereby limiting the ability to practice skills in challenging situations. Based on our experience delivering interventions, group settings can create social barriers that can make it difficult to "immerse" in a role-play situation. Teens report feeling embarrassed to behave realistically in front of peers when simulating risk situations, such as those involving sexual advances or substance use cues. To facilitate skill practice in this domain, technological tools may serve to support and enhance contextual cues.

One technological tool that has been shown to serve this function is virtual reality (VR). Since the early 1990s, VR has been used as a tool for intervention with persons presenting with a variety of disorders including specific phobias, Post-Traumatic Stress Disorder (PTSD), substance use, and autism spectrum disorders, with increasing acceptance and adoption by clinicians (Baumann & Sayette, 2006; Bordnick et al., 2008; (Parsons & Rizzo, 2008; Smith et al., 2015). Multiple studies have demonstrated that VR can elicit emotional responses (Diemer, Alpers, Peperkorn, Shibani, & Mühlberger, 2015) and provide realistic contextual cues to elicit substance use cravings (Baumann & Sayette, 2006; Bordnick et al., 2008; Cho et al., 2008). Furthermore, a study among adult men who have sex with men found that a virtual environment intervention, compared with peer counseling, led to a decrease in the number of unprotected anal sex acts (Read et al., 2006). Although promising, these studies did not focus on adolescents.

Many recent technological improvements to VR may result in an even greater impact, such as directly

interacting with avatars (e.g., through immersive VR). Immersive VR allows for the use of “life-like avatars” with technologically advanced facial mapping and 3D images with whom to interact. To date, studies that have used immersive VR technology as a tool for intervening with children or adolescents, have focused on pain distraction (Dahlquist et al., 2009; Wolitzky, Fivush, Zimand, Hodges, & Rothbaum, 2005), improving academic performance (Cobb, 2007; Parsons, Bowerly, Buckwalter, & Rizzo, 2007), rehabilitation goals (Parsons, Rizzo, Rogers, & York, 2009), and social skill building for children with autism (Ke & Im, 2013). To our knowledge, no study has specifically targeted ER in the context of substance use and sexual risk reduction among adolescents.

Despite using VR as a mechanism to improve skill building across a number of domains, only one other study has evaluated the impact of skill training using VR relative to role-plays (RPs). Among a sample of adults with schizophrenia, this study found that social skills training (SST) plus VR was superior to SST plus traditional RPs in improving conversational skills, increasing assertiveness skills, and increasing participant interest in SST (Park et al., 2011). The purpose of the current pilot study was to expand on this literature and evaluate the feasibility and acceptability of using immersive virtual reality environments (IVREs) paired with a brief ER and risk reduction intervention (ER + IVRE) among a sample of early adolescents. In addition, we aimed to examine preliminary impact of this same intervention (ER) content paired with traditional role-plays (ER + RP) on sexual health attitudes and ER skills. We hypothesized that adolescents randomized to ER + IVRE would report greater satisfaction with the intervention, demonstrate higher attendance, evidence greater improvement in ER skills, and report greater self-efficacy for engaging in safer behaviors at the 3-month follow-up. Unfortunately, this pilot trial was neither designed nor powered to identify group differences in risk-taking behaviors at follow-up.

Methods

Participants

Eighty-nine adolescents were recruited from two urban public middle schools, in an urban city in the Northeast, for participation in this preliminary trial. Participants were recruited and followed for study assessments from October 2015 to June 2016. Adolescents were recruited for participation through a series of school presentations, conducted in grade-wide morning announcement symposiums. Parents were contacted by research staff after providing school personnel with signed consent to contact forms. Adolescents were eligible for participation if they were able to speak and read English and adolescents were in Grades 6–8 (ages 12–15 years). Adolescents were

excluded if they were cognitively unable to give assent. All adolescents were also screened for motion sicknesses (see Measures) before consent and those exceeding the cutoff score were excluded (see Figure 1). Eligible and interested adolescents and caregivers were then scheduled to meet with a trained research assistant (RA) to obtain parent/guardian consent for adolescent participation and assent from minors.

