

Effects of Violent Video Game Exposure on Aggressive Behavior, Aggressive Thought Accessibility, and Aggressive Affect among Adults with and without Autism Spectrum Disorder

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Abstract

Recent mass shootings have prompted the idea among some members of the public that exposure to violent video games can have a pronounced effect on individuals with autism spectrum disorder (ASD). Empirical evidence for or against this claim currently is absent. To address this issue, adults with and without ASD were assigned to play a violent or nonviolent version of a customized “first-person shooter” video game, after which responses on three aggression-related outcome variables (aggressive behavior, aggressive thought accessibility, and aggressive affect) were assessed. Results showed strong evidence that adults with ASD are not differentially affected by acute exposure to violent video games compared to typically developing adults. Moreover, model comparisons showed modest evidence against any effect of violent game content whatsoever. Findings from the current experiment suggest that societal concerns over whether violent game exposure has a unique effect on adults with autism are not supported by evidence.

Key Words: Violent video games, Aggressive behavior, Aggressive thought accessibility, Aggressive affect, Autism spectrum disorder

Introduction

In the aftermath of two widely publicized mass shootings, some media pundits and lay people have speculated that violent video games (VVGs) cause adults with autism spectrum disorder (ASD) to commit violent crimes (e.g., RWW Blog, 2013; also see Harmon, 2012 for responses from experts and members of the ASD community urging caution in interpreting these isolated events as evidence for a link between ASD and planned violence). This speculation is amplified by evidence indicating that people with ASD spend more time playing video games than typically developing (TD) people (Engelhardt, Mazurek, & Sohl, 2013), are more likely to become preoccupied with video games than TD people (Mazurek & Engelhardt, 2013), and often prefer game genres that contain large amounts of violent content (Mazurek & Engelhardt, 2013). However, no study to date has examined whether VVGs influence aggressive behavior among adults with ASD or whether they place adults with ASD at greater risk for aggression than neurotypicals. The current study provides the first empirical evidence bearing on these clinical and societal concerns.

Autism spectrum disorder is primarily characterized by difficulties in social communication and interaction and by restricted and repetitive behavior; however, these core symptoms often are accompanied by difficulties with emotional and behavioral regulation (American Psychiatric Association, 2013). One reason that VVGs might differentially affect adults with ASD is because of a reduced ability to down-regulate arousal. Some meta-analyses have suggested that acute exposure to VVGs causes increases in physiological arousal relative to nonviolent video games (NVVGs) (see Anderson et al., 2010; but see Adachi & Willoughby, 2011, for an argument that such differences may be caused by confounding game contents). Because individuals with ASD are at increased risk for situational hyperarousal compared to their TD peers (see Ben-Sasson et al., 2009), they might find it difficult to down-regulate this

proposed mechanism of aggression following exposure to VVGs (see Anderson & Bushman, 2002). Another reason to suspect that VVGs may differentially affect people with ASD is because of a decreased ability to inhibit prepotent responses (for a meta-analytic review, Geurts, Bergh, & Ruzzano, 2014). Consistent with some research suggesting that acute exposure to VVGs can undermine the neural correlates of response inhibition (e.g., Hummer et al., 2010), adults with ASD might behave aggressively following exposure to VVGs due in part to an inability to override the prepotent responses activated by a VVG – such as “attack” or “harm” – when given a chance to aggress in real life.

However, these hypotheses are offset by alternative possibilities that suggest aggression among adults with ASD might not be affected by VVG exposure. For example, people with ASD are sometimes unable to correctly project mental states onto the self and others (see Baron-Cohen, 1997). Thus, while adults with ASD might be able to successfully report on specific violent in-game behaviors, the ability to ascribe social attributions (e.g., I am behaving aggressively) to them might be impaired. This reasoning may also have implications for reactive aggression, because adults with ASD might not exhibit hostile expectations and attributional biases following exposure to VVGs in the same way TD people do (see Hasan, Bègue, Scharkow, & Bushman, 2013).

Current Study

Despite a large corpus of studies, meta-analyses of these studies (Anderson et al., 2010; Ferguson, in press; Greitemeyer & Mügge, 2014; Sherry, 2007) have reached differing conclusions about the degree to which experimental research has demonstrated links between VVGs and aggression. Although some meta-analytic scholars have found the evidence convincing (Anderson et al., 2010; Greitemeyer & Mügge, 2014), others have concluded that the

effect sizes are small, and likely explained as a result of publication bias or the use of unstandardized outcome measures (e.g., Ferguson & Kilburn, 2010). In this report, we test whether there is an effect of violent game content on aggressive behavior and on two proposed mechanisms of this behavior – aggressive thought accessibility and aggressive affect (see Anderson & Bushman, 2002) – and if so, whether these effects are more pronounced for adults with ASD compared to TD adults (aim 1). We also test whether there is an effect of violent game content on these outcomes separately by diagnostic group (aim 2). This study is the first to use an experimental paradigm to test the effects of VVGs on aggression in adults with ASD.

Method

Recently, there have been a number of critiques of the usual practice of reporting experiments and interpreting experimental results. In response, we provide an expanded coverage of methods, including how measures, sample sizes, and data exclusions were determined. In the next section, we report Bayes factor, standardized effect size estimates (Cohen's d and r), and 95% confidence intervals.

All raw data, verifiable analysis code, measures, video game manipulations, confederate videos, and study scripts relevant to this report are hosted on the Open Science Framework (OSF) and can be accessed at osf.io/84xut.

Participants

One hundred twenty adults (60 with ASD, 60 with TD; 9 women in each group) ranging in age from 17 to 25 years ($M = 20.48$; $SD = 1.71$) participated in the current experiment in exchange for \$20. Participants in the ASD group were recruited from an interdisciplinary treatment and research center specializing in the treatment and diagnosis of ASD. Participants in this group had been previously diagnosed with an ASD according to the center's clinical care

model. This diagnosis generally includes interviews and behavioral observation focused on DSM-IV criteria, and evaluations conducted by a physician and/or psychologist using standardized tools, such as the Autism Diagnostic Observation Schedule (ADOS) (Lord, DiLavorne, & Risi, 2002) and/or the Autism Diagnostic Interview – Revised (ADI-R) (Lord & Rutter, 1994). Eligibility for the ASD group also required that individuals: 1) were verbally fluent, 2) could read and write, 3) were not prone to seizures, 4) could tolerate loud noises for periods of about 5 seconds, and 5) were not prone to vertigo while playing video games. Participants in the TD group were recruited through undergraduate psychology courses, undergraduate university mass emails, and campus flyers. Eligibility for this group required that the individuals had no history of neurological or developmental disorders. Sample size in the ASD group was set to 60; sample size in the TD group was determined by the sample size in the ASD group. This stopping rule (60 per group) was determined prior to recruiting any participants and was informed by funding constraints and by our expectations regarding recruitment. Specifically, because we had not recruited adults with ASD from the database at our treatment and research center in the past, we estimated that about 40% of the sample in our geographic area with an IQ greater than eighty-five would participate in the study. The current study was approved by our institutional review board.

Video Game Manipulation

As other scholars have pointed out, violent and nonviolent video games often differ on numerous dimensions other than violence, such as competitiveness (Adachi & Willoughby, 2011), pace of action (Elson, Breuer, Van Looy, Kneer, & Quandt, 2013), and the extent to which in-game needs are thwarted (Przybylski, Deci, Rigby, & Ryan, 2014), factors which can also affect outcomes related to aggression. An ideal manipulation of violent video game content, then,

would involve two video games which differ in violent content but are matched in all other game features. Control of such factors permits cleaner inferences concerning effects of game content on outcomes of interest.

