




# Video games, frustration, violence, and virtual reality: Two studies

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The degree to which the content of video games influences aggression continues to be debated in the scholarly literature. The current article includes two studies, one of which replicates one study from Przybylski *et al.* (2014, *J. Pers. Soc. Psychol.*, 106, 441) and the other which extends related concepts into virtual reality. In the first study, two versions of Tetris were examined, differing in levels of difficulty. In the second study, participants played virtual reality games which differed in regard to difficulty and violent content. Difficulty increased hostility in the second study but not the first. Violent content influenced neither hostility nor aggressive behaviour. Results partially supported the frustration theory of aggression, but not theories of violent content effects. Implications for the field are discussed.

Despite several decades of research, the issue of whether aggressive video games (AVGs) contribute to aggression in real life remains controversial. That controversy has hit policy statements by professional guilds such as the American Psychological Association (APA). Recently, the APA acknowledged that evidence did not link AVGs to real-world violence, but reaffirmed their stance that AVGs could increase aggression (Suls *et al.*, 2020). However, over 200 scholars had written to the APA when this policy position was being developed asking the APA to avoid making such definitive declarations about a highly divided research field (Consortium of Scholars, 2013). More recently, a reanalysis of the meta-analysis at the core of the APA's policy statement revealed it to be deeply flawed. The APA's meta-analysis missed numerous studies, included some studies that had no actual relevant data, and failed to consider methodological mistakes that, in the reanalysis, were demonstrated to artificially inflate effect sizes. On balance, the reanalysis concluded that the data, even at the time of the APA's original policy statement, could not be used to conclude that AVGs contribute to real-world aggression (Ferguson, Copenhaver, & Markey, 2020).

## Why is AVG research so controversial?

The issue of AVGs and their impact on society have, arguably, been part of larger societal issues involving the politics of gun violence and censorship (Ferguson, 2013),

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generational divides (Przybylski, Deci, Rigby, & Ryan, 2014), and moral panic (Bowman, 2016). Though references to the dangerousness of AVGs continue, particularly after well-publicized mass shootings, arguably at the societal level, matters came to a head in the 2011 court case *Brown v. Entertainment Merchants Association*, which ruled that video game sales to minors could not be regulated under the protection of the First Amendment. The firm decision by SCOTUS emphasized the lack of conclusive research linking AVGs and aggressive behaviour. Arguably, this placed an unexpected and undesired critical lens on psychological science at a time when psychology was already beginning to enter its replication crisis (Ferguson, 2013).

Much of the confusion in AVG research has stemmed from decades-long systematic problems with the way research questions were framed, measured, and reported. As other reviews have covered these issues extensively, and we will not go into significant depth here, though these include issues of poor standardization (Elson, Mohseni, Breuer, Scharnow, & Quandt, 2014) and validity (Mitchell, 2012) of commonly used aggression instruments, failure to match control and experimental video games carefully (Adachi & Willoughby, 2011) as well as evidence for demand characteristics in many of the studies. Questionable researcher practices, such that some research groups appear to be either intentionally or unintentionally manipulating statistics such as to create 'statistically significant' results (see Przybylski & Weinstein, 2019 for documentation of one case involving a large sample of Singapore Youth, i.e., Busching et al., 2013; Gentile, Li, Khoo, Prot, & Anderson, 2014) and several retractions (Whitaker & Bushman, 2014; Zhang, Espelage, & Zhang, 2018) and failed replications (Przybylski et al., 2014; Tear & Nielsen, 2013) or reanalyses (Ferguson & Wang, 2019) have occurred in this field. As a consequence, it is unlikely to be surprising to find that publication bias is a problem for this field. For instance, one 2010 meta-analysis suggested that there were links between AVGs and aggression (Anderson et al., 2010); however, a reanalysis of this meta found that, for experimental studies, effects were likely inflated due to publication bias, with the true effect size difficult to infer from this group of studies (Hilgard, Engelhardt, Bartholow, & Rouder, 2017; Hilgard, Engelhardt, & Rouder, 2017).

As noted above, questionable researcher practices in general appear to have spuriously driven both 'statistical significance' and effect sizes. This has led to the adoption of preregistration and other open science practices in some studies. At present, there have been roughly a dozen preregistered studies on the issue of AVGs (for a review, see Ferguson, 2020). To date, none of these, including longitudinal studies, have provided evidence for a relationship between AVGs and aggression (only a single cross-sectional study provided mixed outcomes; Ivory, Ivory, & Lanier, 2017). As such, at present, there is little clear evidence to link AVGs to aggressive behaviour.

### **Virtual reality**

More recently, virtual reality (VR) has become available for commercial video games. VR involves technology that more fully immerses a player in a game such as the environment appears all around them, typically using a VR headset. This may give the player the sensation that they are more fully moving within the environment and interacting with it with their hands and movements rather than with a standard controller. This raises the question of whether games with VR might see the potential to stimulate aggression effects even if these are less of an issue for standard AVGs.

The argument for why VR may enhance any negative outcomes relies on the increased immersion of the medium (Arriaga, Esteves, Carneiro, & Monteiro, 2008). Specifically, the

realism of VR may enhance immersion, increasing physiological responses, and emotional arousal. This can lead to greater involvement and identification with characters and realism, all of which some scholars (Huesmann, Moise, Podolski, & Eron, 2003) claim may be associated with increased aggression. However, evidence for this hypothesis has not always been clear with, for instance, the arguably more immersive video game genre generally showing no more evidence for negative effects than for television (Sherry, 2001).

