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The Virtual Reality Scenario Method: Moving from Imagination to Immersion in Criminal Decision-making Research

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Abstract

Objectives: This study proposes an alternative hypothetical scenario method capitalizing on the potential of virtual reality (VR). Rather than asking participants to imagine themselves in a specific situation, VR perceptually immerses them in it. We hypothesized that experiencing a scenario in VR would increase feelings of being "present" in the situation, and add to perceived realism compared to the written equivalent. This, in turn, was

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expected to trigger stronger emotional experiences influencing subsequent behavioral intentions. *Methods:* In an experiment, participants ($N = 153$), visitors of a large music festival, either read a "bar fight" scenario or experienced the scenario in VR. Following the scenario, they were presented a series of questions including intention to aggress, perceived risk, anticipated shame/guilt, presence, perceived realism, and anger. Analyses were conducted using analysis of variance, stepwise regression, and mediation analysis using nonparametric bootstrapping. *Results:* In line with expectations, the results indicate significant differences between conditions with the VR scenario triggering stronger presence, higher realism, and higher intention to aggress. Importantly, presence and anger mediated the relation between condition and intention to aggress. *Conclusions:* We show that the VR scenario method may provide benefits over written scenarios for the study of criminal decision-making. Implications are discussed.

Keywords
virtual reality, 360° video, scenarios, anger, emotions

The late 1980s and early 1990s saw two related developments that mark the study of criminal decision-making to this day. On the one hand, rational choice perspectives (Clarke and Cornish 1985; Cornish and Clarke 1986) emerged to establish themselves as the principal theoretical choice models, next to the hitherto dominant deterrence paradigm. On the other, the hypothetical scenario method was introduced to a criminological readership and became the preferred method for testing decision-making perspectives (Klepper and Nagin 1989; Nagin and Paternoster 1993). By providing contextual information surrounding (hypothetical) offenses and locating the choice process within the situation, rational choice/deterrence-based scenario studies were better able to capture the situation-specific nature of offending decisions compared to other methods (Pogarsky 2004) and were also less prone to measurement error (Bachman, Paternoster, and Ward 1992). Arguably, with the development of the scenario method, crime research moved a significant step closer to importing the context in which offending decisions are actually made and thereby greatly advanced our knowledge of criminal decision-making processes.

Nonetheless, the extent to which written scenarios can serve as valid proxies for actual criminal decision-making is questionable. For one thing,

they are limited in their ability to capture the more visceral and emotional aspects involved in real-world offending, which commonly occurs during "hot" and altered states of mind (Exum and Bouffard 2010:581). Secondly, a 10- to 15-line narrative may not reflect the complex reality of real-life situations and realistically incorporate important nuances of social experience (e.g., Bouffard and Niebuhr 2017; Christian, Edwards, and Bradley 2010; Ditto et al. 2006; Parkinson and Manstead 1993). Finally, the scenario method relies on the ability of people to imagine themselves in a hypothetical situation and is not sensitive to individual differences in this ability (Collett and Childs 2011; Van Gelder, Martin, et al. 2017).

In this article, we propose and test a virtual reality (VR)–based scenario method to address these limitations. Because of their ability to provide contextual detail, VR scenarios contribute to the perceptual realism of a hypothetical situation. Furthermore, by more directly engaging the senses, VR scenarios may be better able to elicit the visceral and emotional processes typically involved in decision-making. Thirdly, by perceptually placing research participants in the center of the action, VR reduces concerns regarding individual differences in people's ability to imagine a hypothetical situation. In other words, we contend that by immersing participants in the situation of interest and providing more contextual information, VR scenarios can enhance our understanding of choice processes.

We test our assumptions using a branch of VR known as 360° video (see Method section). Participants, visitors of a large music festival in the Netherlands, either read a "bar fight" scenario (e.g., Exum 2002; Mazerolle, Piquero, and Capowich 2003; Schoepfer and Piquero 2006) or experienced the scenario in VR and subsequently responded to a series of questions including intention to aggress, perceived risk, shame/guilt, presence, perceived realism, and anger. Participant responses to both versions of the scenario were compared. Below, we first discuss a number of characteristics of the traditional scenario method and how it has been used in criminology prior to elaborating on the potential of VR for studying criminal decision-making and outlining the VR scenario method.

Scenarios and Criminal Decision-making Research

Hypothetical scenarios, or vignettes, involve short descriptions of realistic situations. Participants are asked to read the text and subsequently to respond to a number of questions pertaining to it. Scenarios have several strengths that have resulted in them becoming the method of choice for studying criminal decision-making. For one thing, compared to surveys,

they can enhance realism by providing a certain degree of contextual detail while simultaneously ensuring that these details are uniform across respondents (Alexander and Becker 1978; Siponen and Vance 2010). Survey questions, which lack reference to context, may result in measurement error by leading respondents to impute their own details such as the relationship with the victim, the location of the crime, context, the availability of a weapon, and so forth (Bachman et al. 1992; Exum and Bouffard 2010). Another advantage of scenarios is that they allow researchers to isolate and systematically vary specific factors that are often embedded, infrequent, illegal, unethical, and/or unpredictable in the natural social environment.

Of course, scenario studies may still fall short of realistically depicting important nuances of social experience, as the amount of contextual information they can provide is limited. Consider, for example, a scenario starting out with the text: "Imagine you are having a beer in a local bar with friends." Even a detailed description of this bar, e.g., "crowded, noisy, with television screens broadcasting sports, and several individuals making a very intoxicated impression" would still fail to convey potentially relevant information regarding what the bar looks like, lighting, the type of people in it in terms of race, gender, age, socioeconomic status (SES), dress, distribution of people over the premises, the sounds in the bar (e.g., level, pitch, intensity, music), and so on (Van Gelder, Otte, and Luciano 2014). Moreover, scenarios are restricted in their ability to provide information about the nonverbal behavior of those present—such as facial expressions of anger, happiness or contempt, or body posture—which signal important cues determining perceivers' social responses (Van Gelder, Martin, et al. 2017).