To create such an ideal manipulation, we modified two versions of the classic video game *Doom II* using freely available online software (e.g., vd Heiden, 2012). The versions created and used here are hosted and available on the OSF (see Hilgard, 2014). In the classic first-person shooter version of *Doom II*, players adopt a first-person perspective as they shoot and kill demons and zombies in order to progress through the game. We adapted the violent version of the game from the *Doom II* modification *Brutal Doom*, which increases the quantity and graphical precision of the violent content; we adapted the nonviolent version of the game from the *Doom II* modification *Chex Quest*, which changes the game's graphics and narrative to be non-violent. We designed these two game versions to be identical in all ways other than violence: computer code which determined game mechanics, controls, level design, enemy locations, and enemy behavior were identical across conditions. In other words, these games are not off-the-shelf retail games. We modified these games from the ground-up using modification software tools and substantial amounts of computer programming. It can therefore be inferred that any observed differences in players' experiences and behaviors are due to violent content alone and not to other structural features of the games. Similar game modifications have been used in previous research (see Elson et al., 2013; Przybylski et al., 2014).

Separate cover stories illustrating the storyline, in-game characters, power-ups, controls, and in-game items were also crafted for each game version. For example, the VVG cover story indicated that players assume the role of a space marine tasked with shooting and killing demons with a Gatling gun or a shotgun on a military base on Mars' moon, Phobos, and that the monsters

would shoot the player with bullets or fireballs. In contrast, the NVVG cover story indicated that players assume the role of a hero tasked with helping frightened and confused aliens return to their home planet by using two teleporters, and that the aliens would fling green gobs at the player because they are *confused* and *upset*, not because they mean harm to the player.

We manipulated Violent content across game versions by changing the appearance and behavior of in-game characters, the cues associated with hitting game characters with gunfire, the type of guns used, and on the depictions of ammo and character health. Specifically, in the violent game version: 1) monsters attempted to shoot, bite, and claw the player, 2) demons exploded into intense gore upon being shot, blood splattered on the floors and walls, and teeth and limbs were sent bouncing across the floor, 3) participants controlled a Gatling gun and a shotgun, and 4) participants picked up boxes of bullets, health packs, and armor vests. In the nonviolent game version: 1) aliens attempted to hit the players with green gobs, 2) aliens bloodlessly disappeared with a gentle, twinkling sound, 3) participants controlled two teleporter tools, objects similar to large remote controllers, and 4) participants picked up electrical teleporter fuel, food, and Chex cereal armor.

Measures

Demographics. Participants responded to questions about their age, gender, race, ethnicity, relationship status, current residence, highest level of education, employment status, academic status, current medications, and any previous chronic medical condition, psychological or developmental disorder (see Table 1 for relevant demographic characteristics by group).

Intelligence (IQ). IQ was measured using the Abbreviated Battery IQ (ABIQ) scale from The Stanford-Binet Intelligence Scales: Fifth Edition (SB5) (Roid, 2003). The ABIQ is comprised of two routing tests: the verbal (vocabulary) routing test and the non-verbal (object

series/matrices) routing test. The ABIQ has demonstrated adequate reliability (α s greater than or equal to .90 in samples of similar ages) and validity (correlations larger than .80 between the ABIQ and other full-scale IQ measures) in previous research (Roid, 2003).

Autism-Spectrum Quotient. ASD symptoms were assessed using the Autism Spectrum Quotient - Short Form (AQ-S, Hoekstra et al., 2011). The AQ-S is a 28-item self-report questionnaire. This measure is intended to assess ASD symptoms along a continuum, with higher total scores indicating a greater degree of ASD symptomatology. Participants responded to items corresponding to social skills, routine, switching, imagination, and numbers/patterns on a 4-point Likert scale (1 = *definitely agree*; 2 = *slightly agree*; 3 = *slightly disagree*; 4 = *definitely disagree*). Consistent with previous research (Hoekstra et al., 2011), the current study utilized the full range of responses to calculate a total score, with a possible range of 28 – 112. The AQ-S has shown adequate reliability and validity in the general population and in clinical samples (Hoekstra et al., 2011).

Table 1. *Demographic Characteristics by Diagnostic Group*

	ASD (n = 60)	TD (n = 60)	
	<i>M(SD)</i>	<i>M(SD)</i>	<i>d_{unb}</i> [95% CI]
Age	20.42 (2.01)	20.54 (1.34)	-0.07 [-0.43, 0.29]
IQ Scores	103.50 (10.75)	103.40 (8.86)	0.01 [-0.35, 0.37]
Autism-Spectrum Quotient Scores (AQ-S)	70.24(9.36)	57.17(8.10)	1.48 [1.07, 1.90]
	n	n	
Gender			
Female	9	8	
Male	51	52	
Race			
American Indian or Alaskan Native	1	-	
Asian	3	2	
Black or African American	1	1	
White	50	56	
Other	4	1	
Ethnicity			
Hispanic or Latino	7	-	
Non-Hispanic/Non-Latino	50	59	
Previous Psychiatric or Developmental Disorder Diagnoses			
No	15	55	
Yes	44	5	

Note: One individual in the ASD group did not complete the demographic survey because her experimental session was terminated following the first game play period. Two additional individuals with ASD did not report ethnicity; one TD individual did not report ethnicity. Individuals with ASD reported the following previous diagnoses: chromosome deletion disorder (n=1); Tourette’s disorder (n=1); attention deficit disorder (ADD; n=2); bipolar disorder (n=2); depression (n=2); attention-deficit hyperactivity disorder (ADHD; n=3); mood disorder (n=3); obsessive compulsive disorder (n=3). TD individuals reported the following previous diagnoses: depression/anxiety (n=1); panic disorder (n=1); anxiety disorder (n=2). *d_{unb}* = unbiased estimate of Cohen’s *d*. CI = confidence interval.

Aggressive Behavior. Because extreme acts of violence cannot be studied ethically in the lab, researchers often test the causal effects of VVGs on aggression, defined as any behavior intended to cause harm to another individual motivated to avoid that harm (Anderson & Bushman, 2002). Aggressive behavior was measured using a variant of the competitive reaction time task (CRTT), a task that has been widely used in previous video game research (see Elson et al., 2013; Engelhardt, Bartholow, & Saults, 2011; Hasan et al., 2013).

In the version used here participants were led to believe that they were competing against another participant to determine who could react more quickly – by clicking their computer mouse – following the presentation of a colored square on their computer monitor. Before each of the 9 experimental trials, participants had the opportunity to set both the intensity (on a 1-10 scale ranging from 60 to 105 dB, with a 0 dB no noise option) and duration (on a 1-10 scale ranging from 1 s to 5 s, with a 0 duration option) of a noise blast that would be delivered to their opponent if the participant were to win that trial. Participants received noise blasts set by the ostensible opponent on losing trials (5 of the 9 trials).

In reality, however, there was no opponent; a pre-determined computer algorithm controlled the outcome of all trials. All participants lost the first trial and received a loud noise blast (level 9 noise intensity; level 8 noise duration) in order to provoke them and to examine differences in unprovoked (their initial noise setting) and reactive aggression (their subsequent noise setting). The intensity and duration of the 8 remaining noise blasts, half of which were lost by the participant, were randomly determined by the computer algorithm. In order to prevent suspicion, trials on which response times were longer than 2 s were automatically lost by participants.

Although the CRTT has been used extensively to measure aggressive behavior in previous game research, there seems to be little standardization on how to quantify the data it produces, thus perhaps leading to inflated effect size estimates in studies that have used the CRTT (for a review, see Elson, Mohseni, Breuer, Scharkow, & Quandt, 2014). With this issue in mind, the following CRTT aggression scores were calculated and reported: noise intensity, noise duration, and a standardized and summed composite of noise intensity and duration for trial 1 (unprovoked aggression), trial 2 (reactive aggression), and trials 3 to 9 (average aggression). These scores represent the operationalization of aggressive behavior.