Consented and enrolled adolescents completed the baseline assessment before randomization. Adolescents were randomized to one of two intervention conditions, with equal numbers across conditions, using urn randomization, stratified by gender (Stout, Wurtz, Carbonari, & Del Boca, 1994). Randomization was blocked using predetermined size-6 blocks. Within the limited budget of this pilot study, there were only two RAs hired to perform study duties. RAs performed multiple roles, including enrollment, entering subjects into the randomization program, assigning subjects to conditions, and all follow-up assessments. Adolescent follow-up assessments were completed 3 months after completing the intervention. All assessments were conducted within respective school libraries or classrooms. Adolescents were compensated for completion of assessments. All study procedures were approved by the institutional review board at the study site.

Procedure

Both conditions received the same ER group intervention (see below). Groups were conducted in single-gender groups of four to eight adolescents after school within recruitment school classrooms. Sessions were conducted over the course of 4 weeks (one session per week). Sessions lasted 2 hours each and were led by two facilitators (one male and one female; one study investigator and one master-level graduate student). Each 2-hr session included didactics and games for purposes of teaching sexual and substance use risk information and ER topics. At the end of each session, adolescents practiced the skills taught using the format of the condition to which they were randomized, either IVRE or traditional RP. In both conditions, participants were given explicit instructions to achieve the relevant session objective (e.g., Session 2: purchase condoms).

ER Intervention

The ER group intervention aimed to enhance ER skills to reduce poor decision-making that can lead to unplanned sex or other health risk behaviors, such as substance use. This intervention was based on two previously validated and efficacious 12-hr, face-to-face group interventions targeting ER and risk reduction (Brown et al., 2011; Houck et al., 2016). The previous interventions were condensed to four intervention sessions, which included didactics, games, and IVREs/RPs, that lasted 2 hr each (1.5 hr for in-person

Figure 1. Consort.

Note. Data on the total number of consent to contact forms distributed at each school was unavailable.

group and 0.5 hr for practice within the paired IVRE/RP). Total intervention time was 8 hr (see Table I).

The first two sessions of the program presented the relationship between emotions and behaviors as well as emotion education, such as identifying emotional arousal in oneself through somatic cues, labeling these feelings, and recognizing their sources (“triggers”). The last two sessions of the program taught developmentally appropriate strategies for regulating emotions during moments of decision-making. The program presented connections between ER and peer relationships, and risk behaviors. Adolescents also received sexual health education, including information about anatomy, STDs (including HIV), and disease/pregnancy prevention (abstinence, condoms, and non-

penetrative sexual behaviors). Across sessions, some themes were repeated such as the influence of substance use on the ability to use condoms and negotiate safer sex with a partner. This organizational scheme mimicked that of the original face-to-face group interventions (Brown et al., 2011; Houck et al., 2016) and targeted the same key components.

For the current study, each of the four intervention sessions was paired with either a complimentary IVRE Scene or RP that mirrored the content of the IVRE.

Immersive Virtual Reality Environments

Four IVREs (adolescent party, condom purchasing, sexual negotiation, and HIV/STD testing) were developed and pilot tested over several years with 130 youths.

Table I. *Session Content*

Session	Risk behavior info	Emotion regulation skill training	IVRE/RP practice
1	Male and female reproductive system, STI, and HIV Information	Introduction to triggers, feelings, and actions, recognizing/labeling feelings, and quantifying feelings	HIV/STD testing scene
2	Sex and substance use myths, feelings about condoms, and condom use demonstration and practice	Triggers related to emotional dysregulation, identifying personal triggers, and ER strategy introduction (GET OUT and LET IT OUT)	Purchasing condoms scene
3	Impact of substance use on sexual decision-making	Review of previous ER strategies, dysfunctional thinking, and using THINK IT OUT	Party scene, including substance use and sexual risk cues
4	Understanding safe and risky sexual behaviors and how to avoid risk	Assertive communication, practice with emotion regulation strategies	Partner negotiation scene