Additionally, the validity of a scenario relies in part on the degree to which research participants are able to imagine themselves in the described situation (Collett and Childs 2011; Parkinson and Manstead 1993). Written scenarios require a relatively high degree of cognitive effort, consisting of reading the text, processing the information provided, imagining the situation, and subsequently taking perspective (Mayer 2008). Those lacking the ability to easily do so may respond differently to the scenario compared to those who can do it without effort (Van Gelder et al. 2017). This may be particularly pertinent in unconventional, unethical, or uncommon situations, as is frequently the case in crime research, and can result in measurement error. Therefore, responses to scenarios may still inadvertently capture individual variation in people's ability to imagine themselves in a situation and their cognitive capacity, rather than actual reactions to it.

Another key limitation of scenario-based criminal decision-making research to date regards its relative neglect of emotional states, which have been shown to be fundamental drivers of human decision-making in virtually all behavioral domains (Exum and Bouffard 2010; Nagin 2007; Pogarsky, Roche, and Pickett 2018; Van Gelder et al. 2013). Traditionally, criminal decision-making research has embraced the rational choice paradigm, according to which the choice for crime is the result of a calculated assessment of costs and benefits in which emotions play little role of importance (e.g., Clarke 2013; Cornish and Clarke 1986). Importantly, the research in this tradition that has addressed the influence of affect on decisions to offend has tended to focus on moral emotions such as regret, guilt, and shame (e.g., Grasmick and Bursik Jr 1990; Nagin and Paternoster 1993; Piquero and Tibbetts 1996). However, such emotions tend to be operationalized in this research as cognitions about future feeling states. Stated differently, they are *predictions* of aversive feeling states that may emerge after a decision has been made, instead of feelings actually experienced at the time of decision. Hence, the decision-making process in these studies remains modeled as a largely cognitive or rational enterprise rather than an emotional one (Loewenstein and Lerner 2003; Van Gelder 2017).

More recently, there has been an increased interest in the role of emotions actually experienced at the time of decision, such as anger and fear (e.g., Bouffard, Exum, and Paternoster 2000; Nagin 2007; Van Gelder 2013; Van Gelder and de Vries 2012, 2014). This research has shown that such immediate emotions, which are difficult to model as costs within rational choice–based decision frameworks (see Van Gelder 2013, 2017), are strong predictors of criminal choice. Importantly, people tend to be surprisingly oblivious to the influence of feelings on their own behavior, both prospectively and retrospectively, and also limited in their ability to predict their own preferences and decisions (Ariely and Loewenstein 2006; Loewenstein 1996; Wilson and Gilbert 2005).

Because criminal decision-making research typically employs scenarios, and due to the limited ability of scenarios to induce affective states such as anger and fear, the correlation between behavioral intention as reported and actual behavior as measured by scenarios in this research is likely to be attenuated.[1] The problem at stake here may to an extent be inherent in the method; short written narratives have a limited capacity to elicit some of the type of strong emotions that real-life situations evoke. This, in turn, may have inadvertently reinforced the idea that emotions are also unlikely to play a role of importance in offending decisions, and strengthened the belief that crime is a largely rational process. Although it is possible that some

individuals may experience strong feelings from reading words on a page or a computer screen, descriptions of a situation may simply not invoke such a strong response in the average person.

VR and Its Potential for Crime Research

Whilst still a relatively recent method in criminology, VR has been used to study a variety of phenomena relevant to criminologists, such as stereotyping and racial bias (Dotsch and Wigboldus 2008), disorderly conduct (Toet and van Schaik 2012), obedience and authoritarianism (Slater et al. 2006), aggression (Slater et al. 2013), moral judgment (Navarrete 2012), victimization risk (Park et al. 2012), delinquency (Van Gelder, Hershfield, and Nordgren 2013), and crime (Van Gelder, Nee, et al. 2017).

The study of offender decision-making ideally involves situations that allow for systematic study and replicability but which are also realistic enough to assume that participant responses will resemble their behavior in real life (Van Gelder, Otte, and Luciano 2014). As Loomis et al. (1999) observe, the effectiveness of scenarios to induce cognitive and affective states varies according to attentional, motivational, and imaginative capabilities of participants. By more directly eliciting cognitive and affective processes, VR can substantially augment experimental realism (Loomis et al. 1999:559) and reduce the cognitive burden involved in reading traditional scenarios. Because a scenario in VR is presented visually and can be experienced from a point-of-view perspective, no cognitive effort has to be spent on reading and imagining the situation.

By shutting off real-world input, VR replaces real sense perceptions by those displayed in the VR goggles and therefore substitutes real-world visual input with the input from the virtual environment. As Bailenson (2018) argues, because users' brains are treating the VR experience they are having as psychologically real, they are physiologically aroused in a way that is similar to what occurs during a real experience. The human mind cannot be in two places at once, so feeling present in the virtual world leads to psychological absence in the real world (Bailenson 2018:250). The key concept in this context is "presence," which denotes the subjective feeling of being in the virtual environment rather than the actual physical environment where one's body is located (Slater et al. 2006). Achieving sufficient levels of presence may increase the fidelity of the behavior displayed in the virtual environment in relation to the behavior that would have been displayed in its real-world equivalent (Van Gelder, Otte, et al. 2014).

It should be noted that experiencing presence is not restricted to VR per se. Research suggests that people can also experience it when viewing or engaging in a variety of situations including playing video games, watching a movie, or reading a book (Hartmann et al. 2016). According to Schubert and Crucius (2002), the underlying psychological phenomenon may be identical for different media: The actual physical environment is suppressed in favor of an alternative, medially presented and cognitively construed environment. However, in spite of the ability of other media to generate presence, the immersive and enveloping nature of VR makes it particularly suited for achieving this and to do so in a relatively brief time span. Written narratives, in contrast, may require more acclimation, and a computer or TV screen can easily be looked away from, diverting attention from the scenario and reducing the experience of presence.

An example of the potential of VR in eliciting behavioral and physiological reactions and mimicking real situations is Slater and colleagues' (2006) variation of Stanley Milgram's famous obedience experiment. Milgram's experiment aimed to understand obedience by demonstrating that people would administer severe and dangerous electric shocks to a stranger when instructed to do so by an authority figure. In their "virtual reprise," Slater et al. used a similar paradigm but in an immersive virtual environment. Instead of examining obedience in itself, the authors looked at the extent to which participants responded to this extreme social situation as if it were real. Participants delivered "electric shocks" to a virtual "trainee" when she made errors during a word association memory test. The virtual trainee protested against the shocks in similar ways as the confederate in the original Milgram study. Even though participants in the study knew that neither the trainee nor the shocks were real, they tended to respond to the situation at the subjective, behavioral (e.g., withdrawal from the experiment), and physiological (e.g., heart rate, skin conductance) levels as if they were. This study shows VR can engage the senses and trigger strong emotional and physiological processes. Furthermore, it demonstrates that powerful experiments with VR can be carried out when ethical or safety considerations rule out using real-world situations or real humans as participants.