Aggressive Thought Accessibility. Aggressive thought accessibility was measured with the 98-item word stem completion task (see Anderson et al., 2004). In this task, participants are asked to complete word stems with the first word that comes to mind. For example, “K I _ _” could be completed as “kind”, “kiss”, “kick” or “kill.” Fifty of the word stems could be completed aggressively; the remaining word stems could only be completed with non-aggressive or neutral words. Aggressive thought accessibility was calculated as the proportion of words completed aggressively to the total number of words attempted.

Aggressive Affect. Aggressive affect was measured with the 10-item short form of the state-anger scale (Spielberger, Jacobs, Russel, & Crane, 1983) and with 7 filler items from the state hostility scale (SHS) (Anderson & Carnagey, 2009). The filler item “I feel positive” also was included. All 18 items were rated on a 5-point Likert-type scale (1 = *strongly disagree*; 2 = *disagree*; 3 = *neither agree nor disagree*; 4 = *agree*; 5 = *strongly agree*). Example items included “I feel like hitting someone” and “I feel like banging on the table.” The 18-item scale showed adequate reliability in the current study (α s = .90 and .92 for the ASD and TD groups, respectively). While scale reliabilities were adequate, inspection of the item-level correlations

indicated that 3 of the 18 items loaded poorly on the latent factor, particularly in the ASD group ($r_s < .20$). These items included: “I feel tender,” “I feel tame,” and “I feel sympathetic.” Thus, analyses for this outcome variable were conducted on a 15-item composite score (the 3 poorly loading items were excluded). Removing these items had no effect on the interpretation of the data.

Post-game Rating Measures. Following all other experimental procedures, participants rated their assigned video game on several dimensions intended to measure their perceptions of the video game they played. Five of these items were rated on a Likert scale using the following anchor points: 1 = *strongly disagree*; 4 = *neither agree nor disagree*; 7 = *strongly agree*. The item measuring frustration used the following anchor points: 1 = *not at all*; 4 = *moderately*; 7 = *extremely*. All post-game items can be found in Table 2.

Table 2. *Post-game Ratings by Video Game Condition*

Post-game Item	Violent Game	Nonviolent Game	
	(n = 59)	(n = 60)	
	<i>M(SD)</i>	<i>M(SD)</i>	<i>d_{unb}</i> [95% CI]
I felt the video game featured a great amount of violence.	5.97(1.36)	3.23(1.81)	1.70 [1.27, 2.13]
To what extent were you <i>frustrated</i> by the video game you played?	3.19(1.36)	3.02(1.44)	0.12 [-0.25, 0.49]
I felt <i>excited</i> while playing the video game.	4.80(1.62)	4.22(1.55)	0.36 [-0.01, 0.73]
I felt <i>engaged</i> while playing the video game.	5.44(1.58)	5.12(1.35)	0.22 [-0.15, 0.58]
I found the game I played to be <i>interesting</i> .	4.81(1.70)	4.48(1.73)	0.19 [-0.18, 0.56]
I found the game I played to be <i>challenging</i> .	5.10(1.57)	4.65(1.77)	0.27 [-0.10, 0.63]

Note: d_{unb} = unbiased estimate of Cohen’s d . CI = confidence interval.

Procedure

Prior to arrival participants with and without ASD were assigned to play the violent video game (VVG; $n = 59$) or the nonviolent video game (NVVG; $n = 61$) using a random number generator.¹ Randomized cell sample sizes were as follows: among adults with ASD, 29 played the VVG and 31 played the NVVG; among TD adults, 30 played the VVG and 30 played the NVVG. Stratified random assignment was used to ensure that approximately equal numbers of men and women within each diagnostic group were assigned to play a VVG or NVVG.

Participants were greeted by an experimenter who was not blind to the experimental condition. After participants were escorted to the experiment room, the experimenter explained that the purpose of the study was to understand how the reaction times of young adults with and without ASD were affected by screen-based media (the cover story). Informed consent was then obtained after affording participants an opportunity to ask any remaining questions about the study. Participants were informed that there would be a brief competition during the study, but that the bulk of the experiment, including the video game play sessions, would be completed individually.

Three activities were completed before participants were exposed to any stimulus or discussion related to their assigned video game; each is described in turn. The verbal and non-verbal routing subtests from the SB5 were administered first. Next, participants were told that they would be given a chance to practice two of the reaction time tasks to be completed later in the experiment. The first practice task included completing 10 of the word stems from the 98-item word stem aggressive thought accessibility measure. An experimenter explained that the word stems should be completed with the first word that comes to mind, instructions consistent with the cover story. Importantly, five of the ten words had a .25 probability of being completed

aggressively; the remaining word stems could only be completed with neutral (non-aggressive) words. The practice task thereby provided a baseline measure of the accessibility of aggressive thoughts. Illegible responses were clarified using non-leading questions (e.g., “*what word did you intend to write here?*”).

The second practice task involved the CRTT. Specifically, experimenters explained all CRTT instructions and showed participants examples of a low (intensity level 1), medium (intensity level 5), and high (intensity level 10) noise blast for periods of 1 second each in order to demonstrate that the noise blasts were aversive. Participants were then allowed to practice the task individually (experimenters told participants that they were indeed practicing, not competing) to ensure comfort with the instructions and controls. Participants were told that another participant, who was ostensibly completing a separate study, would be competing against them later in the experiment. A purported live video connection was established with their opponent (matched for gender). In actuality, this was a pre-recorded video of a confederate, similar to that used in previous research (see Engelhardt et al., 2011). Prior to this interaction, individuals were informed that although they would be able to see their opponent, their opponent would not be able to see them. This statement was intended to provide participants with anonymity. The communication between the experimenter and their opponent during this staged interaction appeared to transpire in real time. For example, a timing cue (head scratch) in the video prompted the experimenter to pretend to communicate with the confederate over an intercom by stating “there is a camera in the corner of the room – can you turn around and give us a wave?” Upon purportedly hearing this request, the confederate – instructed to sustain a neutral facial expression throughout the interaction – briefly scanned the room prior to orienting to the corner with the camera and waving to the participant as requested.

Participants were then shown the video game they would be playing throughout the experiment. After participants read the cover story associated with their assigned game, experimenters unobtrusively watched participants play their assigned video game until it was clear that they were comfortable with the controls. This generally occurred within 30 seconds.

Starting with this initial play period, participants alternated between playing their assigned video game for a period of time (15 min. during the first play period; 10 min. during the second and third play periods) and completing a measure of aggression. Specifically, participants completed the CRTT, aggressive thought accessibility, and aggressive affect measures approximately 1.5 minutes following the first, second, and third game play periods, respectively.²

Once the experiment had ended, participants were probed for suspicion concerning the cover story and their alleged opponent. For example, participants responded to open-ended questions about what they thought the study was designed to investigate, whether any aspects of the study seemed confusing or strange, and their impression of the participant they competed against during the CRTT. If suspicions were reported, experimenters used a funneled questioning procedure to probe for when and why such suspicions arose (e.g., during the staged video recording vs. during or after the CRTT). All participants were then thanked for their time. Debriefing occurred after data collection had been completed so that the cover story would not be foiled by word of mouth communication.

Results

Analytic Strategy

As mentioned, there is increased scrutiny in experimental psychology as to what constitutes evidence for effects. Based on numerous critiques of conventional null hypothesis

significance testing (e.g., Wagenmakers, 2007), we adopted the use of Bayes factors for quantifying the strength of evidence (see Edwards, Lindman, & Savage, 1963). Unlike point estimates and CIs, Bayes Factors provide a direct measure of evidence for a null statement that there is no effect for a specific contrast relative to an alternative statement that there is such an effect (Rouder, Morey, Speckman, & Province (2012).