Most research to date on VR has looked at positive uses of VR technology in games (Rizzo, Thomas Koenig, & Talbot, 2019). Only a single, remarkably old (from 2008) study of VR has been conducted with somewhat mixed results regarding VR (Arriaga et al., 2008). However, this study is limited by several of the non-best practice issues noted earlier, including unstandardized measures, poor matching of game conditions, and evident demand characteristics. As to this last, video game violence condition was paired closely to measures of aggressiveness such that it may have been possible for participants to reasonably guess the study hypothesis. Although the authors claim no participants guessed the hypothesis, we find this unlikely as rigorous debriefing typically finds 20–25% hypothesis guessing including in the present study as we report below (see also Hilgard, Engelhardt, Rouder, Segert, & Bartholow, 2019). As such, there is more room for studies involving VR.

### **Games, difficulty, frustration, and aggression**

A few studies have examined the possibility that any links between games and aggression may not have anything to do with violent content at all, but rather originate from other issues such as competitiveness (Adachi & Willoughby, 2016) or difficulty (Kneer, Elson, & Knapp, 2016). From this perspective, many prior studies, by not carefully matching experimental and control video games, confounded these other variables with violent content. Once these other variables are controlled, no relationship between violent content and aggression is found. Different results were found in Anderson and Carnagey (2009) who concluded violent content remained significant despite controlling for competitiveness. However, a close examination of the dissertation upon which this article appears to have been based (Carnagey, 2006) reveals significant omissions in the published article. Specifically, game conditions did differ on multiple levels other than either violence or competitiveness. The violent games were rated by participants as more difficult, frustrating, faster pace of action, with more distracting sound and less realism and less strategic. Players also rated themselves as less competent at the violent games. These suggest significant matching differences between the game conditions which undermine any ability to attribute any differences to violent content. Their omission from the published paper is worrisome as are other omissions from the paper regarding inconsistencies in outcomes. This appears to be an example of the *Chrysalis Effect* (O'Boyle, Banks, & Gonzalez-Mulé, 2017) wherein inconvenient details from messy theses and dissertations are omitted from final published papers making their results appear more conclusive than was actually the case.

Much of this work has focussed on frustration and difficulty. Specifically, that frustration and difficulty in games, rather than violent content, lead to aggression. Particularly as AVGs tend to be more difficult to learn than control games without violent content, and experimental gameplay sessions tend to be quite short, often no more than 10–15 min, gaming may be discontinued while players are still learning to play AVGs and this could cause frustration. Several studies have suggested that this is the case.

Breuer, Scharkow, and Quandt (2015) examined the frustration–aggression hypothesis through the manipulation of the social context surrounding gameplay. In this study, the participants played a multiplayer soccer video game against a trained confederate. The experimental conditions involved the confederate winning or losing, in addition to either acting friendly towards or trash-talking the participant. The results of this study indicated that negative affect can mediate the participants' aggressive behaviours. Also, Breuer et al. (2015) found that frustration was a significant variable in the relationship between aggression and video game usage, with frustration having the strongest correlation to the participants' aggression score. The researchers wanted to assess the influence of frustration hindering the desired event of winning the game; the findings showed that frustration led to the negative effect, which increased aggressive behaviour in the participants. Thus, the study done by Breuer et al. (2015) provides evidence that game characteristics, such as violent content, are not sufficient to explain subsequent aggression in video game players; rather, research should continue examining frustration as a catalyst for aggressive behaviour.

In one recent important study, Przybylski et al. (2014) investigated the utility of the motivational hypothesis in determining subsequent aggression in electronic game players through the completion of seven experiments. The motivational hypothesis (i.e., Self-Determination Theory) examines the basic psychological needs of humans such as competence, autonomy, and relatedness and their influence on the need-thwarting aggressive responses. The researchers hypothesized that, when participants played games on high difficulty leading to frequent failures, then aggressive behaviours and feelings would increase due to the participants' thwarted competence. For example, in study six within that article, the researchers found that the difficulty level of the game (Tetris) was related to increased aggression as those who played in the overly challenging condition (designed to impede competence) displayed more aggressive feelings than those in the standard condition. Across the seven studies, Przybylski et al. (2014) concluded that different kinds of games can enhance or lessen a player's competence with this, in turn, fostering aggressiveness. Regardless of the type of game played or the manipulated complexity levels, the researchers found that, when a player's need for competence is disrupted, cognitive, affective, and behavioural aspects of aggression are increased. By contrast, the researchers found that violent content did not increase aggression.

It is worth noting that difficulty and frustration are somewhat overlapping constructs in this context yet maintain some distinction. One would presume that the difficulty of the game would lead to increased frustration, a position implicitly endorsed by Przybylski et al. (2014). Yet it is fair to note that frustration might arise from multiple sources aside from difficulty, and the two terms are not synonymous.