In sum, VR scenarios have different advantages over written scenarios. For one thing, they can convey a far greater amount of information and provide more contextual detail resulting in a higher ecological validity. This increased physical and psychological fidelity, in turn, may be better able to elicit the emotions typically involved in decision situations. Compared to the cognitively more effortful written scenarios, VR scenarios allow

participants to perceptually enter the situation and thus place a much lower demand on their imaginative capabilities. Because VR simulations more closely resemble actual criminogenic contexts and fill in details that would otherwise be left to the imagination of participants, we argue that VR scenarios should be more strongly related to real-world criminal decision-making.

The Present Study

In this study, we use VR to generate a faithful reproduction of reality using 360° video, which uses multiple cameras to record the full 360° × 180° field of view to create an immersive experience. Instead of being read, a viewer experiences the scenario from a first-person perspective through VR goggles and is at liberty to look around as she or he would in the real world. Thus, rather than asking participants *to imagine* themselves to be in a situation, the VR scenario actually *immerses* them in it.

We posit that, in comparison to written scenarios, the use of VR more directly engages the senses, which is manifested in a stronger sense of being in the depicted situation, that is, feelings of "presence," as well as the perceived realism of the situation. In turn, we assume that increased presence and perceived realism are likely to trigger emotions in ways similar to an actual real-life experience. Due to the strong behavioral drive properties of emotions, we expect that this in turn will influence decision-making. In other words, we hypothesize a serial mediation model according to which experiencing the scenario in VR will increase reported levels of presence and perceived realism, which in turn heightens people's levels of reported anger, which in turn increases subsequent intentions to aggress. We test these hypotheses using an experimental research design consisting of both a written and a VR version of a "bar fight" scenario describing a conflict between two individuals.

We compare participant responses to the written scenario with those to its VR equivalent on a series of variables including intention to aggress, perceived risk, anticipated shame/guilt, presence, perceived realism, and anger. Additionally, we measured participants' alcohol consumption using a breathalyzer device. Data collection was conducted during, and among visitors of, a large music festival in the Netherlands. We opted for using festival grounds for data collection because they provide more context relevant cues, such as the presence of others, the availability and consumption of alcohol, music, and a leisure environment, compared to the more sterile research labs and university classrooms where decision-making

studies of this type are mostly conducted. This may reduce the cognitive effort required for participants to imagine and identify with the situation of interest and also contributes to the ecological validity of the research design.

Method

Setting

Data were collected at the Lowlands Festival in 2015 (www.lowlands.nl), an annual three-day music festival in the Netherlands attended by approximately 50,000 visitors yearly. This venue allowed for data to be collected from participants who would likely vary across race, age, SES, and so on. The festival features live music and other cultural events such as cinema, stand-up comedy, literature, and theater. Festival organizers opened a call for research proposals, offering the opportunity for scientists to use the festival terrain as a living lab, labeled "Lowlands Science." At any time between 10 a.m. and 6 p.m. over the three days, festival attendees could participate in various experiments, including the present study.

Participants

Due to the nature of the bar fight and the actors involved in the scenario, participants had to be male with a heterosexual (or bisexual) orientation and 18 years or older. Of the 153 participants who signed up for participation, two participants who responded "homosexual" to our sexual orientation item were excluded from the study. In addition, six participants failed to respond to one or both background variables (age and education) and/or had a missing value on blood alcohol concentration (BAC) and were excluded from further analysis, leaving the present sample at $n = 145$ ($M_{age} = 27.9$, age range = 18–48).[2] Educational levels ranged from prevocational secondary education (0.7 percent), vocational secondary education (19.3 percent), higher-level secondary education (5.5 percent), higher professional education (43.4 percent), to university-level education (31.0 percent). Education levels were converted into an ordinal scale. Furthermore, 31 (21.4 percent) participants indicated using at least one type of recreational drug (e.g., marihuana, cocaine, XTC, heroin, MDMA, magic mushrooms), and 75 (51.7 percent) of the participants indicated consuming at least one glass of alcohol ($M = 1.46$, range = 0–8 glasses) prior to their participation in the study. In total, 23.4 percent of the participants had a BAC of 0.08 percent or higher ($M = 0.01$ percent, range = 0.00–0.17 percent).

Materials

Immediately following the presentation of either the written or the VR bar fight scenario, participants responded to a survey presented on a laptop computer. The survey measured risk probability (henceforth "probability"), anticipated risk severity (henceforth "severity"), anticipated shame/guilt, anger, presence, realism of the scenario, and the dependent variable intention to aggress, as well as several demographic variables. All materials were in Dutch.

Perceived risk. The perceived risk measure, which was a composite measure of the probability of anticipated negative consequences multiplied by their anticipated severity, was based on Nagin and Paternoster (1993). Two items, using seven-point scales, measured probability, that is, "How likely is it that there will be negative consequences for you if you use violence?" (*very unlikely-very likely*) and "How big do you think the chance is that things will end badly for you, should you use violence?" (*very small* to *very large*). Rather than experimentally manipulating probability, respondents were asked to give their own estimate to avoid the artificiality of furnishing probabilities that respondents could find unrealistic (see Nagin and Pogarsky 2001). Severity was also measured by two items using seven-point scales, "How serious are the possible consequences for you if you use violence?" (*not at all serious-very serious*) and "How severe are the potential negative consequences if things end badly for you?" (*not at all severe* to *very severe*). Following Van Gelder and de Vries (2014), a perceived risk measure that reflected both risk probability and severity was constructed multiplying the average of both severity items with the average of both probability items.

Anger. An anger scale was developed specifically for the purposes of the present study and consisted of five items using seven-point scales ("Would you be angry in this situation?," "Would you be annoyed?," "Would you be irritated?," "Would you be furious?," and "Would you feel frustrated?"; *not at all-very much*; $\alpha = .86$).