In what follows, we apply a 2 (Violent content) x 2 (Group diagnosis) analysis of variance (ANOVA) design, using Bayesian analyses to test for main effects and interactions. The approach with Bayes factors differs in that Bayes factors provide a method of model comparison in which models that encompass main effects and interactions, or their selective absence, are compared. Five models are considered: a null model in which there are no effects of Group diagnosis or of Violent content; a model in which there is an effect of Group diagnosis but not of Violent content; a model in which there is an effect of Violent content but not of Group diagnosis; an additive model in which there is an effect of both variables but no interaction between them, and a full model in which there is not only an effect of both variables, but an interaction as well. Rouder and colleagues (2012) provide the models and computational algorithms for the associated Bayes factors reported here. Computations were performed in Morey and Rouder's (2014) BayesFactor package for R.

Bayes factors have a convenient interpretation. They are reported in ratios, such as 10-to-1, for a model with an effect relative to a model without one. These ratios are the probability of the observed data in one model relative to another model. In the Bayesian framework, they describe how the data affect the change in beliefs. In the case that the data are uninformative, the ratio shrinks to 1-to-1, and the data do not affect a change in beliefs.

Researchers using Bayes factors need to place prior distributions on effects, should they occur. We use what Rouder et al. (2012) call a default prior, where the effect size under the alternative is distributed around zero and smaller effects are more likely than larger ones. With this default, negative effects, where video games lead to a reduction of aggression, are *a priori* as likely as the more traditional positive effects. We follow Rouder et al.'s advice and use prior research to tune the size of the expected effects to be in line with the effect sizes reported in previous research (see Anderson et al., 2010).

In line with the recommendations of the American Psychological Association (2010), we also report standardized effect size estimates and confidence intervals (CIs). Unbiased Cohen's d (d_{unb}) effect sizes for independent mean comparisons were calculated using the pooled within-groups standard deviation as the standardizer. The 95% CIs for d_{unb} were derived using approximations for the noncentral t distribution (see Algina & Keselman, 2003). Effect size r and its CI are reported for all single degree of freedom interaction terms (Rosenthal & Rubin, 2003).

Below, estimated effect sizes are sometimes referred to as tiny, small, or moderate in magnitude, but such labels are not necessarily isomorphic with *statistically significant* results. Sufficient information (F statistics, sample sizes, and confidence intervals) is provided, however, to determine whether an effect is significant at the .05 level.

Demographics and Manipulation Checks

As expected, large group differences were observed on the AQ-S measure, $d_{\text{unb}} = 1.48$, suggesting that adults with ASD had more autism-like traits than TD adults, whereas group differences on IQ scores and age were estimated to be near zero (see Table 1). The manipulation check items indicated that the VVG was perceived to be more violent than the NVVG, $d_{\text{unb}} = 1.70$, as intended, and that the games were comparable on dimensions other than perceived

violence (see Table 2). Tables 1 and 2 suggest that the diagnostic groups were well-matched and that the manipulation of violent content across game versions was powerful.

Aggressive Behavior

All data from 27 participants were excluded from the CRTT analyses: 13 due to level of suspicion regarding the ‘other’ participant; 10 due to a response set (e.g., setting the noise and duration meters at the same level on each trial); 3 due to not understanding or following task instructions; 1 because the participant felt uncomfortable completing the CRTT with noise. Additionally, 1 participant believed that the opponent was real on the first trial only, and 1 participant believed that the opponent was real on every trial but the first trial. These two participants were included in analyses, when appropriate. Approximately equal numbers of participants were excluded from each of the experimental conditions (see Table 3 for cell sizes). Because noise intensity and noise duration settings were highly correlated on the first trial, $r = .53$ [0.35, 0.71], on the second trial, $r = .68$ [0.53, 0.83], and on trials 3 through 9, $r = .67$ [0.52, 0.83], aggression was also quantified by standardizing and summing the intensity and duration scores. This standardized and summed composite is the outcome measure discussed in the sections that follow. However, Table 3 displays means and standard deviations separately for noise intensity and duration, in line with recommendations from other researchers (Elson et al., 2014). Figure 1 depicts the standardized and summed means for all measures of aggressive behavior.

Figure 1

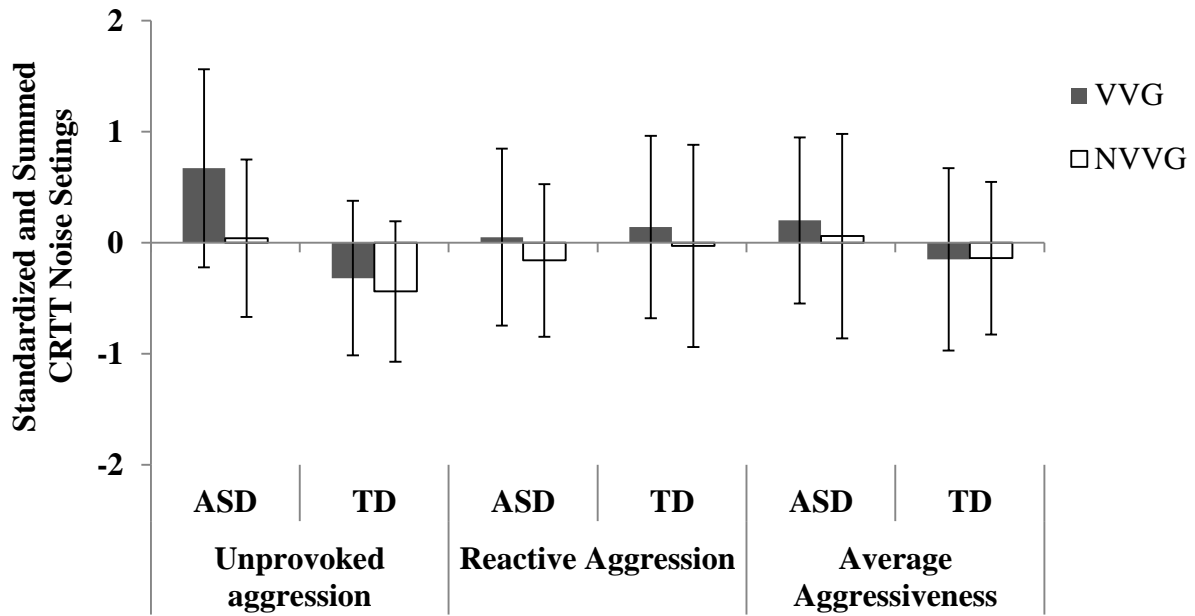


Figure 1. Standardized and summed CRTT noise settings for unprovoked (left), reactive (middle) and average aggressiveness (right) as a function of Violent content and Group diagnosis. Error bars denote 95% confidence intervals for the mean. ASD = Autism spectrum disorder. TD = Typical development. VVG = violent video game. NVVG = nonviolent video game.

Table 3. *CRTT Aggression Scores by Experimental Factors and Cells.*

Variable	Means and Standard Deviations by Game		Means and Standard Deviations by Group	
	VVG (n = 48)	NVVG (n = 45)	ASD (n = 48)	TD (n = 45)
	<i>M(SD)</i>	<i>M(SD)</i>	<i>M(SD)</i>	<i>M(SD)</i>
Trial 1 Intensity	4.32(2.26) ¹	4.22(2.33)	4.72(2.33) ¹	3.80(2.16)
Trial 1 Duration	3.38(2.22) ¹	2.73(1.51)	3.38(2.00) ¹	2.73(1.81)
Trial 1 Standardized & Summed	0.19(1.92) ¹	-0.19(1.54)	0.36(1.90) ¹	-0.38(1.50)
Trial 2 Intensity	6.46(2.90)	6.89(2.76) ¹	6.65(2.71)	6.68(2.98) ¹
Trial 2 Duration	6.46(2.97)	5.43(2.87) ¹	5.83(2.97)	6.11(2.96) ¹
Trial 2 Standardized & Summed	0.09(1.90)	-0.10(1.78) ¹	-0.05(1.76)	0.06(1.93) ¹
Trials 3-9 Average Intensity	5.69(1.45)	5.73(1.35) ¹	5.73(1.49)	5.68(1.30) ¹
Trials 3-9 Average Duration	5.32(1.57)	5.16(1.66) ¹	5.42(1.69)	5.05(1.50) ¹
Trials 3-9 Standardized & Summed	0.03(1.84)	-0.03(1.84) ¹	0.13(1.95)	-0.14(1.70) ¹