### **The present study**

For the current article, we proposed a replication and extension of study six from Przybylski et al. (2014) regarding the frustration hypothesis of gaming (study 1) as well as extending these issues to the context of AVGs in VR (study 2). Thus, study 1 is a direct replication of study 1 from Przybylski et al. (2014), whereas study 2 is a conceptual replication examining violent content and difficulty in the context of VR gameplay.

For study 1, in the original study (Przybylski et al., 2014, study six), prior to the stimulation, participants first put their hand in the bucket of chilled water, which was used later in the study as a way to measure aggressive behaviour/feelings. During the

stimulation, the participants played two different versions of *Tetris* game, one with an original algorithm and one with a more challenging one. Following the participation in one of the two conditions, participants' aggressive response was measured by asking the length of time that they believed the next participant should put their hand in the chilled water. According to the hypothesis, researchers anticipated that playing a more challenging version of the same game would result in the participants assigning longer durations for the next participant to hold the hand in the water for, as they were frustrated by the more difficult game. In Przybylski et al., 2014, this hypothesis was supported showing that those who played the more challenging *Tetris* version were more likely to experience aggressive feelings and, therefore, more likely to inflict the negative experience with chilled water task on others.

However, society has been changing rapidly and new technologies are on the rise among young adults and children (Hatch, 2011). Consequently, to fill the gap between modern technology and older video game content, we decided to conduct study 2 with more modern technology. For the second study, we utilized the virtual reality (VR) set and two different games, one with violent content and another with nonviolent content. Moreover, each game (nonviolent and violent) was played either in the easy or challenging setting to test how level of difficulty affects aggression levels.

The main purpose of the current study was to test the following hypotheses: Participants who played the difficult (and thus frustrating) version of *Tetris* will be more likely to reflect aggression onto others and therefore assign a longer duration to keep their hand in ice water, unlike those who played an easier version of the video game (study 1, H1). Secondly, participants who played a violent video game using VR will be more likely to reflect aggression onto others and therefore assign a longer duration to keep a hand in the ice water, unlike those who played nonviolent video game (study 2, H1). We wish to be transparent that this hypothesis was not clearly indicated in our preregistration. This was an oversight. In our preregistration, we did note the randomization to violence condition and that statistical analyses would consider this as an independent variable; however, we neglected to specifically note violence condition in the hypotheses section. Thirdly, participants who played a more difficult (and thus frustrating) version of a violent or nonviolent video game will be more likely to reflect aggression onto others and therefore assign a longer duration to keep a hand in the ice water, unlike those who played an easier version of the video game (study 2, H2). In our preregistration document, we also indicated a hypothesis about competence needs moderating outcomes but did not specify specific analyses. As such, we have addressed this where we consider competence needs in exploratory follow-ups for each main analysis.

The preregistration for both studies can be found at: <https://osf.io/mr59a/>. The full project url is as follows: <https://osf.io/mr59a/>. Data for study 1 can be found at: <https://osf.io/j3fzt/>. The data file for study 2 can be found at: <https://osf.io/gs6pf/>. The study 1 outcome file is available at: <https://osf.io/fmc34/>. The study 2 outcome file is available at: <https://osf.io/43ahf/>. We adopt the 21-word statement of Simmons, Nelson, and Simonsohn (2012): 'We report how we determined our sample size, all data exclusions, all manipulations, and all measures in the study'. Data collection occurred over the course of two years, beginning in February 2017 and concluding in May 2019, approximately one year for each study. This required several extensions of the original IRB approval, which were granted.

## STUDY I

### Methods

Study 1 is a direct replication of study 6 from Przybylski et al. (2014), involving two versions of the game Tetris, one more difficult (and thus frustrating) than the other.

### Participants

Participants in the study were 169 students at a liberal arts university in the south. A larger proportion ( $n = 114$ , 67.5%) were female. Regarding ethnicity, 68.6% were White, 8.9% were Black, 13.0% were Hispanic and 7.7% were Asian, the remainder reporting as 'Other'. Their mean age was 19.62 ( $SD = 2.71$ ). Participants were offered course credit in exchange for participation. We note that in our preregistration we had hoped to recruit approximately 100 participants. This is a bit lower than the a priori power analysis suggested, but more realistic for a small laboratory at a small university (and still larger than the sample in Przybylski et al., 2014). We exceeded this number somewhat in anticipation that a non-trivial percentage of participants would need to be disqualified due to hypothesis guessing. As such, our final participant pool was 125 as described below. These decisions were not made in regard to issues involving statistical significance.

### Materials

#### Video games

As with Przybylski et al. (2014), participants were randomized to play one of two versions of the video game *Tetris*. This game is a nonviolent puzzle game during which players assemble differently shaped pieces to create solid rows at the bottom of the screen. Pieces fall from the top of the screen and can obstruct one another if not properly placed in rows. Should the obstructed pieces reach the top of the screen, the game ends. In the control condition, players played the standard Tetris game. In the difficulty/frustration condition, players played an alternative version of the game called *Bastet* (for Bastard Tetris) for which the computer algorithm, rather than being random, chooses the worst possible piece for the player almost every time for the player to be able to complete the rows as required.