Anticipated shame/guilt. An anticipated shame/guilt scale was developed specifically for this study and consisted of two items using seven-point scales ("Would you later feel guilty if you were to use violence?" and "Would you later feel shame if you were to use violence?"; *not at all-very much*; $\alpha = .88$).

Perceived realism. A realism scale developed by Van Gelder et al. (2017) consisting of six items using seven-point scales was used to measure the

realism of the scenario (e.g., "The situation was realistic" and "I had the idea the scenario was fictitious," reverse scored; *strongly disagree-strongly agree*; $\alpha = .79$).

Presence. Presence was measured using an adapted 13-item version of the Igroup Presence Questionnaire (Schubert, Friedmann, and Regenbrecht 2001; $\alpha = .86$), for example, "I had a feeling I was present in the scenario" and "I was not aware of my real environment" (*strongly disagree-strongly agree*). Adaptations served to fit questions to both the VR and the written scenario. Furthermore, the phrasing of several of the items was altered to a *strongly disagree* to *strongly agree* answering format (which was the case for most, though not all, of the original items).

Intention to aggress. Intention to aggress was measured by two items. One item was measured on a seven-point scale "How likely is it that you would use violence against this person by pushing, kicking or hitting him?" (*very unlikely* to *very likely*). The other item regarded a percentage estimate, for example, "Can you give a percentage estimate of the probability that you would use violence (i.e., push, kick or hit the other person)?" Four participants failed to enter a valid score on the percentage item of the intention to aggress scale. Given the very high correlation between the two items making up this scale ($r = .79$), we decided to replace these four missing values with the participants' score on the other scale item. The percentage item was recoded to a seven-point scale, and an intention to aggress scale was constructed based on the mean score of both items ($\alpha = .88$).

Scenario

The scenario was adapted from the frequently used "bar fight" scenario (e.g., Exum 2002; Mazerolle and Piquero 1997; Mazerolle et al. 2003; Schoepfer and Piquero 2006). The scenario was written in the second person and described an argument at a local bar between the participant and another male who makes a pass at the participant's girlfriend "Lisa." Briefly, the participant is out with his girlfriend, and as he returns from paying the tab at the bar, he finds his girlfriend being approached by the other male who asks Lisa for her phone number. A quickly escalating (verbal) conflict between the participant and the other male ensues (see Appendix for the full scenario).

In the written scenario condition, participants were presented the scenario text on a laptop screen. In the VR condition, they were presented a 360° video

Figure 1. 360° video camera rig.

version of the scenario, filmed from the perspective of the participant, which puts him in the center of the action, and with a voice-over explaining the context and setting (identical to the introductory lines of the written scenario).[3] The scenario was acted out by professional actors and filmed in an Irish pub in downtown Amsterdam. To capture the perspective of the participant i, six GoPro cameras were affixed back to back in the shape of a six-sided die with all lenses facing outward (Figure 1). The cameras were suspended from a helmet worn by an actor who enacted the scenario from the perspective of the participant. This allowed for video to be recorded and merged from six angles simultaneously, such that an individual experiencing the VR could turn their head in various directions to observe the video from different angles resulting in a naturalistic viewing experience.

Procedure

Data were collected in a dedicated pavilion on the festival grounds. The study was advertised as "Experiencing a bar fight in virtual reality." Participants could freely browse the various studies at the pavilion and participate with any study whenever space was available or otherwise form a queue. Upon arriving at the section for this study, participants were presented with an informed consent form. After giving consent, an

experimenter measured their BAC level with a certified, handheld breathalyzer device (Alcovisor Satellite).

Following this intake procedure, participants were alternately assigned to the written scenario or VR scenario condition: The first group were directed to a laptop computer where they read the written form of the scenario followed by the survey. The second group were directed to a station where one of the three experimenters fitted them with Samsung Gear VR goggles and over-the-ear, noise canceling headphones. Participants stood while wearing the goggles, bracing themselves on a tall cocktail table to prevent them from falling over should they become disoriented. Participants then experienced the complete scenario from beginning to end. When they were done watching, they were directed to a laptop computer to complete the survey. Participants in both conditions viewed a written debriefing on the laptop screen upon completing the survey. Those participants who were assigned to the written scenario condition were given the opportunity to experience the VR scenario after completing all the materials of the study. Data collection took about 20 minutes per participant.

Results

First, we examined differences between both conditions in terms of the perceived attractiveness of Lisa. Because participants in the written scenario condition had to impute their own image of Lisa, whereas an image was provided in the VR scenario condition, this may have led to potentially consequential differences between conditions. The results showed that Lisa was perceived as more attractive in the written scenario condition ($M = 5.26$, $SD = 1.35$) compared to the VR scenario condition, $M = 3.92$, $SD = 1.42$; $t(143) = -5.80$, $p < .001$. In the remainder of the analyses, we therefore controlled for perceived attractiveness of Lisa.

Second, we computed partial correlations (controlling for the perceived attractiveness of Lisa) between condition, participant age, BAC, perceived risk, guilt/shame, anger, presence, perceived realism, and the outcome variable intention to aggress (Table 1). All correlations were in the expected direction. Participant age, education, perceived risk, and guilt/shame were all significantly negatively correlated with intention to aggress, whereas the correlations between BAC, anger, presence, perceived realism, and intention to aggress were all significant in the positive direction.

Third, we checked whether the VR scenario condition differed from the written scenario condition on the predictor and outcome variables. The two conditions differed significantly on presence, $M_{VR} = 3.16$ ($SD_{VR} = .65$) versus $M_{W} = 2.92$ ($SD_{W} = .56$), $F(1, 142) = 11.03$, $p < .01$, $d = .40$,

perceived realism, $M_{VR} = 3.50$ ($SD_{VR} = .56$) versus $M_{W} = 3.33$ ($SD_{W} = .64$), $F(1, 142) = 5.21$, $p < .05$, $d = .28$, and intention to aggress, $M_{VR} = 2.42$ ($SD_{VR} = 1.40$) versus $M_{W} = 2.18$ ($SD_{W} = 1.28$), $F(1, 142) = 4.11$, $p < .05$, $d = .18$, with participants in the VR scenario condition scoring higher on each of these variables than those in the written scenario condition. In other words, as anticipated, participants who experienced the scenario in VR experienced higher presence in the situation, evaluated it as being more realistic, and expressed a higher intention to behave aggressively. Contrary to expectations, there were no significant differences in anger between the two conditions nor were there differences in terms of perceived risk and anticipated shame/guilt.