Variable	Means and Standard Deviations by Cell			
	ASD/VVG (n=25)	ASD/NVVG (n=23)	TD/VVG (n=23)	TD/NVVG (n=22)
	<i>M(SD)</i>	<i>M(SD)</i>	<i>M(SD)</i>	<i>M(SD)</i>
Trial 1 Intensity	5.00(2.45) ¹	4.43(2.21)	3.61(1.83)	4.00(2.49)
Trial 1 Duration	3.75(2.25) ¹	3.00(1.65)	3.00(2.17)	2.45(1.34)
Trial 1 Standardized & Summed	0.67(2.11) ¹	0.04(1.64)	-0.32(1.61)	-0.44(1.43)
Trial 2 Intensity	6.36(2.91)	6.96(2.50)	6.57(2.94)	6.81(3.09) ¹
Trial 2 Duration	6.44(3.08)	5.17(2.76)	6.48(2.91)	5.71(3.04) ¹
Trial 2 Standardized & Summed	0.05(1.93)	-0.16(1.59)	0.14(1.90)	-0.03(2.00) ¹
Trials 3-9 Average Intensity	5.66(1.45)	5.81(1.57)	5.71(1.49)	5.64(1.08) ¹
Trials 3-9 Average Duration	5.61(1.58)	5.22(1.80)	4.99(1.52)	5.10(1.52) ¹
Trials 3-9 Standardized & Summed	0.20(1.81)	0.06(2.13)	-0.15(1.90)	-0.14(1.51) ¹

Table 3 Continued.

Note: ¹Sample size was one less participant than the number indicated in the column heading. ASD = autism spectrum disorder. TD = typical development. VVG = violent video game. NVVG = nonviolent video game.

Unprovoked Aggression (Trial 1). Trial 1 noise blasts represent unprovoked aggression because they are not influenced by interactions with the perceived opponent over the remainder of the CRTT. Conventional analysis revealed a small effect of Violent content, $F(1,88) = 1.09$, $d_{\text{unb}} = 0.22$ [-0.20, 0.64], some evidence that adults with ASD were more aggressive than TD adults, ($F = 4.21$, $d_{\text{unb}} = 0.43$ [0.00, 0.85], and virtually no evidence for a Violent content x Group diagnosis interaction, $F = 0.54$, $r = 0.08$ [-0.13, 0.28].

To examine our first aim, we set the scale parameter r of the prior to 0.43, commensurate with an expected effect size of $\rho = .21$ (see Anderson et al., 2010). Bayes factor model comparison yielded modest evidence against any effect of Violent content. The best model was the Group diagnosis model with no effect of Violent content. This model was preferred by a factor of 2.5-to-1 over the additive model with main effects of both Group diagnosis and Violent content, and was preferred by a factor of 6.1-to-1 over the full model with both effects and an interaction. These results indicate that Trial 1 aggressive behavior seems invariant to the degree of violence in the video game. Although the Group diagnosis model was preferred over the null model with no effects whatsoever, this preference is only by a factor of 1.5-to-1. To examine our second aim, we performed follow-up contrasts to assess the Violent content effect separately for adults with ASD and TD adults. Results showed a slight preference for null effects among adults with ASD (1.8-to-1) and TD adults (2.9-to-1).³

The Bayes factor model comparison results largely agree with more conventional analyses. However, this comparison allows quantification of the strength of evidence for the null hypothesis, which conventional null hypothesis significance tests (NHSTs) cannot provide. That is, NHST can only demonstrate that no evidence has been found for an effect, while Bayesian analysis can demonstrate the presence of some evidence for invariance of aggressive behavior despite the manipulation of Violent content.

Reactive Aggression (Trial 2). All participants lost the first CRTT trial and received a noise blast intended to provoke them (level 9 noise intensity and level 8 noise duration). As a result, the second trial of the CRTT is believed to provide a measure of aggression immediately following provocation. Conventional analyses from ANOVA showed tiny effects of Violent content, $F(1,88) = 0.25$, $d_{\text{unb}} = 0.11$ [-0.31, 0.53], and Group diagnosis, $F = 0.08$, $d_{\text{unb}} = -0.06$ [-0.48, 0.36], and a nonexistent interaction between these two variables, $F = 0.00$, $r = 0.00$ [-0.20, 0.20].

Bayes factor model comparison revealed that the null model was preferred to a model with Violent content only (3.6-to-1), to a model with Group diagnosis only (3.9-to-1), to a model with both variables (13.8-to-1), and to the full model (43.5-to-1) (aim 1). Follow-up contrasts also showed slight a preference for null effects for adults with ASD (2.9-to-1) and TD adults (2.9-to-1) (aim 2). In sum, there is positive evidence of an invariance of this measure to adults with ASD and violent game content.

Average Aggression. CRTT trials following the second trial (trials 3 to 9) were included in the composite score. A conventional ANOVA revealed tiny empirical effects for Violent content, $F(1,88) = 0.03$, $d_{\text{unb}} = 0.04$ [-0.38, 0.46], Group diagnosis, $F = 0.49$, $d_{\text{unb}} = 0.15$ [-0.27, 0.57], and for the interaction between these terms, $F = 0.04$, $r = .02$ [-0.18, 0.22]. Bayes factor

revealed support for the null model over the Violent content model (4.0-to-1), the Group diagnosis model (3.2-to-1), the additive model (13.0-to-1), and the full model (41.0-to-1) (aim 1). Follow-up contrasts also showed a slight preference for null effects among adults with ASD (3.0-to-1) and TD adults (3.0-to-1) (aim 2).

Aggressive Thought Accessibility

Data from 2 participants were removed from these analyses: 1 because the participant thought we were examining subliminal aggression; 1 due to knowledge that the word stems could be completed in aggressive or non-aggressive ways. Table 4 depicts all means and standard deviations.

Post-game Aggressive Thought Accessibility. The final row in Table 4 (also see Figure 2) indicates no evidence that the factors in the study had any appreciable effect on the accessibility of aggressive thoughts.