#### Aggressive affect

Aggressive affect was measured using the State Hostility Scale (Anderson, Deuser, & DeNeve, 1995). The State Hostility Scale (SHS) is a 35-item, 5-point Likert-type scale in which respondents are asked to report their current mood. A series of adjectives are presented to the respondent, and they are asked to rate how strongly they disagree or agree (i.e., 1 for 'strongly disagree' and 5 for 'strongly agree') with each word. In this study, the SHS was highly reliable at pretest (Cronbach's  $\alpha = .91$ ) and post-test (Cronbach's  $\alpha = .94$ ).

#### Aggressive behaviour

For aggressive behaviour, we used the same procedure as Przybylski et al. (2014). Participants, upon entering the laboratory, were informed they would be exposed to a physical stressor, namely having their hand placed in a bucket of ice water. They were told

that the previous participant had determined the length of time that their hand would remain in the ice water. In fact, the time was set to 25 s for each participant. Participants were asked to rate how painful they considered the ice water on a 10-point scale with 10 being the highest. On average, participants found the ice water to be moderately painful ( $M = 4.82$ ,  $SD = 2.25$ ).

Later, after playing the game and other procedures, participants were asked to set a time duration for the following participant to place their hand in the ice water in seconds. As with Przybylski et al. (2014), participants in the mean assigned about the same amount on the ice water task ( $M = 22.19$ ,  $SD = 11.43$ ) as they themselves received, albeit with significant variation. Higher time lengths were interpreted as more aggressive than lower time lengths.

### *Competence needs*

One difference from the Przybylski et al. (2014) procedure is we wished to examine whether competence needs would influence aggression in response to difficulty/frustration. Note this measure is for the motivation to feel competent, not self-perceived competence. This appeared to be consistent with what might be expected given Self-Determination Theory. As such, we developed a 7-item Likert scale of competence needs ( $\alpha = .699$ ) that was part of a 21-item survey of all 3 Self-Determination Theory motivations. Competence motivation will be used as a covariate in the analyses. A copy of this form can be found at: <https://osf.io/v6zsp/>

### **Procedure**

Participants entered the laboratory where they signed the informed consent form. Participants were provided with a cover story that the experiment involved examining how physiological experiences influenced computer game enjoyment and emotion. After this they completed the first part of the behavioural aggression task, namely putting their hand in the bucket of ice water for 25 s after being informed that this time was set by the previous participant. Next, they filled out the demographic form, competence items, and pre-state hostility questionnaire. Following this, they were randomized to video game condition and played the game for a 10-min period, consistent with Przybylski et al. (2014). Following gameplay, they filled out the post-state hostility questionnaire and decided on the length of time the next participant would put their hand in the bucket of ice water (though, in fact, 25 s was used for all participants.)

After this was completed, all participants were queried for hypothesis guessing. In this case, we did not merely ask if they had guessed the hypothesis but encouraged them a bit further. We asked them, 'If you had to guess what the hypotheses of this study were, what would it be?' Any responses that mentioned video games and aggression were tagged as successful hypothesis guessing. 44 participants (26%) were able to come reasonably close to guessing the hypothesis of the study. These participants were removed from analyses, leaving the final sample at 125.

### **Results**

All means and standard deviations are presented in Table 1.

**Table 1.** Means and standard deviations across tetris game conditions ( $n = 125$ )

Variable	Tetris ( $n = 59$ )	Bastet ( $n = 66$ )
Hostility pre	1.83 (0.46)	1.73 (0.34)
Hostility post	2.02 (0.60)	1.94 (0.50)
Aggressive Beh.	21.71 (9.88)	21.68 (10.51)
Competence	38.97 (4.32)	39.94 (4.84)

Consistent with the preregistration, ANCOVA designs were used with game condition as the independent variable and gender as the covariate. In the preregistration, we did not specifically mention competence motivation as a covariate though it was included as a hypothesized variable, so we will run the ANCOVAs with and without this covariate for transparency, with the latter understood as an exploratory addition of a covariate.

For state hostility, the pre- and post-scores were treated as a within-participants variable. Results indicated [ $F(1, 121) = 6.05, p = .015, \eta^2 = .048$ ] that participants felt more hostile after gameplay ( $M = 1.98, SD = .55$ ) than before ( $M = 1.78, SD = .41$ ). However, neither game condition [ $F(1, 121) = 0.29, p = .594, \eta^2 = .002$ ] nor the interaction between game condition and time [ $F(1, 121) = 0.13, p = .723, \eta^2 = .001$ ] were significant.

For aggressive behaviour, results indicated [ $F(1, 122) = 0.06, p = .800, \eta^2 = .001$ ] that participants were no more aggressive after the difficult game ( $M = 21.68, SD = 10.51$ ) than the control game ( $M = 21.71, SD = 9.88$ ).

As a follow-up analysis, we considered the interaction between competence needs and frustration. In our preregistration, we preregistered the hypothesis, but failed to be clear on the analysis plan which, by necessity, introduces degrees of freedom. As such, we consider this analysis exploratory rather than preregistered. Quartiles were built for the competence measure based on standard deviations (i.e., lower than  $-1 SD$ ,  $-1 SD$  to mean, mean to  $1 SD$ , higher than  $1 SD$ ). The ANCOVA was rerun with this competence quartile variable included as a between-subjects variable. For aggressive affect, results indicated that neither the game by competence interaction [ $F(3, 115) = 1.29, p = .280, \eta^2 = .033$ ] nor the interaction of time  $\times$  game  $\times$  competence [ $F(3, 115) = 0.62, p = .604, \eta^2 = .016$ ] were significant. For aggressive behaviour, results indicated that the game by competence interaction [ $F(3, 116) = 0.15, p = .993, \eta^2 = .004$ ] was non-significant.