Direct Effects

Our regression analysis, which includes both conditions and hence regards the full sample, proceeded in multiple steps. We predicted intention to aggress from our state variables using stepwise ordinary least squares regression analysis. In each of the models tested, we included attractiveness of Lisa, age, education, and BAC as control variables. Unstandardized and standardized regression coefficients are displayed in Table 2. In step 1, age was a significant predictor of intention to aggress, whereas the effects of education and BAC were marginally significant. Attractiveness of Lisa did not predict intention to aggress. Proceeding with the rational choice variables in step 2, perceived risk (i.e., the Probability × Severity of Negative Consequences) was a significant predictor of intention to aggress, whereas anticipated guilt/shame was not, when controlling for attractiveness, age, education, and BAC. In step 3, we added anger, which turned out to be the strongest predictor of intention to aggress, adding 17 percent of explained variance to the model. In the final model, age ($\beta = -.18$, $p < .05$), perceived risk ($\beta = -.21$, $p < .01$), and anger ($\beta = .42$, $p < .01$) were the significant predictors of intentions to aggress. In conjunction, the predictor variables explained nearly 35 percent of the total variance in intention to aggress.

Mediation by Presence, Realism, and Anger

As a final step in the analyses, we examined whether the effect of condition on intention to aggress is explained by presence, that is, the subjective sense of actually being in the situation, and realism. We predicted that those participants who experienced higher presence and those who reported higher realism would also report a higher intention to aggress in the

Table 1. Bivariate Correlations (Above Diagonal), Partial Correlations (Below Diagonal), and Descriptives for Condition, Attractiveness Lisa, Age, Blood Alcohol Concentration, Perceived Risk, Anticipated Guilt/Shame, Anger, Presence, Realism, and Intention to Aggress.

		1	2	3	4	5	6	7	8	9	10	11
Mean		—	4.57	27.92	4.99	.10	24.82	4.13	4.57	3.05	3.41	2.30
SD		—	1.54	7.52	.89	.25	10.71	1.77	1.30	.62	.60	1.34
1.	Condition (written/VR)	—	.44**	.01	−.05	.05	.13	−.10	.04	.20*	.15	.09
2.	Attractiveness Lisa	—	—	−.03	−.05	−.02	−.07	.10	.07	.10	.05	.14
3.	Age	.00	—	—	.16	.06	−.02	.04	−.15	−.16	−.10	−.25**
4.	Education	.03	—	.16	—	−.06	−.04	.07	−.11	.02	−.03	−.21*
5.	BAC	.05	—	.06	−.06	—	.03	.04	.11	.06	.04	.14
6.	Perceived risk	.11	—	−.02	−.04	.03	—	.31**	.08	−.01	−.04	−.20*
7.	Anticipated guilt/shame	−.06	—	.04	.07	.04	.32**	—	−.07	−.06	−.09	−.18*
8.	Anger	.08	—	−.15	−.11	.11	.09	−.08	—	.26**	.23**	.46**
9.	Presence	.27**	—	−.15*	.02	.06	.00	−.07	.26**	—	−.62**	.34**
10.	Realism	.19*	—	−.10	−.03	.04	−.04	−.10	.23*	.63**	—	.25**
11.	Intention to aggress state affect	.17*	—	−.25**	−.20*	.14*	−.19*	−.19*	.46**	.33**	.24**	—

Note: $N = 145$; condition (written = 0, VR = 1); BAC = blood alcohol concentration; VR = virtual reality.
*$p < .05$. **$p < .01$.

Table 2. Unstandardized and Standardized Regression Coefficients of Intention to Aggress on Attractiveness Lisa, Age, Education, BAC, Perceived Risk, Anticipated Guilt/Shame, and Anger.

	Step 1		Step 2		Step 3	
	B (*SE*)	β	*B* (*SE*)	β	*B* (*SE*)	β
Background variables						
Attractiveness Lisa	.11 (.07)	.13	.11 (.07)	.13	.08 (.06)	.09
Age	−.04 (.01)	−.23**	−.04(.01)	−.23**	−.03 (.01)	−.18*
Education	−.24 (.12)	−.16†	−.23 (.12)	−.15†	−.19 (.11)	−.12
BAC	.78 (.42)	.15†	.83 (.41)	.16*	.58 (.37)	.11
Rational choice variables						
Perceived risk			−.02 (01)	−.16*	−.03 (.01)	−.21**
Anticipated guilt/ shame			−.10 (06)	−.13	−.06 (.06)	−.08
Emotions						
Anger					.43 (.07)	.42**
R^2		.13		.18		.35
ΔR^2				.06*		.15**

Note. $N = 144$; BAC = blood alcohol concentration; *SE* = standard error; VR = virtual reality.
†$p < .10$.
*$p < .05$. **$p < .01$.

scenario. Additionally, we predicted that condition would be related both to intention to aggress and to presence/realism. To examine whether presence and realism mediated the relation between condition and intention to aggress, we used a nonparametric bootstrapping procedure (Hayes 2013; Preacher and Hayes 2004). Because indirect effects are not normally distributed and the traditional approaches (e.g., Baron and Kenny 1986; Sobel 1982) suffer from several weaknesses, such as a higher probability of type I error rates and low power (e.g., MacKinnon et al. 2002; Shrout and Bolger 2002), bootstrapping has become the preferred method for testing mediation. The bootstrapping method statistically tests the indirect effect, respecting the nonnormality of its sampling distribution (Hayes 2013).

We used the PROCESS macro for testing our simple and serial mediation models (Hayes 2013) with 5,000 bootstrap samples. In each of these models, we controlled for attractiveness of Lisa, age, level of education, BAC, perceived risk, anticipated shame/guilt, and anger by entering these variables as covariates. The mediation is significant at the .05 level if the bootstrapping confidence interval of the indirect effect does not include 0.