IVREs mirrored the RPs in content and script with the exception that roles were played by facilitators and peers in the intervention group. All developed IVREs were based on RPs used in our previous face-to-face laboratory interventions, and they complimented the skills taught within the group sessions. Before the preliminary trial, each environment was evaluated by adolescents who provided feedback through written self-report measures (acceptability and feasibility), and qualitative interviews conducted immediately following the immersive experience. Modifications were then made to the IVREs based on feedback, such that adaptations were made in an iterative process. Adolescent reactivity (heart rate) was also collected from each adolescent while viewing each IVRE to establish that these environments could cause emotional arousal (see blinded cite for more details on the IVRE development process). Each environment was designed to elicit emotional reactions that require adolescents to use ER skills (taught within the ER intervention) to negotiate safer behaviors (e.g., refusing substances, purchasing condoms, negotiating condom use, and getting tested for HIV/STDs) that corresponded to content learned in that session. The IVREs provided context rich environments in which adolescents practiced skills taught within the intervention session. For example, in Session 3, which teaches information about risky sexual behaviors and assertive communication skills, adolescents randomized to ER + IVRE practiced assertive communication skills in the IVR partner negotiation scene after the group session was completed. Before beginning each IVRE, adolescents were instructed to complete an objective (e.g., purchasing condoms at the pharmacy, asking the physician for an HIV/STD test), which mirrors the approach to RPs within previous HIV prevention interventions.

The IVRES contained both passive and interactive environmental elements. Passive environmental elements included those events happening in the background that did not directly address the participant

(e.g., laughter from a group of teens in the condom purchasing environment) but were designed to contribute to the emotional experience. Interactive elements included events in which an avatar directly approached the participant and attempted to elicit a response from the participant. For example, within the condom purchasing scene, the cashier at the pharmacy asked the participant about whether they liked a particular brand of condoms. Across IVREs, embedded cues targeted both substance use and sexual risk behavior. The sexual risk behavior cues were specified by the gender of the participant within the partner negotiation and HIV/STD testing scenes. For example, male participants received pressure lines consistent with their experience (i.e., “Can’t you get it up?”), whereas females were asked about pregnancy testing within the HIV/STD testing scene. Adolescents were also able to choose potential romantic partner avatars from various racial/ethnic backgrounds before entering the IVREs.

Across IVREs, participants were able to verbally respond to the avatars’ inquiries or statements. Avatar behaviors were predetermined by the research team through initial piloting and delivered during the IVRE experience by a trained facilitator following a prescribed protocol for systematic delivery of verbal and nonverbal cues. From a separate room, the facilitator monitored participant play (through digital display of participants movements) and verbalizations (via headphones synced to participant microphones) within the IVREs. For each participant utterance, the facilitator was able to select from a menu of responses (one to two options), programmed within a user interface (UI). For example, within the sexual negotiation scene, the facilitator could select a variety of avatar responses to encourage sexual risk that included but were not limited to “You know what I want to do...” or “Come on, you don’t have to be shy.”

Pairs of adolescents simultaneously viewed IVREs based on space and staffing constraints (only two RA's available) until all group participants had the opportunity to experience the session IVRE. Further details regarding equipment and IVRE administration protocol can be obtained by contacting the first author.

Role-plays

Adolescents randomized to the ER + RP intervention received the ER intervention described above. In the place of IVREs, adolescents practiced skills using a traditional RP format. Each RP was conducted once per group, and participants served as actors or observers during the scenario.

Measures

Before consent, adolescents were asked to complete the motion sickness screening measure to determine eligibility. All eligible and consented/assented parents and teens then completed the demographics form. All remaining measures were administered via audio computer-assisted self-interview (ACASI) to increase adolescent comfort reporting on sexual and substance use attitudes and behaviors. The ACASI was administered before randomization (baseline) and then 3 months later.