## Discussion

To our surprise, we did not replicate the results of study 6 from Przybylski et al. (2014). Playing the more difficult Bastet game did not increase either feelings of hostility or aggressive behaviour in our participants.

It is possible that, although a direct replication in the main, some subtle differences may have crept into our replication effort. First, one not-so-subtle difference, we include a competence motivation measure that was not part of the Przybylski et al. (2014) study. Although we do not think this likely explains the differences in our results, it is always a possibility.

Nonetheless, to examine whether the frustration hypothesis might more appropriately apply to more modern games, we turn to this issue in the context of VR games. In study 2, we consider two video games, one violent and one nonviolent, each of which will be randomly played on two different difficulty settings so as to induce frustration. This will



allow us to test for both difficulty/frustration and violent content effects in the context of VR games.

## STUDY 2

Study 2 sought to extend the findings of study 1 into the realm of virtual reality. This is done by using virtual reality games differing in both violent content and difficulty/frustration to examine which variable has more impact (if any) on hostility and aggression.

### Methods

#### Participants

Participants included 136 students at a liberal arts university in the South. As with study 1, a larger proportion ( $n = 90$ , 66.2%) were female. Regarding ethnicity, 61.8% were White, 13.2% were Black, 16.9% were Hispanic and 3.7% were Asian, the remainder reporting as 'Other'. Their mean age was 19.03 ( $SD = 3.17$ ). Participants were offered course credit in exchange for participation. We note that in our preregistration we had hoped to recruit approximately 100 participants. We exceeded this number somewhat in anticipation that a non-trivial percentage of participants would need to be disqualified due to hypothesis guessing. As such, our final participant pool was 90 as described below. These decisions were not made in regard to issues involving statistical significance.

#### Materials

##### Video games

Two games were selected for this study, one with significant violent content, one without. These were an M-rated shooter game featuring graphic blood and violence *Rush of Blood* and *DriveClub* and nonviolent racing game. Both of these are VR games. Each game allowed for adjustments to the difficulty settings such as to make the games more difficult and, thus, frustrating. For instance, *Rush of Blood* had difficult conditions (Easy, Normal, Insane, and Psychotic) whereas *DriveClub* had difficulty settings allowing for such things as steering control and road conditions (i.e., turning off breaking assist, turning on hardcore handling).

As with violent content, each participant was randomized to a difficulty/frustration condition. Thus, the four conditions were used: violent/frustrating, violent/easy, nonviolent/frustrating, and nonviolent/easy. All participants were randomized to one of these four conditions.

##### Other measures

All other measures were identical to those used for Aggressive Affect (coefficient alpha pre = .91, post = .95), Aggressive Behaviour, and Competence Needs (coefficient alpha = .75) from study 1.

#### Procedure

The procedure was identical to study 1 with the exception of the randomized game conditions. For the VR game, the games were played on a PlayStation 4 with a VR headset.

The mask was cleaned between each use. Specific difficulty settings are described above. Participants played their assigned game for a 30-min period. Participants were provided with basic instructions on the use of the controller, which was a standard PS4 controller. They were asked not to move from their initial spot (neither VR game required physical movement in the room.) At this point, they were informed that they would have a 30-min period to play the game. Difficulty settings had been preset for them. Players played from the beginning point of the game (i.e., the first level or set race). Playing was discontinued at exactly the 30-min point. Thirty-two participants (23.5%) were able to reasonably guess the hypothesis of the study and were eliminated from further analyses.

## Results

### *Simulator sickness*

Though not one of our hypotheses, during testing we observed that a percentage of players reported simulator sickness, usually involving dizziness, mild headaches, or nausea. In each of these cases, we discontinued the VR procedure, moving immediately on to the post-procedure surveys. This occurred for 18 (13.2%) of our participants. Because of their specific unpleasant experiences, we eliminated these participants from all analyses. Because we nonetheless gave them the follow-up questionnaires, these participants overlap with hypothesis guessing somewhat. As such, the final number of participants for analyses was 90.

### *Manipulation checks*

With the 90 participants remaining, the games were checked for proper matching. One observation is that it is difficult to match violent and nonviolent games on variables other than violent content (Adachi & Willoughby, 2011). As such, in a follow-up questionnaire, we asked participants questions related to the difficulty, competitiveness, and exciting nature of the games they played. As hoped, the two game conditions (Rush of Blood and Drive Club) did not differ from each other in regard to difficulty or competitiveness. The games conclusively differed in regard to excitability  $t(71) = 2.28, p = .025$ . Rush of Blood was rated as more exciting ( $M = 3.37, SD = 1.11$ ) than DriveClub ( $M = 2.77, SD = 1.13$ ). As such, exciting will be used as a covariate in further analyses. Note that this decision was not included in the preregistration but was made prior to examination of the data. However, due to a printing error, the exciting variable was missing from 17 participants. As such, the analyses will be run both with and without the exciting covariate. As expected, the frustrating conditions were rated as more difficult than the non-frustrating conditions  $t(71) = 2.13, p = .037$ , suggesting this manipulation worked as hoped. It was also the case that participants in the frustrating condition rated the 'I feel frustrated' item from the Aggressive Affect post questionnaire more highly ( $M = 2.726, SD = 1.537$ ) than did those in the non-frustrating condition ( $M = 2.051, SD = 1.146$ ),  $t(87.957) = 2.384, p = .019, d = 0.496$ .