Simple Mediation with Presence and Realism as Mediators

Running two simple mediation models (Table 3), we tested whether presence and realism mediated the relation between condition (written vs. VR) and intention to aggress. Because presence and perceived realism were strongly related ($r = .62$, $p < .01$; see Table 1), suggesting high levels of collinearity, we tested separate models for both variables. We first regressed the mediators (presence [first column] and perceived realism [third column]) on condition. In line with findings reported earlier, condition was significantly related to both presence and perceived realism, with the VR condition provoking higher presence and perceived realism than the written condition. In the second step, we regressed intention to aggress on condition and the mediators (presence [second column] and perceived realism [fourth column]). The relation between condition and intention to aggress became nonsignificant when presence was added, and the bootstrap procedure showed a significant indirect effect of condition, through presence, on intention to aggress ($B = .12$ [$SE = .06$]; 95% CI [.02, .27]), indicating presence fully mediated the relation between condition and intention to aggress, with higher intention to aggress among those participants with a higher presence. Despite the high correlation between presence and perceived realism, a similar mediation effect did not occur for perceived realism. The indirect effect of perceived realism was not significant ($B = .05$ [$SE = .05$]; 95% CI [−.15, .03]), while the direct effect of condition on intention to aggress did remain significant (see fourth column in Table 3).

Serial Mediation with Anger and Presence as Mediators

Next, we tested two serial mediation models, one with presence and anger as mediators of the relation between condition and intention to aggress (Table 4) and the other with perceived realism and anger as mediators of the relation between condition and intention to aggress (Table 5). We used the same variables as covariates as in the simple mediation models (with the exception of anger).

In the first mediation model, we assumed a causal chain in which condition influences presence, which predicts increased anger, which in turn increases intention to aggress. The results of the PROCESS analyses showed support for this model, with a significant indirect effect ($B = .07$ [$SE = .03$]; 95% CI [.02, .14]), whereas the direct effect of condition on intention to aggress was not significant anymore ($B = .34$ [$SE = .21$]; 95% CI [−.07, .76]).

Table 3. Unstandardized Regression Coefficients with Standard Errors and 95% Confidence Intervals (CIs) Estimating the Relations between the Predictor Condition, the Mediator Presence/Realism (Mediators), and the Outcome variable Intention to Aggress with Attractiveness Lisa, Age, Education, BAC, Perceived Risk, and Anticipated Guilt/Shame as Covariates (Simple Mediation).

	Dependent Variables						Dependent Variables					
	Presence (Mediator)			Intention to Aggress			Realism (Mediator)			Intention to Aggress		
Independent Variables	*B*	*SE*	95% CI	*B*	*SE*	95% CI	*B*	*SE*	95% CI	*B*	*SE*	95% CI
Condition (written/VR)	.34	.11	[.13, .56]	.34	.21	[−.07, .76]	.23	.11	[.02, .45]	.42	.21	[.01, .83]
Presence/realism (*M*)				.36	.16	[.05, .68]				.20	.16	[−.12, .51]
Covariates												
Attractiveness Lisa	.08	.04	[.01, .15]	.11	.07	[−.02, .25]	.05	.04	[−.02, .12]	.14	.07	[.00, .27]
Age	−.01	.01	[−.02, .00]	−.03	.01	[−.05, −.00]	−.01	.01	[−.02, .12]	−.03	.01	[−.06, −.01]
Education	.04	.06	[−.07, .15]	−.21	.10	[−.42, −.01]	−.00	.06	[−.11, .11]	−.20	.10	[−.41, .01]
BAC	.09	.20	[−.30, .47]	.52	.36	[−.20, 1.23]	.03	.20	[−.36, .42]	.54	.37	[−.19, 1.27]
Perceived risk	−.00	.01	[−.01, .01]	−.03	.01	[−.05, −.01]	−.00	.00	[−.01, 01]	−.03	.01	[−.05, −.01]
Anticipated guilt/shame	−.01	.03	[−.06, .05]	−.05	.05	[−.16, .06]	−.02	.03	[−.07, .04]	−.05	.06	[−.16, .06]
Anger	.10	.04	[.03, .18]	.38	.07	[.24, .53]	.09	.04	[.02, .17]	.40	.07	[.25, .55]
	R^2 =.16 $F(8, 136) = 3.21$, $p < .01$			R^2 = .39 $F(9, 135) = 9.68$, $p < .001$			R^2 = .10 $F(8, 136) = 1.80$, $p = .08$			R^2 = .38 $F(9, 135) = 9.02$, $p < .001$		

Note: $N = 145$; condition (written = 0, VR = 1); BAC = blood alcohol concentration; *SE* = standard error; VR = virtual reality.

In the second serial mediation model, perceived realism and anger were entered as subsequent mediators (Table 5). In this model, condition was significantly related to realism, realism was related to anger, and anger was related to intention to aggress. However, none of the indirect effects were significant, whereas the direct effect of condition on intention to aggress did remain significant ($B = .42$ [$SE = .21$]; 95% CI [.01, .83]), indicating a lack of support of this serial mediation model.

In sum, results from the simple and serial mediation models show that presence is an important mediator of the relation between condition and intention to aggress, whereas perceived realism is not.

Discussion

In this study, we argued that experiencing a scenario in VR can trigger stronger feelings of presence in the situation compared to its written equivalent, and also elicit more intense emotional experiences, resulting in a better approximation of real-world decision-making. We tested our VR scenario method using an adapted version of a commonly used bar fight scenario and compared participant responses on the VR scenario to responses on the traditional written version of the scenario. We tested our method at a large music festival, which both provided an environment with more context relevant signals compared to the typical environment where scenario studies tend to be conducted—the classroom or university laboratory—and a more diverse sample in terms of age, education, and social background than is common in such studies, which generally tend to involve university undergraduates.

We hypothesized participant responses would differ between both versions of the scenario in a number of meaningful ways. First, we expected presence to be higher in VR compared to the written scenario. We also expected the VR scenario to be perceived as more realistic compared to the written scenario. Aside from differences between conditions, we specified several mediation hypotheses. We expected that the effect of condition on aggressive intentions would be mediated by people's experienced presence and perceived realism of the scenario. Furthermore, we specified a serial mediation model according to which we expected increased presence and realism to result in higher levels of anger, which, in turn, would result in increased aggressive intentions.

In support of our hypotheses, we found that presence and realism were higher in the VR condition compared to the written vignette condition, with the effect being slightly stronger for presence than for realism. Participants

Table 4. Unstandardized Regression Coefficients with Standard Errors and 95% Confidence Intervals (CIs) Estimating the Relations between Condition (Predictor), Presence (Mediator 1), Anger (Mediator 2), and Intention to Aggress (Outcome) with Attractiveness Lisa, Age, Education, BAC, Perceived Risk, and Anticipated Guilt/Shame as Covariates (Serial Mediation).