Screening Measure

The Motion Sickness Susceptibility Questionnaire (Golding, 1998) was used to screen out participants who may be at greater risk for developing Cybersickness symptoms in the VR environments, before enrollment in the study. Based on prior studies and in accordance with Stanney, Kennedy, and Kingdons' (2002) protocol for managing Cybersickness, adolescents with a score of 11.3 or higher (≥ 50 th percentile) were not eligible for participation in the trial to minimize risk to subjects.

Assessment Measures

Demographics (Baseline). Items collected from parents and adolescents included age, gender, race, and ethnicity. Adolescents provided self-report of sexual and drug behaviors. Items assessed history of sexual activity (oral, vaginal, or anal) and history of alcohol or marijuana use (yes/no) for purposes of describing the sample.

Acceptability and Feasibility (Postintervention). (a) Intervention acceptability (eight items; e.g., What was their experience, did they like it? How would you rate the overall experience?) was assessed immediately post intervention in both conditions. This measure has been used with multiple intervention development trials in our laboratory. Items are rated on a scale of 1 (*strongly disagree*) to 4 (*strongly agree*) with higher scores indicating greater intervention acceptability

($\alpha = .72$). (b) Intervention attendance data were collected for all participants across the four sessions to assess feasibility. Additionally, cybersickness of enrolled participants was monitored.

ER (Baseline and 3 Months). (a) Affect Dysregulation Scale (Brown et al., 2012) was used to assess the frequency of difficulties with affect regulation based on self-report. Six items include "In the past month—small problems got me very upset; my feelings got in the way of doing things; I had trouble controlling my feelings; people have suggested that I 'calm down'; I have felt overwhelmed by strong feelings; 'I have felt able to manage strong feelings'." Participants respond on a four-point scale ("not at all, a little, sometimes, often"), and higher scores indicate greater emotional dysregulation. One item ("I have felt able to manage strong feelings.") was dropped because of poor reliability resulting in an overall alpha of .87. (b) Two subscales of the Difficulties in Emotion Regulation Scale (Schutte et al., 1998) were used to assess self-report of ER. The Lack of Emotional Awareness subscale assesses emotional awareness via six items (e.g., "I pay attention to my feelings"), and the Limited Access to Emotion Regulation Strategies subscale evaluates respondents' perceived abilities to manage negative emotions via eight items (e.g., "When I'm upset, I believe that there is nothing I can do to make myself feel better"). Items are rated on a five-point Likert scale, 1 (*almost never*) to 5 (*almost always*); higher scores indicate less emotional awareness or less access to strategies. The measure demonstrated good internal reliability in the current sample for both the Awareness ($\alpha = .87$) and Strategies ($\alpha = .72$) subscales. (c) Emotional Self-Efficacy (Muris, 2002) was measured using eight items assessing adolescents' perceived abilities to manage emotional upset (e.g., "How well do/can you ...control your feelings? ...succeed in being calm again when you are very scared?"). Adolescents responded on a five-point scale, 1 (*not at all*) to 5 (*very well*). Higher scores indicate higher emotional self-efficacy ($\alpha = .89$).

Sexual Risk Knowledge and Attitudes (Baseline and 3 Months). (a). The 10-item Sexual Risk Knowledge quiz (Brown & Fritz, 1988) assessed HIV-related knowledge, such as routes of transmission and course of illness. Response options included true, false, and "not sure," which was coded as incorrect. (b) The Self-Efficacy for Sexual Risk Prevention scale (Lawrence, Levy, & Robinson, 1990) was developed to assess the extent to which adolescents "could" engage in specific sexual risk preventive behaviors, such as safe sex discussions with partners. Comprising 12 items with responses that range from 1 (*very sure*) to 4 (*couldn't do it*), this scale was reverse coded such that higher scores indicate greater self-efficacy for engaging in

protective behaviors. The alpha for the current sample was .91. (c) The Self-Efficacy for Condom Use scale (Prochaska et al., 1994) contains items that reflect the context of condom use, such as “could use a condom when I’m very upset” and “could use a condom when my partner doesn’t want to.” This 13-item scale found to have a good factor structure in previous studies (Brown, et al., 2000). Internal reliability for the current sample was .95.