All means and standard deviations are presented in Table 2.

For aggressive affect, the pre- and post-scores were treated as a within-participants variable. For the game condition, results indicated that neither game [ $F(1, 85) = 1.49, p = .226, \eta^2 = .017$ ] nor the game  $\times$  time interaction was significant [ $F(1, 85) = 2.96, p = .089, \eta^2 = .034$ ]. These results suggest that violent content had little discernible impact on aggressive affect. However, regarding the difficulty/frustration condition, difficulty by

**Table 2.** Means and standard deviations across VR game conditions ( $n = 90$ )

Variable	Viol/Frust ( $n = 31$ )	Viol/Easy ( $n = 22$ )	Nonviol/Frust ( $n = 20$ )	nonviol/Easy ( $n = 17$ )
Difficulty	2.43 (0.96)	1.85 (1.02)	2.91 (0.84)	2.39 (1.24)
Competitiveness	3.35 (0.95)	2.74 (1.12)	3.28 (0.90)	2.64 (1.24)
Excitement	3.35 (0.90)	3.40 (1.39)	2.84 (1.02)	2.69 (1.27)
Hostility Pre	1.64 (0.29)	1.84 (0.45)	1.74 (0.34)	1.71 (0.37)
Hostility Post	2.43 (0.74)	2.12 (0.57)	2.24 (0.64)	1.99 (0.56)
Aggressive Beh.	23.58 (10.47)	26.05 (13.75)	21.75 (8.63)	24.82 (11.40)
Competence	41.13 (4.65)	40.14 (5.00)	41.35 (3.56)	42.18 (3.41)

itself did not impact aggressive affect [ $F(1, 85) = 0.74, p = .392, \eta^2 = .009$ ] but the interaction between difficulty/frustration condition and time [ $F(1, 85) = 6.22, p = .015, \eta^2 = .068$ ] did. At post-test, those in the difficulty/frustrating condition felt more hostile ( $M = 2.35, SD = .70$ ) than did those in the non-frustrating condition ( $M = 2.11, SD = .57$ ). The interaction between game condition and difficulty/frustration condition was also non-significant [ $F(1, 85) = 0.57, p = .453, \eta^2 = .007$ ]. With excitement included as a covariate results indicated that neither game [ $F(1, 67) = 1.42, p = .238, \eta^2 = .022$ ] nor the game  $\times$  time interaction was significant [ $F(1, 67) = 1.53, p = .221, \eta^2 = .022$ ]. Effect sizes were slightly reduced for the interaction effect, suggesting that differences in excitement may have accounted for some of this variance.

For aggressive behaviour, results indicated that none of the game variables whether violent content [ $F(1, 84) = 0.16, p = .687, \eta^2 = .002$ ], difficulty/frustration [ $F(1, 84) = 1.44, p = .234, \eta^2 = .017$ ], or the interaction between them [ $F(1, 84) = 0.15, p = .696, \eta^2 = .002$ ] were significant. With excitement included as a covariate, results indicated that neither game [ $F(1, 66) = 0.86, p = .375, \eta^2 = .001$ ], difficulty/frustration [ $F(1, 66) = 0.99, p = .323, \eta^2 = .015$ ], nor the game  $\times$  difficulty/frustration interaction was significant [ $F(1, 66) = 0.10, p = .752, \eta^2 = .000$ ]. Effect sizes were slightly reduced for the interaction effect, suggesting that differences in excitement may have accounted for some of this variance.

We also examined effect size confidence intervals for the raw difference in outcome variables at post-assessment for violent content. For hostility at post, the confidence interval was (95% CI for effect size  $r = -.082/.325$ ) and cold pressor aggression (CI for effect size  $r = -.145/.266$ ) indicated clearer support for the null hypothesis than the alternative hypothesis as these confidence intervals crossed zero. This gives us more confidence in accepting the null hypothesis, particularly for aggressive behaviour.

For frustration as an outcome, results were somewhat different. Confidence intervals for the cold pressor aggression (CI for effect size  $r = -.09/.318$ ) indicated clearer support for the null hypothesis, but the hostility post-score was indeterminate (95% CI for effect size  $r = -.02/.379$ ) with the interval only just crossing 0, indicating the need to exert some caution in interpretation.

As a follow-up analysis, we considered the interaction between competence needs and frustration. In our preregistration, we preregistered the hypothesis, but failed to be clear on the analysis plan which, by necessity, introduces degrees of freedom. As such, we consider this analysis exploratory rather than preregistered. Quartiles were built for the competence measure based on standard deviations (i.e., lower than  $-1 SD$ ,  $-1 SD$  to mean, mean to  $1 SD$ , higher than  $1 SD$ ). The ANCOVA was rerun with this competence quartile variable included as a between-subjects variable. For aggressive affect, results indicated that neither the frustration by competence interaction [ $F(3, 74) = 0.25, p = .885$ ,

$\eta^2 = .010$ ) nor the interaction of time  $\times$  frustration  $\times$  competence [ $F(3, 74) = 0.96, p = .415, \eta^2 = .038$ ] were significant. For aggressive behaviour, results indicated that the frustration by competence interaction [ $F(3, 116) = 0.20, p = .897, \eta^2 = .008$ ] was non-significant.