	Mediators						Dependent Variable		
	Presence (Mediator 1)			Anger (Mediator 2)			Intention to Aggress		
Independent Variables	*B*	*SE*	95% CI	*B*	*SE*	95% CI	*B*	*SE*	95% CI
Condition (written/VR)	.36	.11	[.14, .58]	−.02	.25	[−.50, .47]	.34	.21	[−.07, .76]
Presence (M1)				.49	.18	[.14, .85]	.36	.16	[.05, .68]
Anger (M2)							.38	.07	[.24, .53]
Covariates									
Attractiveness Lisa	.09	.04	[.02, .16]	.04	.08	[−.11, .20]	.11	.07	[−.02, .25]
Age	−.01	.01	[−.03, −.00]	−.02	.01	[−.05, .01]	−.03	.01	[−.05, −.00]
Education	.03	.06	[−.08, .14]	−.12	.12	[−.36, .11]	−.21	.10	[−.42, −.01]
BAC	.15	.20	[−.25, .54]	.49	.42	[−.34, 1.33]	.52	.36	[−.20, 1.23]
Perceived risk	−.00	.01	[−.01, .01]	.01	.01	[−.01, .03]	−.03	.01	[−.05, −.01]
Anticipated guilt/shame	−.02	.03	[−.08, .04]	−.07	.06	[−.19, .06]	−.05	.05	[−.16, .06]
	$R^2 = .11 F(7, 137) = 2.49, p < .05$			$R^2 = .11 F(8, 136) = 2.15, p < .05$			$R^2 = .39 F(9, 135) = 9.68, p < .001$		

Note: $N = 145$; condition (written = 0, VR = 1); BAC = blood alcohol concentration; *SE* = standard error; VR = virtual reality.

Table 5. Unstandardized Regression Coefficients with Standard Errors and 95% Confidence Intervals (CIs) Estimating the Relations between the Condition (Predictor), Realism (Mediator 1), Anger (Mediator 2), and Intention to Aggress (Outcome) with Attractiveness Lisa, Age, Education, BAC, Perceived Risk, and Anticipated Guilt/Shame as Covariates (Serial Mediation).

	Mediators						Dependent Variables		
	Realism (Mediator 1)			Anger (Mediator 2)			Intention to Aggress		
Independent Variables	*B*	*SE*	95% CI	*B*	*SE*	95% CI	*B*	*SE*	95% CI
Condition (written/VR)	.25	.11	[.03, .47]	.05	.24	[−.43, .53]	.42	.21	[.01, .83]
Realism (M1)				.44	.18	[.08, .80]	.20	.16	[−.12, .51]
Anger (M2)							.40	.07	[.25, .55]
Covariates									
Attractiveness Lisa	.06	.04	[−.02, .13]	.06	.08	[−.09, .22]	.14	.07	[.00, .27]
Age	−.01	.01	[−.02, .01]	−.02	.01	[−.05, .01]	−.03	.01	[−.06, −.01]
Education	−.01	.06	[−.12, .10]	−.10	.12	[−.34, .14]	−.20	.10	[−.41, .01]
BAC	.09	.20	[−.31, .48]	.53	.42	[−.31, 1.37]	.54	.37	[−.19, 1.27]
Perceived risk	−.00	.01	[−.01, .01]	.01	.01	[−.01, .03]	−.03	.01	[−.05, −.01]
Anticipated guilt/shame	−.02	.03	[−.08, .04]	−.06	.06	[−.19, .06]	−.05	.06	[−.16, .06]
	$R^2 = .06 F(7, 137) = 1.17, p = .32$			$R^2 = .10 F(8, 136) = 1.95, p = .06$			$R^2 = .38 F(9, 135) = 9.02, p < .001$		

Note: $N = 145$; condition (written = 0, VR = 1); BAC = blood alcohol concentration; *SE* = standard error; VR = virtual reality.

in the VR condition did not experience significantly higher levels of anger compared to the written condition, however. In hindsight, we think that it was our experimental setup that may have accounted for the lack of effect for anger. As mentioned earlier, an important difference between both conditions was that participants who read the scenario imputed their own partner or an imaginary partner in the narrative, whereas those who experienced it in VR were presented with a specified partner who was a stranger to them (and had to imagine this stranger as their partner). Participants in the written scenario condition also reported finding Lisa more attractive compared to the VR condition. It stands to reason that an argument with a challenger making a pass at one's own romantic partner elicits stronger feelings of anger. An alternative explanation for the lack of difference in anger between the conditions is that participants may have "cooled" off in the period between experiencing the scenario and responding to the survey. Given the fact that participants were presented the survey immediately after experiencing or reading the scenario, we think this latter explanation is less likely.

With respect to our mediation hypotheses, the results supported the hypothesis regarding the influence of presence but not the hypothesis regarding perceived realism. Furthermore, the serial mediation models also showed support for the predicted causal chain for presence. In contrast, although perceived realism was related to condition as well as the outcome variable, it did not mediate the relation between the two. We can only speculate at this point about the different cognitive processes at stake for presence and realism, but it may be the case that the experience of presence is a more automatic and unconscious process, whereas realism is more reasoned and cognitive in nature. The reason why realism may have failed to mediate the relationship between the predictor and outcome variables is that both conditions involve the same narrative and differ only in terms of the medium through which it is delivered.

In spite of promising initial findings, as a first and still tentative research effort, this study was also prone to a number of limitations that merit discussion and that need to be addressed in future research. For one thing, our VR approach using 360° video was linear in nature and restricted in terms of the amount of interaction it allowed with the virtual environment. That is, participants were exposed to the scenario as it unfolded, and even though they were at liberty to look around, they were not able to influence the course of events themselves. Compared to rendered or animated VR, which allows for interaction with objects and avatars in a computer-

generated virtual environment and a user to influence the course of events, the limited amount of interaction in the present study has implications for levels of presence that are experienced. Indeed, although significant, the difference between conditions on this variable was modest (Cohen's $d = .40$). Nonetheless, it is important to note that the goal of this study was the comparison of a VR-based scenario with a written equivalent that also depicts a fixed ordering of events and does not allow participants to exert any influence over them. Hence, our design was appropriate for these research purposes. An additional strength of our design regards the level of visual realism of 360° video, which is substanially higher than what can currently be achieved with rendered VR, given a similar budget.