Analysis Plan

Analyses of covariances (ANCOVAs) were used to evaluate study outcomes using SPSS 20. For each outcome measure their respective baseline assessment was included in each separate ANCOVA. A total of seven ANCOVAs were run for the current study. Because this was a pilot trial of two active interventions, we chose to focus our interpretation of findings based on effect sizes instead of statistical significance. Both within and between condition effect sizes were calculated using η^2 and then converted to Cohen’s d (small = 0.20, medium = 0.50, and large = 0.80) for ease of interpretation. Effect sizes $\geq .20$ were considered meaningful and are discussed below.

Based on the two preliminary intervention studies off of which this pilot trial was modeled, a final sample of 85 adolescents ($N = 100 \times 85\% = 85$) was proposed to provide adequate power to detect a moderate effect size (0.6) on sexual health attitudes and ER skills. Given these estimates, post hoc testing between the two intervention groups (~40 per group) yields a power of .80 for a t -test ($\alpha = .05$, one-tailed test).

Results

Baseline Characteristics

Total 190 adolescents returned signed consent to contact forms and their parents were subsequently contacted for participation in the current study (Figure 1, Consort). Of those contacted, 79 adolescents were excluded for the following reasons: ineligibility ($n = 15$), cybersickness propensity ($n = 18$), parents’ refusal to have their child participate in the trial ($n = 18$), or we were unable to reach them during the study period ($n = 28$). Of those who were scheduled to meet with the RA to obtain formal in-person consent, 10 declined participation and 12 did not show for the consent meeting and could not be reached for rescheduling during the brief recruitment period. Of eighty-nine recruited and enrolled in the study, one withdrew before randomization because of a medical emergency and three adolescents did not complete the follow-up assessments. These losses resulted in a final sample of eighty-five adolescents (94%) with complete data across the three assessments and were therefore included in all remaining analyses.

The sample of adolescents randomized to the ER + RP condition ($n = 41$) was composed of 54% females, and adolescents were an average of 13.0 years old ($SD = 0.91$). Reported racial identities included the following: 32% African American, 29% mixed race, 29% “other,” and 10% Caucasian. Ethnically, 42% of the sample reported a Hispanic/Latino identity. Total 17% of these adolescents reported that their sexual orientation was homosexual, bisexual, or undecided. At baseline, 7% of adolescents reported ever having sex, 22% reported ever having used alcohol, and 7% reported ever having used marijuana.

Among adolescents randomized to the ER + IVRE condition ($n = 44$), 55% reported female gender, and adolescents were an average of 12.9 years old ($SD = 0.82$). Racial identities reported for this group were as follows: 34% African American, 30% mixed race, 18% “other,” and 18% Caucasian. Ethnically, 34% of the sample reported a Hispanic/Latino identity. Three adolescents (7%) reported that their sexual orientation was homosexual, bisexual, or undecided. In response to baseline risk behavior items, 11% of adolescents reported engaging in oral, vaginal, and/or anal sex, 16% reported ever having used alcohol, and 9% reported ever having used marijuana.

There were no significant differences on any of the baseline characteristics between intervention conditions.

Acceptability and Feasibility

Adolescents across both conditions reported high satisfaction with their participation in the groups ($M_{ER + IVRE} = 3.70$ vs. $M_{ER + RP} = 3.71$, on a four-point scale), with minimal differences between the two groups ($d = 0.06$, $p = .81$). In contrast, attendance records indicated that adolescents randomized to the ER + IVRE condition attended more sessions ($M_{ER + IVRE} = 3.67$ vs. $M_{ER + RP} = 3.33$; $d = 0.43$, $p = .06$). Relatedly, 96% of adolescents randomized to ER + IVRE versus 81% of adolescents in the ER + RP condition attended three or more intervention sessions ($p = .07$). None of the adolescents randomized to the ER + IVRE condition reported cybersickness while participating in the four IVREs.