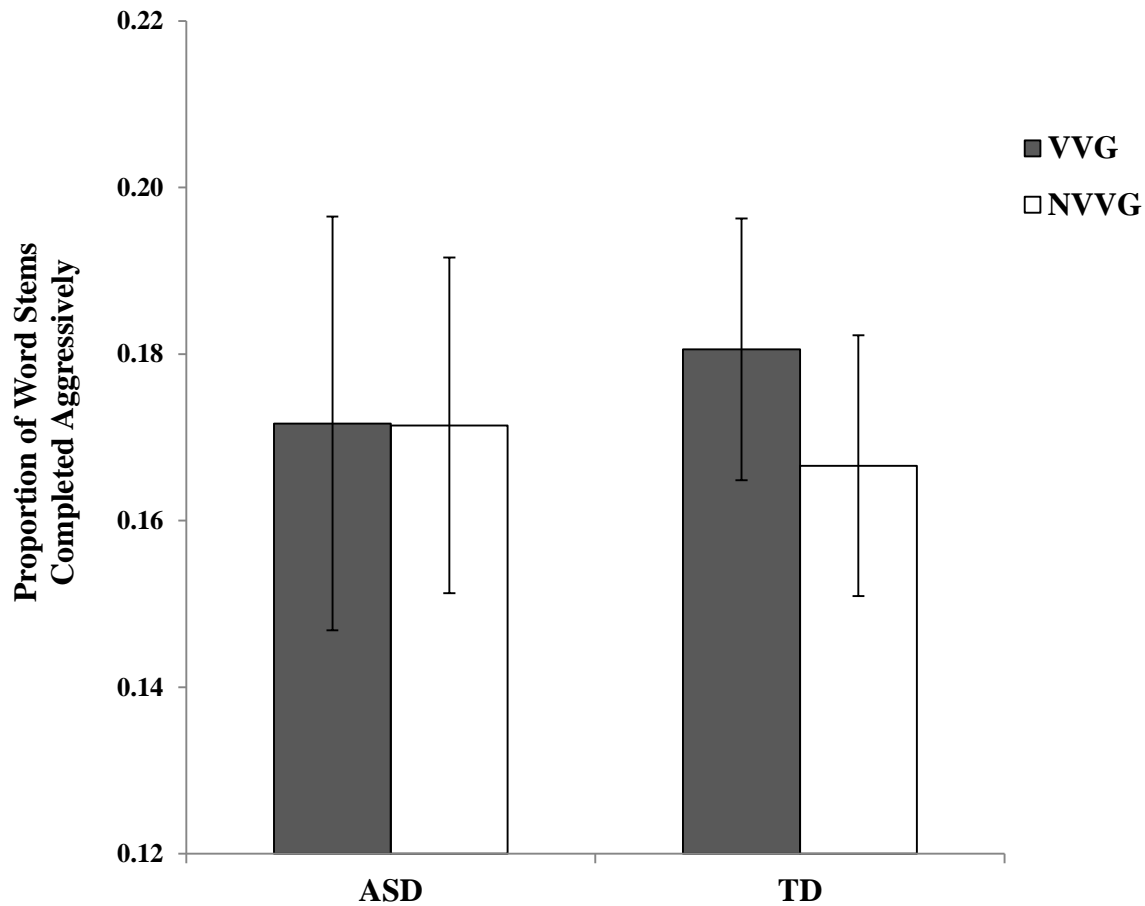
Figure 2

Figure 2. Proportion of words completed aggressively on the post-game measure of aggressive thought accessibility as a function of Violent content and Group diagnosis. Error bars denote 95% confidence intervals for the mean. ASD = Autism spectrum disorder. TD = Typical development. VVG = violent video game. NVVG = nonviolent video game.

Table 4. *Proportion of Word Stems Completed Aggressively by Experimental Factors and Cells.*

Variable	Means and Standard Deviations by Game		Means and Standard Deviations by Group	
	VVG (n = 59)	NVVG (n = 61)	ASD (n = 60)	TD (n = 60)
	<i>M(SD)</i>	<i>M(SD)</i>	<i>M(SD)</i>	<i>M(SD)</i>
Practice Words	0.10(0.14)	0.10(0.14)	0.10(0.15)	0.10(0.14)
Words Following Game Play (Practice)	0.15(0.15) ²	0.16(0.17) ¹	0.15(0.15) ²	0.17(0.17) ¹
Words Following Game Play (All Words)	0.18(0.05) ²	0.17(0.05) ¹	0.17(0.06) ²	0.17(0.04) ¹

Variable	Means and Standard Deviations by Cell			
	ASD/VVG (n=29)	ASD/NVVG (n=31)	TD/VVG (n=30)	TD/NVVG (n=30)
	<i>M(SD)</i>	<i>M(SD)</i>	<i>M(SD)</i>	<i>M(SD)</i>
Practice Words	0.10(0.14)	0.10(0.16)	0.10(0.14)	0.11(0.13)
Words Following Game Play (Practice)	0.17(0.15) ¹	0.13(0.16) ¹	0.14(0.15) ¹	0.19(0.18)
Words Following Game Play (All Words)	0.17(0.06) ¹	0.17(0.05) ¹	0.18(0.04) ¹	0.17(0.04)

Note: Practice words = proportion of word stems completed aggressively on the baseline (10-item) measure of aggressive thought accessibility. Words following game play (practice) = proportion of word stems from the baseline thought accessibility measure completed aggressively on the full scale (98-item) aggressive thought accessibility measure (i.e., following game exposure). Words following game play (all words) = proportion of word stems completed aggressively on the full scale (98-item) aggressive thought accessibility measure. ¹Sample size was one less participant than the number indicated in the column heading. ²Sample size was two fewer participants than the number indicated in the column heading. ASD = autism spectrum disorder. TD = typical development. VVG = violent video game. NVVG = nonviolent video game.

This visual inspection is corroborated by the conventional ANOVA and by the Bayes factors. ANOVA showed a small effect for Violent content, $F = 0.57$, $d_{\text{unb}} = 0.14$ [-0.23, 0.51], Group diagnosis, $F = 0.05$, $d_{\text{unb}} = -0.04$ [-0.41, 0.33], and for the two-way interaction between these terms, $F = 0.53$, $r = .07$ [-0.12, 0.25].

Scale parameter r of the prior was set to 0.45 in this analysis, commensurate with an expected effect size of $\rho = .22$ (see Anderson et al., 2010). Consistent with the results from the ANOVA, Bayes factor revealed support for the null model over the Violent content model (3.6-to-1), the Group diagnosis model (4.5-to-1), the model with Violent content and Group diagnosis (16.1-to-1), and the full model with all terms (46.9-to-1) (aim 1).

We also performed follow-up contrasts to assess the Violent content effect separately for adults with ASD and TD adults. Once again, these contrasts showed a slight preference for a null effect for both adults with ASD (3.4-to-1) and TD adults (1.8-to-1) (aim 2). Taken together, positive evidence of an invariance of the accessibility of aggressive thoughts to adults with ASD and violent game content was observed.

Aggressive Affect

Means and standard deviations for this outcome variable can be seen in Table 5 and are depicted in Figure 3. Results from a traditional ANOVA showed tiny effects of Violent content, $F = 1.11$, $d_{\text{unb}} = 0.19$ [-0.17, 0.56], and Group, $F = 0.29$, $d_{\text{unb}} = 0.09$ [-0.27, 0.46], but a small-to-moderate effect of Violent content x Group diagnosis, $F = 3.73$, $r = 0.18$ [-0.01, 0.34].

Scale parameter r of the prior was set to 0.61, commensurate with an expected effect size of $\rho = .29$ (see Anderson et al., 2010). The Bayes factor, by contrast, demonstrated that the null model was preferred to the model with Violent content (3.6-to-1), the model with Group

diagnosis (5.4-to-1), the additive model (19.9-to-1), and, importantly, the model with the main effects and interaction term (16.6-to-1) (aim 1).

Follow-up contrasts to assess the effect of Violent content on this measure separately for adults with ASD and TD adults were also conducted.