Another aspect of this study that could be addressed in future research relates to the measurement of the outcome variable. Instead of asking people to act out their behavior in response to the behavior of the challenger in the scenario, this study relied on declarative responses. Hence, this was prone to a similar limitation as written scenarios, that is, the measurement of behavioral intentions rather than actual behavior. The possibility of dishonest or inaccurate reporting or thoughtfulness in answering questions (see, e.g., Loughran et al. 2014) cannot be excluded. Relatedly, the fact that participants gave their responses on a survey after being presented the scenario may have influenced their choice: Rather than acting out "in the heat of the moment," they had at least some time for cognitive deliberation. This may have attenuated the effects of experienced anger on people's reported intentions to behave aggressively. Future research could experiment with paradigms that collect participant responses within the VR environment, thus removing the "cooling off" period.

These limitations may be remedied in future studies in a number of ways. For one thing, VR can be used in combination with different physiological measures such as heart rate, blood pressure, or galvanic skin response, which can provide important information regarding individual reactions to decision-making situations (see Van Gelder et al. 2017 for a recent example). These physiological reactions can be related to specific events, objects, or individuals ("avatars") in the virtual environment during an interaction or as a scenario unfolds. Specifically in combination with recent VR hardware developments, which include the possibility of using eye tracking, the amount and level of detail of information that can be obtained is unprecedented. Furthermore, VR also allows for measuring actual behavior in detailed and intricate ways. For example, VR systems can measure physical distance between individuals and objects (see Dotsch and Wigboldus 2008, for an interesting illustration), and specialized body suits that provide haptic

feedback can have participants experience events such as a push or even a punch in the stomach. VR studies making use of behavioral or physiological measures are evidently much less prone to the possibility of deception, thoughtfulness, or inaccurate reporting on the part of research participants.

Whether a VR scenario is to be preferred over a written scenario will depend on different factors. One relevant consideration when contemplating the choice for a VR scenario versus a written scenario regards the type of offense under study and the typical circumstances under which it is committed. Certain types of offenses may be better approximated using survey-based scenarios and/or may simply be too cumbersome to model in VR, particularly those that do not require physical action or interaction in time and space with other agents. White-collar crimes or property crimes such as fraud, illegal downloading, or identify theft are examples that easily come to mind. Furthermore, bar fights, and many other contexts in which crime and aggressive behavior can occur, could be influenced by a participant's own friends being present in the situation or their own daily surroundings (e.g., the home environment). In cases where it would be necessary to take this into account, written scenarios can be more flexible than VR scenarios. Finally, as with written scenarios, the effectiveness and possibilities of VR scenarios are contingent on the quality of the VR. Ill-designed virtual environments are likely to result in ill-informed research. Given the difference in costs involved in creating virtual environments compared to drawing up a narrative on a sheet of paper, this is an important consideration to keep in mind when contemplating the use of VR for research purposes.

Conclusion

The introduction of the written scenario method and the rational choice paradigm in the late 1980s and early 1990s have both left their mark on the field and significantly increased our knowledge of criminal decision-making. New technologies such as VR can herald the next step in criminal decision-making research as they can move yet another step closer toward approaching the real-life context in which crimes take place. In combination with the ability of VR to trigger emotional processes and the possibility of measuring physiological responses in real-time as a scenario unfolds, VR can also further refine criminal choice theory. As was mentioned earlier, the limited ability of traditional research methods to induce and measure emotions may have led researchers to prematurely conclude that emotions and other visceral factors play little role of importance in criminal choice, reinforcing the view of crime as a strictly rational

process. Triggering and more accurately measuring emotional processes are likely to contribute to descriptively more accurate theoretical models of criminal decision-making and advance our understanding of crime in important ways.

We consider this study to be only a first and modest step towards demonstrating some of the potential of VR for studying criminal decision-making. We are convinced, however, that the potential of this technology extends far beyond what was shown here and hope that it will evolve into a standard tool in crime research to further refine theoretical models of criminal decision-making. We can see that the move from written scenarios to VR scenarios, possibly interactive ones, can be as consequential for the field as the introduction of the written scenario method has been since its introduction in the late 1980s.

Appendix

Imagine the following situation: It's Friday night and you are out with your girlfriend Lisa in Irish Pub Molly Malone's in the center of Amsterdam. You and Lisa, with whom you have been dating for two years now, went to Molly's for food. The food was great and you enjoyed a nice glass of wine with it. After the main course you decide against taking desert or coffee but to head home instead. You walk to the bar to pay. The bartender asks you whether you enjoyed the food while presenting you the bill of €47,- You tell him the food was great while paying him with a €50,- note and tell him to keep the change. While returning to your table you see a guy in his 20s that you don't know standing close to and talking with Lisa. Walking back to your table you hear him ask for Lisa's phone number. The following dialogue unfolds:

YOU: "What's going on? Are you hitting on my girlfriend?"
GUY: (keeps looking at Lisa) "I don't see a ring on her finger so she can talk to whoever she wants to."
YOU: "Lisa, let's go."
GUY: (to you): "Maybe you should go."
YOU: (louder) "I am not talking to you!"
GUY: (turning towards you): "But I am talking to you."
YOU: (raised voice) "Fuck off!"
GUY: (raised voice) "You fuck off!"
YOU: (raised voice and threatening) "And now stop it!"
GUY: (provocative) "Or what . . . ?"

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Notes

1. We note that written scenarios do not preclude the possibility of eliciting visceral responses per se. For example, sexual arousal can be induced by having participants read erotic passages. In other words, the ability to induce visceral states by scenarios is in part contingent on the type of state. We thank one of the anonymous reviewers for bringing this point to our attention.
2. We decided to restrict the upper age limit for inclusion to 50 due to the age of the actors in the scenario. Although this choice is somewhat arbitrary, and an age limit of around 40 or even 30 years may seem more appropriate, we found no differences in correlations between the independent and dependent variables for these age groups. Hence, we opted for 50 years to avoid sample attrition and reducing statistical power.
3. The virtual reality scenario can be obtained from the first author and is available in both the English and Dutch language.

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