## Discussion

Study 2 sought to extend the results from study 1 into VR, while also considering the impact of violent content as well as difficulty/frustration. All analyses revealed that violent content whether alone or interacting with difficulty had no appreciable impact on either aggressive affect or behaviour at least in the current analysis. By contrast, difficulty increased aggressive affect but did not increase aggressive behaviour. These results partially confirm the expectations of Self-Determination Theory in regard to feelings, but caution they may not extend to behaviour.

These results are important, first in confirming that an increasing number of results, including from preregistered experiments, do not find links between violent content and aggression. It is possible that the results for more interactive VR games may have differed in this regard, but our results suggest that is not the case. As such, the observation that violent content is unrelated to aggression is now being generalized to include VR games as well as non-VR games, although future study particularly with larger samples is warranted. It is worth noting that, due to sample size limitation, power in the current study was less than desired (51% power to detect  $d = 0.43$  when using a two-tailed test). That effect sizes were not nearly this large, particularly for behaviour, suggests that Type II error is an unlikely explanation for our results. Nonetheless, large sample studies with preregistration would be helpful in confirming these preliminary results.

Regarding difficulty, our results suggest that difficulty can increase aggressive affect, but does not necessarily extend to aggressive behaviour. This partially supports Self-Determination Theory but also cautions that, at least as applied to VR games, should not be extended too far.

The difference in result between our two studies in regard to aggressive affect suggests that perhaps engagement with the game is a key variable regarding the impact of difficulty/frustration. By contrast, it appears that gaming in neither the context of violent content nor difficulty/frustration is related to aggressive behaviours.

## GENERAL DISCUSSION

The issue of how video games impact aggression continues to be debated among scholars. Such debates are only likely to increase as VR games become more popular. The goal of this study was to examine the relationship between difficulty/frustration and aggression in individuals who played violent or nonviolent video games that were more or less frustrating. This study aimed to not only replicate one study on frustration in games from Przybylski et al. (2014), but also extend these issues to more modern video gaming (virtual reality) and focus on the direct impacts on aggression and hostility in individuals who played violent or nonviolent video games with either high or low difficulty.

In study 1, a direct replication of study 6 from Przybylski et al. (2014), our findings did not replicate the previous results. We found that playing a more difficult version of Tetris (Bastet) did not increase feelings of hostility or aggressive behaviour in the participants. This was surprising to us, particularly as our sample was larger than that for the original study.

In study 2, an extension on the previous study with a focus on virtual reality, we found that violent content, with or without participant frustration, did not have a significant impact on aggressive affect or behaviour. Although our findings suggested that difficulty/frustration can lead to increased aggressive affect, it does not directly relate to increased aggressive behaviours. In this conceptual extension, our results partially support Przybylski et al. (2014) though suggesting effects of difficulty/frustration on aggression-related outcomes are nuanced. Importantly, however, the observation that violent games have little impact on aggression in higher quality studies (Drummond, Sauer, & Ferguson, 2020) appears to extend to VR at least in this initial study.

For this reason, the significance of violent video game content being unrelated to aggression can be applied to nonviolent and violent video games across different gaming platforms (i.e., computerized vs. virtual reality). Although engagement was noted as a potential variable in the impact of difficulty/frustration in participants, our results demonstrated that gaming in relation to either violent context or difficulty/frustration is unrelated to aggressive behaviours, though difficulty/frustration did increase hostility in VR games.

### ***How does this relate to self-determination theory***

To recall, Przybylski et al. (2014) found that frequent failure on highly difficult games led to an increased aggression among individuals. The motivational hypothesis (Self-Determination Theory) explains this by looking at video games as a means to provide the opportunity to satisfy basic psychological needs, such as competence. Through frequent failure, the feeling of competence may get threatened and aggressive behaviour and feelings develop. The first current study sought to replicate one study from Przybylski et al. (2014), in which negative experiences in games were related to increased aggression and hostility. Unfortunately, it was not possible to replicate these findings, since the more difficult game did not lead to an increase in aggressive feelings or behaviour, which therefore does not appear to support Self-Determination Theory. Possible reasons for this were discussed earlier.

However, in the second study, which extended the results from the first study, an increased aggressive affect was observed, though this did not extend to aggressive behaviour. This finding partially supports Self-Determination Theory. The reasons for the discrepancy between the two studies in regard to aggressive affect are unclear to us. It may be that there were different levels of engagement with the games used, but we have no particular theory as to why that might be. The magnitude of effect size difference between the studies,  $\eta^2 = .001$  in study 1 versus  $\eta^2 = .068$  in study 2 is substantial, suggesting this is not explainable simply as an aspect of sampling error. In terms of effect size  $d$ , the effect difference is 0.003 in study 1 and 0.376 in study 2. Using Welch's  $t$ -test, this difference appears to be significant  $t(173.26) = 2.39, p = .009$ .