Sexual Risk Knowledge and Attitudes

Table II presents means and effect sizes for the two conditions at baseline and 3-month follow-up. Adolescents in both conditions showed small to large effect sizes across these outcomes. They reported greater increases in sexual risk knowledge (ER + IVRE: $d = 2.13$, $p < .001$; ER + RP: $d = 2.04$, $p < .001$), self-efficacy for engaging in sexual risk prevention behaviors (ER + IVRE: $d = .93$, $p < .001$; ER + RP: $d = 1.06$, $p < .001$), and greater self-efficacy for using condoms (ER + IVRE: $d = 0.39$, $p = .12$; ER +

Table II. Treatment Group *Ms*, *SDs*, and Within- and Between-Condition Effect Sizes

Variable	ER + IVRE condition (<i>n</i> = 44)					ER + RP condition (<i>n</i> = 41)					Between Conditions Pre to 3-month <i>d</i>
	Pre		3-month		Effect size	Pre		3-month		Effect size	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>		<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>		
Sexual Risk Knowledge and Attitudes											
HIV Knowledge	3.91	1.95	6.23	1.82	2.13	3.51	1.95	6.10	1.71	2.04	.01
Self-Efficacy HIV Prevention	35.86	8.78	39.64	7.41	0.93	35.07	8.58	40.10	6.41	1.06	−.11
Condom Use Self-Efficacy	45.52	8.54	47.10	7.55	0.39	43.40	10.55	45.71	9.38	.22	.11
Emotion Regulation											
Difficulty in Emotional Awareness	18.82	6.41	17.27	5.93	−0.50	19.41	5.77	17.10	5.59	−.61	.09
Difficulty Accessing Emotion Strategies	14.55	4.20	14.91	5.33	0.06	15.29	5.32	17.71	6.66	.71	−.46
Emotional Self-Efficacy	24.95	7.40	25.68	7.55	0.26	23.05	8.27	23.49	7.74	.00	.20
Affect Dysregulation Scale	7.55	2.71	7.95	3.45	0.21	7.80	3.51	8.49	4.03	.36	−.13

Note. Cohen's *d* was converted from η^2 for ease of interpretation.

RP: $d = 0.22$, $p = .39$). Between group differences were small ($d = -0.11$ to 0.11).

Emotion Regulation

In the domain of ER, improvement was variable across the conditions but generally showed report of better ER abilities at the 3-month assessment among those randomized to the ER + IVRE condition. Specifically, adolescents in both conditions demonstrated a moderate decrease in Difficulty in Emotional Awareness across the 3-month assessment period (ER + IVRE: $d = -0.50$, $p < .05$; ER + RP: $d = -0.61$, $p < .01$), with minimal differences between conditions ($d = 0.09$, $p = .67$). In contrast, adolescent report of Difficulty Accessing Emotion Regulation Strategies showed that those in the ER + IVRE condition reported minimal change in this domain ($d = 0.06$, $p = .74$), whereas adolescents randomized to ER + RP reported moderate to large increases in difficulty accessing strategies at the 3-month assessment ($d = 0.71$, $p < .01$), resulting in a moderate difference between conditions ($d = -0.46$, $p < .05$). Likewise, adolescents randomized to the ER + IVRE group reported greater emotional self-efficacy at the 3-month follow-up ($d = 0.26$, $p = .23$), while ER + RP participants only reported minimal improvement ($d = 0.00$, $p = .91$) with a small difference between conditions ($d = 0.20$, $p = .36$). Finally, adolescent report on the Affect Dysregulation Scale showed that adolescents in the ER + IVRE group noted a small increase in dysregulation ($d = 0.21$, $p = .35$), whereas those in the ER + RP condition reported a small-to-moderate increase in dysregulation at 3 months ($d = 0.36$, $p = .10$) with minimal difference between conditions ($d = -0.13$, $p = .59$).