Figure 3

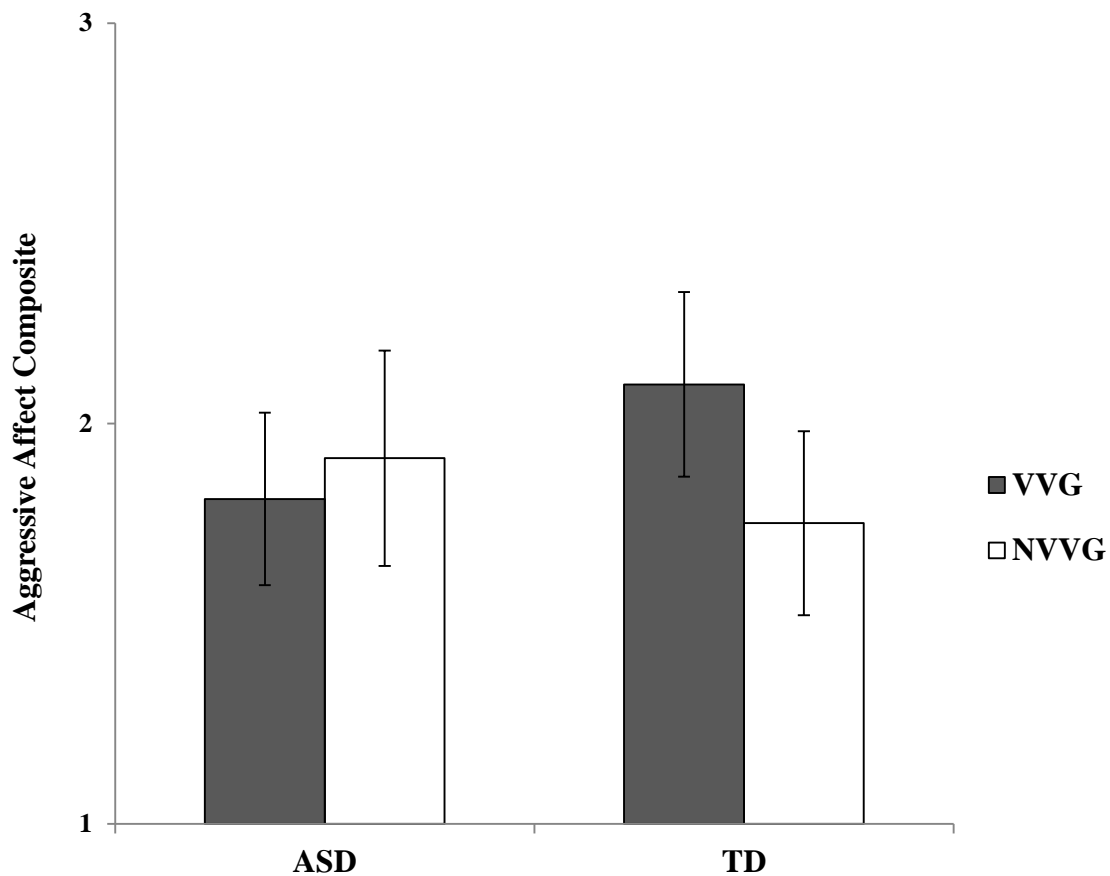


Figure 3. Aggressive affect composite scores as a function of Violent content and Group diagnosis. Error bars denote 95% confidence intervals for the mean. ASD = Autism spectrum disorder. TD = Typical development. VVG = violent video game. NVVG = nonviolent video game.

Table 5. 15-item Aggressive Affect Composite Scores by Experimental Factors and Cells.

Variable	Means and Standard Deviations by Game		Means and Standard Deviations by Group	
	VVG (n = 59)	NVVG (n = 60)	ASD (n = 59)	TD (n = 60)
	<i>M(SD)</i>	<i>M(SD)</i>	<i>M(SD)</i>	<i>M(SD)</i>
Aggressive Affect	1.96(0.61)	1.83(0.67)	1.86(0.65)	1.92(0.64)

Variable	Means and Standard Deviations by Cell			
	ASD/VVG (n=29)	ASD/NVVG (n=30)	TD/VVG (n=30)	TD/NVVG (n=30)
	<i>M(SD)</i>	<i>M(SD)</i>	<i>M(SD)</i>	<i>M(SD)</i>
Aggressive Affect	1.81(0.57)	1.91(0.72)	2.10(0.62)	1.75(0.61)

Note: ASD = autism spectrum disorder. TD = typical development. VVG = violent video game. NVVG = nonviolent video game.

These follow-up contrasts indicated that the null model was slightly preferred to a model with Violent content among adults with ASD (3.8-to-1), but that the model with Violent content was slightly preferred to the null model among TD adults (1.7-to-1) (aim 2).

Discussion

The current experiment is the first to directly test whether VVGs affect adults with ASD differently than TD adults (aim 1), as well as the first to test whether VVGs affect adults with ASD on measures of aggressive behavior (aim 2). We found strong evidence against the first hypothesis, and modest evidence against the second hypothesis. These results add important information to the growing understanding of experiences of adults with ASD, and provide the first experimental evidence countering media speculation about video game effects in this population.

Model comparisons in the TD group indicated modest evidence against an effect of violent content on aggressive behavior as large as that reported ($r = .21$) in one previous meta-analysis conducted on this topic (see Anderson et al., 2010). The present study's use of modified games for increased experimental control may reveal a smaller or eliminated effect. In contrast, most previous research relied on contrasts between games that differed in violent content but may also differ in other ways. Similar to other recent research (e.g., Elson et al., 2013; Przybylski et al., 2014), the games used here were carefully matched on all dimensions but violent content to avoid confounding violent content with other game features. One possibility, then, is that effects ascribed to violent content in previous video game studies (see Anderson et al., 2010; Greitemeyer & Mügge, 2014) actually represent the conflation of violent content with other game features that typically differ between VVGs and NVVGs and that influence aggressive behavior.

Results from the ANOVAs involving the theoretical mediators of aggression – aggressive thought accessibility and aggressive affect – also showed strong evidence against the hypothesis that VVGs affect adults with ASD differently than TD adults on these measures. The follow-up pairwise contrasts among adults with ASD indicated slight evidence that exposure to violent content did not affect these outcomes. However, pairwise contrasts among TD adults suggested slight evidence for an effect of video game violence on aggressive affect.

Although the current study provides the first empirical examination of video game effects in adults with ASD, some limitations of the design should be noted. First, it is possible that the NVVG contained sufficient violence to have an effect on the players, thereby also causing within-person increases on the aggression-related outcomes and reducing the apparent magnitude of the between-subject VVG effect on the variables reported here. Although we cannot rule out

this possibility, we think it is fairly remote. Recall that participants found the NVVG to be much less violent than the VVG (see Table 2). Additionally, the NVVG cover story indicated that participants were trying to *help* (not harm) confused and scared aliens by teleporting them to their home planet. What should be clear is that the perfect control condition is difficult to attain, in that ensuring stringent control over some in-game feature(s) might tend to obscure the differences that often exist between VVGs and NVVGs. Nevertheless, the current design permitted an appropriate test of the specific effects of violent game content per se, consistent with previous studies in which VVGs and NVVGs have been engineered to match on all dimensions but violence (e.g., Przybylski et al., 2014).

A second potential limitation is that baseline measures of aggressive behavior and aggressive affect were not obtained. We therefore cannot determine whether game exposure caused differential increases or decreases on these measures relative to baseline. This decision was not an oversight. Administering these measures both before and after game play could have alerted participants as to the nature of the study, foiled our cover story, and introduced unwanted demand characteristics. Although we acknowledge that pre- and post-game measures can be useful in understanding how game exposure might cause differential changes in outcomes related to aggression, we urge researchers to exercise caution when using such methods.

A third limitation is that the sample size was relatively small. However, paradigms in which adults with ASD are randomly assigned to experimental conditions are exceedingly rare, as are sample sizes larger than the one here in cross-sectional designs. More to the point, our sample size is reasonably large, especially considering the challenges of recruiting a clinical population from a single geographic location. Consequently, the evidence provided here can be considered the best available to date in terms of the special population being investigated (see

Rosnow & Rosenthal, 1989). Yet, a larger sample size would be desirable and may provide stronger, more compelling Bayes factors.

Two additional points are worthy of discussion. The first concerns our decision to use modifications of *Doom II*. Although originally released in 1994, *Doom II* is still very violent, very popular (people actively create and play independent game modifications and levels for this game), and is still a video game. This game was deliberately chosen in order to operationalize the construct of violent content. Thus, the age of the game is irrelevant to our primary research questions. Our decision on how to operationalize violent content is also supported by research suggesting that the technological sophistication of violent game content has no effect on outcomes related to aggression (Ivory & Kalyanaraman, 2007).

The second point concerns the trade-off between internal and ecological validity. Our construct of interest was violent game content. Therefore, to the extent that the games represented violent and nonviolent video game content while holding all other game design elements constant, we believe that our design maximized the aspects of validity that were central to our research questions. As in most experimental research, there are compromises between internal and ecological validity. Had we wanted to maximize ecological validity, we could have purchased two modern video games, one exceedingly violent and one not, and used those in the current study. However, such a manipulation would lack internal validity, as contemporary games containing violent content generally differ substantially from contemporary nonviolent games in dimensions besides violent content. We believe that the current study therefore provides excellent internal validity and acceptable ecological validity. Even so, the current results should not necessarily be generalized to video games in general.