### ***Concerns about virtual reality***

Results from study 2 showed that video games with aggressive content had no effect on the participants' aggressive behaviours. More specifically, even though study 2 used a more modern and realistic style of video games (virtual reality) with the intention of extending the results from study 1, the analyses of violent content with and without the interaction of difficulty/frustration did not report any appreciable impact on aggressive behaviour or affect. This further suggests that AVGs, no matter what way they are played

(i.e., whether with traditional or VR technology), do not affect how aggressively a person behaves. VR games, thus, do not appear to present an unusually dangerous situation for the creation of aggression in the context of aggressive content.

### **Research and policy recommendations**

Based on the findings in both studies, it is suggested that more research should be conducted in relation to VR games. Although the current analysis suggested that aggressive content in VR games does not represent a worrisome context above and beyond traditional gaming, the amount of data on VR and aggression remains limited. Future studies specifically preregistered studies are warranted to assess the long-term effects of aggressive VR video games. It may be particularly useful to see future studies assess individuals that would be susceptible to the effects of AVGs in the context of VR. Susceptibility depends on a variety of factors such as the environment or the mental well-being of an individual. For instance, future studies should consider testing individuals diagnosed with a pre-existing behaviour disorder to see whether they are more likely to be vulnerable to the effects of VR games than individuals in the general population. It is important to note that, at present, no 'vulnerable' population has been identified for traditional aggressive games and it may be the case as well that no vulnerable population emerge for VR gaming. However, more data are clearly needed.

### **Limitations**

As with all studies, ours has several limitations. The first limitation relates to the sample from both study 1 ( $n = 125$  after eliminations for hypothesis guessing) and study 2 ( $n = 90$  after eliminations for hypothesis guessing or simulator sickness). Particularly given the necessary eliminations for either hypothesis guessing or simulator sickness (in study 2), the resultant sample sizes were smaller than desired. Further, both samples were weighted towards female participants, though males engage in more physical aggression than do females. By contrast, though our samples were small, the employment of rigorous debriefing for demand characteristics increases our confidence in the results. As a second limitation, our samples of college students do not allow for easy generalization to the general public. Third, although we looked at the impact of aggressive content in the context of VR games, we did not engage in a comparison of VR and non-VR games. Arguably, however, this may have been more critical had we found evidence for effects for the VR games. Fourth, in relation to VR, we only use one game for each condition. As such, it is difficult to generalize our results more broadly and more research with a wider array of games would be desirable. Fifth, like many studies (Hilgard et al., 2019) hypothesis guessing among participants was non-trivial. It may be wise for future studies to examine ways to reduce demand characteristics. Sixth, we acknowledge two issues which lacked clarity in our preregistration. First was the hypothesis related to interactions between frustration and competence. Although we preregistered the hypothesis, we were unclear on the analysis plan. Thus, we considered these analyses to be exploratory for the purpose of the current study. We also were not clear about excluding participants who were able to guess the study hypotheses. Although such exclusions are common (Hilgard et al., 2019), we regret not making that clear in the preregistration. Exclusions due to simulator sickness were entirely unforeseen and could not have been preregistered. Lastly, there may be some normative influence given the 25 second key for the cold pressor task. We used the same variant as Przybylski et al. (2014) for replication purposes, but it is possible that other variants without this social norm may

produce different results. Nonetheless, if this normative influence on aggression is stronger than the content of video games, this, itself, is valuable to know.

### **Conclusion**

The current study presents a standardized assessment of the relationships between difficulty/frustration and aggression in those who played violent and nonviolent video games in the context of VR. To which, the results yielded partially confirmed Self-Determination Theory. The goal of the study was not only to replicate the findings of Przybylski et al. (2014), but to seek a parallel in study 2. Overall, we conclude the following in relation to virtual reality games: violent content had no impact on either aggressive feelings or behaviours, though difficulty/frustration, caused using difficulty settings in each game, increased aggressive affect but not aggressive behaviour. Our data contribute to the ongoing number of studies that debate whether video games cause aggression. The objective of the study is to help clarify and add to the data used in this controversial topic.

### **Conflicts of interest**

All authors declare no conflict of interest.

### **Author contributions**

Christopher J. Ferguson (Conceptualization; Formal analysis; Methodology; Project administration; Resources; Supervision; Validation; Writing – original draft; Writing – review & editing). Anastasiia Gryshyna (Data curation; Formal analysis; Investigation; Writing – original draft; Writing – review & editing). Jung Soo Kim (Data curation; Formal analysis; Investigation; Writing – original draft; Writing – review & editing). Emma Knowles (Data curation; Formal analysis; Investigation; Writing – original draft; Writing – review & editing). Zainab Nadeem (Data curation; Formal analysis; Investigation; Writing – original draft; Writing – review & editing). Izabela Cardozo (Data curation; Formal analysis; Investigation; Writing – original draft; Writing – review & editing). Carolin Esser (Data curation; Formal analysis; Investigation; Writing – original draft; Writing – review & editing). Victoria Trebbi (Data curation; Formal analysis; Investigation; Writing – original draft; Writing – review & editing). Emily Willis (Data curation; Formal analysis; Investigation; Writing – original draft; Writing – review & editing).

### **Data availability statement**

A preregistration of the project can be found at: <https://osf.io/mr59a/>. All data are available upon request.

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