Discussion

Results from this pilot trial examining the impact of IVREs relative to RPs in enhancing adolescent ER skill building are promising. As designed, the only

difference between these two conditions was that in one condition adolescents entered IVREs to practice the skills taught in session, whereas in the other, skills were practiced through a standard RP format. Notably, across both treatment conditions, adolescents demonstrated improvement across several of the targeted ER domains. Furthermore, while adolescents in both groups reported relatively high intervention acceptability, adolescents randomized to the ER + IVRE attended a greater number of sessions relative to those randomized to ER + RP. This is consistent with other studies (Bosworth, 2006; Marsch & Borodovsky, 2016), suggesting that technology-based formats have high appeal during this developmental period. Engaging teens in health promotion programming can be challenging, and the use of IVRE may have increased interest for some youth. Taken together, these outcomes indicate preliminary evidence that the ER + IVRE intervention was acceptable and feasible to deliver, impacted key ER domains, and was slightly more successful in retaining adolescents relative to the standard RP condition.

As anticipated, both groups demonstrated improvement on outcomes in expected directions. Importantly, these very brief interventions (total delivery time of 8 hr across four sessions) were able to demonstrate impact that was comparable with the primary interventions on which they were based (Brown et al., 2011; Houck et al., 2016). The ER + IVRE condition had a greater impact on two of the ER domains, even when compared with the highly active ER+RP intervention that used the same ER intervention. Specifically, adolescents given the opportunity to practice ER skills within the IVREs reported less difficulty accessing strategies when distressed and perceived slightly greater self-efficacy for managing distress. Given that both groups received the same educational information about ER, it suggests that IVREs may provide advantages in perceived efficacy for using ER strategies. While both conditions achieved improvements in efficacy for safer sexual

behavior, these gains are unlikely to be helpful if emotion dysregulation interferes. As highlighted by Bandura's work (Bandura, 1977, 1982), self-efficacy for performing a behavior has shown to have a linear relationship with more movement to use and maintenance of the behavior as confidence in their ability to carry out the behavior increases (Grimley, Prochaska, Velicer, Blais, & DiClemente, 1994). The combination of improving both accessing ER strategies and greater self-efficacy for managing distress would seem to suggest better behavioral outcomes in the long term; however, further replication of this study with a longer-term follow-up will be needed to determine impact on health risk behaviors.

There may be several reasons IVREs could lead to greater impact on self-efficacy. First, important contextual cues of the risk situations that adolescents encounter in the real world (e.g., drug/alcohol paraphernalia, peers "making out") cannot feasibly be simulated in the school settings and thus were not part of RPs. The IVREs were able to include these cues and may have provided a tool for more realistically simulating real world situations. This, in turn, may have elicited emotion more effectively than the RPs providing more useful practice and greater efficacy. In addition, the IVREs were experienced individually and thus may have removed the social pressure of "performing" in RPs that were conducted in front of group members. Adolescents may have been more likely to "be themselves" when this possible social evaluation was removed, giving teens more opportunity to take risks in their practice to determine what strategies they feel confident using. Additionally, the IVREs may have been especially potent and "life-like" for adolescents participating in this pilot trial. Consistent with a previous study comparing the use of immersive and non-immersive VR, which found that adolescents were better able to distract themselves from cold pressor pain in IVREs relative to non-IVREs (Dahlquist, et al., 2009), adolescents randomized to the ER + IVRE may have been better able to deploy the skills taught within the intervention sessions. This may be because of adolescents' comfort with gaming systems that use advanced graphics or the added benefit of viewing objects and persons in 3D within IVREs, which may have been key for evoking emotion (the primary target). Further research is needed to understand the specific mechanism(s) by which VR impacts ER skill acquisition in risk laden situations.

The current study included limitations that should be noted when interpreting the findings. First, the developed IVREs were not specifically designed for adolescents engaging in risk behaviors with same sex partners. While the program allowed adolescents to choose the race and gender of potential romantic partners before entering the IVREs, the developed scripts and scenarios were based on heterosexual encounters.

This may have made it difficult for some participants to immerse and fully benefit from practice in some scenarios. Unfortunately, earlier piloting of the IVREs with a diverse youth advisory board revealed that same sex romantic encounter experiences were significantly different from the created heterosexual scripts, and therefore, we were unable to develop these additional scenes within the limited time frame (2 years) and funding of the current project. Development of scenarios and scripts that are specifically tailored for youth who identify as non-heterosexual warrants further attention given the higher rates of risk taking within this population (Parkes et al., 2011). Second, given the small sample, study findings may not generalize to all adolescents enrolled in 6th through 8th grades. Third, this pilot study was unable to examine impact on substance use and sexual risk behaviors because of the brief follow-up period. Although we were able to positively impact several ER domains, it is unclear whether these changes will result in longer-term reductions in sexual and substance use risk behaviors for youth participating in the IVRE intervention. Fourth, all outcomes were measured via self-report. Future studies would benefit from the use of computerized tasks or psychophysiological assessment to examine changes in ER abilities to reduce bias inherent in self-reports. Fifth, the analytical challenge of calculating confidence intervals for eta-squared using SPSS should be noted. Finally, it cannot be determined from the current study design whether the differential impact of IVREs versus roleplays was because of variable opportunity to practice. Specifically, participants randomized to ER + RP were not able to complete a RP at each session, whereas all IVRE participants had individualized opportunities to practice.

Despite these limitations the study included a number of strengths. First, to our knowledge, this is the only study to examine the use of IVRE with adolescents to target the reduction of sexual and substance use behaviors via ER skill building. Second, the study included a robust design that allowed for a controlled comparison of the impact of IVRE relative to standard RPs on enhancing response to an adolescent risk prevention program targeting ER relative to standard RPs. Third, the ER content was delivered over four sessions, which is easier to administer than the 12-session interventions it was based on (Brown et al., 2011; Houck et al., 2016). Despite the relatively brief delivery time, it demonstrated short-term impacts on several targeted outcomes that were similar to the parent programs. Finally, the use of IVREs appeared to have slightly increased attendance which is key to implementation of any intervention.

In summary, VR is a technological tool that may be useful in enhancing adolescent learning of ER within HIV prevention interventions and other health promotion interventions targeting ER skills including but not

limited to those addressing diabetes, obesity, and food allergies. VR environments may provide several advantages over current methods (e.g. RPs and vignettes) used to teach these skills. IVREs appear to create an engaging, immersive, and realistic experience that allows for precise and systematic delivery of complex, dynamic, and ecologically relevant stimulus presentations, all within a sophisticated interaction. Relatedly, IVREs provide interventionists with the flexibility to deliver the intervention in small groups or individually. The paired IVREs also allow interventionists and clinicians with the flexibility to have adolescents practice using the skills in sensory rich environments until mastery of the skills is reached which is unlikely in a RP situation. Thus, its ability to maintain and augment impact may be far greater than a single face-to-face intervention. Finally, the ER + IVREs intervention design allows clinicians and interventionists with the ability to choose areas that are currently relevant to the adolescent's experience and can impact important ER skills that may be a necessary component to reducing adolescent engagement in risk behaviors. Notably, over the past 5 years, prices for VR gaming equipment have substantially decreased and there are now several commercially available VR headsets and devices (e.g., Daydream View and <\$800), making future dissemination of VR interventions feasible. The continued validation and use of these tools will hopefully provide interventionists with new tools to target adolescent risk behavior and decrease unnecessary negative outcomes such as substance abuse and dependence, unwanted pregnancies, and STDs.

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