When events or behaviors seem inexplicable, people often generate causal attributions based on anecdotal or correlational evidence. Psychological science can help inform our understanding of such events by directly testing these assumptions. In the aftermath of widely publicized acts of violence, the purpose of this study was to address the controversial question of whether video game violence differentially affects the behavior of adults with ASD (also see Ferguson & Olson, 2014, for complementary correlational findings among people with elevated levels of depression and attention-deficit/hyperactivity disorder). Although the current study did not investigate violent behavior, it did examine the extent to which adults with ASD and TD are willing to harm someone following brief exposure to video games. The results of our study provided strong evidence against the hypothesis that VVGs affect adults with ASD differently than TD adults. Moreover, the results indicated slight evidence that VVGs do not affect aggression in this group whatsoever. As is the case with a single study on any topic, the current findings should not be considered the ultimate arbiter, and we hope that other researchers will endeavor to replicate our approach using similar experimental methods. Although preliminary, we hope that these findings help to correct faulty assumptions among the general public and that they will inform our ongoing understanding of a clinically relevant topic.

Footnotes

1. One parent indicated that her child with ASD would not be comfortable playing a violent video game because he would obsess about the violence for several weeks if asked to play it. Therefore, this participant was not randomly assigned to game condition but was intentionally assigned to play the NVVG during the study.
2. One adult with ASD elected to terminate the experiment immediately following the CRTT.
3. Tuning the prior of the expected effects to be medium or large in size would increase the apparent evidence for the null effects model.

References

- Adachi, P. J., & Willoughby, T. (2011). The effect of video game competition and violence on aggressive behavior: Which characteristic has the greatest influence? *Psychology of Violence, 1*(4), 259–274.
- Algina, J., & Keselman, H. J. (2003). Approximate confidence intervals for effect sizes. *Educational and Psychological Measurement, 63*, 537-553.
- American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Arlington, VA: American Psychiatric Publishing.
- American Psychological Association. (2010). *Publication manual of the American Psychological Association* (6th ed.). Washington, DC: Author.
- Anderson, C. A., & Bushman, B. J. (2002). Human aggression. *Annual Review of Psychology, 53*(1), 27–51.
- Anderson, C. A., & Carnagey, N. L. (2009). Causal effects of violent sports video games on aggression: Is it competitiveness or violent content? *Journal of Experimental Social Psychology, 45*(4), 731–739.
- Anderson, C. A., Carnagey, N. L., Flanagan, M., Benjamin, A. J., Eubanks, J., & Valentine, J. C. (2004). Violent video games: Specific effects of violent content on aggressive thoughts and behavior. *Advances in Experimental Social Psychology, 36*, 199-249.
- Anderson, C. A., Shibuya, A., Ihori, N., Swing, E. L., Bushman, B. J., Sakamoto, A., ... Saleem, M. (2010). Violent video game effects on aggression, empathy, and prosocial behavior in Eastern and Western countries: A meta-analytic review. *Psychological Bulletin, 136*(2), 151–173.

- Baron-Cohen, S. (1997). *Mindblindness—An essay on autism and theory of mind*. Cambridge: MIT Press.
- Ben-Sasson, A., Hen, L., Fluss, R., Cermak, S. A., Engel-Yeger, B., & Gal, E. (2009). A meta-analysis of sensory modulation symptoms in individuals with autism spectrum disorders. *Journal of Autism and Developmental Disorders, 39*(1), 1–11.
- Edwards, W., Lindman, H., & Savage, L. J. (1963). Bayesian statistical inference for psychological research. *Psychological Review, 70*(3), 193–242.
- Elson, M., Breuer, J., Van Looy, J., Kneer, J., & Quandt, T. (2013) Comparing apples and oranges? Evidence for pace of action as a confound in research on digital games and aggression. *Psychology of Popular Media Culture*. Advance online publication. doi: 10.1037/ppm0000010
- Elson, M., Mohseni, M. R., Breuer, J., Scharrow, M., & Quandt, T. (2014). Press CRTT to measure aggressive behavior: The unstandardized use of the competitive reaction time task in aggression research. *Psychological Assessment, 26*(2), 419–432.
- Engelhardt, C. R., Bartholow, B. D., & Sauls, J. S. (2011). Violent and nonviolent video games differentially affect physical aggression for individuals high vs. low in dispositional anger. *Aggressive Behavior, 37*(6), 539–546.
- Engelhardt, C. R., Mazurek, M. O., & Sohl, K. (2013). Media use and sleep among boys with autism spectrum disorder, ADHD, or typical development. *Pediatrics, 132*(6), 1081–1089.
- Ferguson, C. J. (in press). Do angry birds make for angry children? A meta-analysis of video game Influences on children's and adolescents' aggression, mental health, prosocial behavior and academic performance. *Perspectives on Psychological Science*.

- Ferguson, C. J., & Kilburn, J. (2010). Much ado about nothing: The misestimation and overinterpretation of violent video game effects in Eastern and Western nations: Comment on Anderson et al.(2010). *Psychological Bulletin*, *136*(2), 174–178.
- Ferguson, C. J., & Olson, C. K. (2014). Video game violence use among “vulnerable” populations: The impact of violent games on delinquency and bullying among children with clinically elevated depression or attention deficit symptoms. *Journal of Youth and Adolescence*, *43*(1), 127–136.
- Geurts, H. M., Bergh, S. F., & Ruzzano, L. (2014). Prepotent response inhibition and interference control in autism spectrum disorders: Two meta-analyses. *Autism Research*. Retrieved from <http://onlinelibrary.wiley.com/doi/10.1002/aur.1369/full>
- Greitemeyer, T., & Mügge, D. O. (2014). Video games do affect social outcomes: A meta-analytic review of the effects of violent and prosocial video game play. *Personality and Social Psychology Bulletin*, *40*(5), 578-589.
- Harmon, A. (2012, December 12). Fearing a stigma for people with autism. *The New York Times*. Retrieved August 21, 2014.
- Hasan, Y., Bègue, L., Scharkow, M., & Bushman, B. J. (2013). The more you play, the more aggressive you become: A long-term experimental study of cumulative violent video game effects on hostile expectations and aggressive behavior. *Journal of Experimental Social Psychology*, *49*(2), 224–227.
- vd Heiden, P. (2012) Doom builder 2 (Version 2.1.2.1553) [Computer software]. Retrieved from <http://www.doombuilder.com/>
- Hilgard, J., (2014). Hilgard's Modified Video Game Paradigm. Retrieved from Open Science Framework, osf.io/3cb9m

- Hoekstra, R. A., Vinkhuyzen, A. A., Wheelwright, S., Bartels, M., Boomsma, D. I., Baron-Cohen, S., ... van der Sluis, S. (2011). The construction and validation of an abridged version of the autism-spectrum quotient (AQ-short). *Journal of Autism and Developmental Disorders, 41*(5), 589–596.
- Hummer, T. A., Wang, Y., Kronenberger, W. G., Mosier, K. M., Kalnin, A. J., Dunn, D. W., & Mathews, V. P. (2010). Short-term violent video game play by adolescents alters prefrontal activity during cognitive inhibition. *Media Psychology, 13*(2), 136–154.
- Ivory, J. D., & Kalyanaraman, S. (2007). The effects of technological advancement and violent content in video games on players' feelings of presence, involvement, physiological arousal, and aggression. *Journal of Communication, 57*(3), 532–555.
- Lord, C., DiLavorne, P. C., & Risi, S. (2002). *Autism Diagnostic Observation Schedule*. Los Angeles, CA: Western Psychological Services.
- Lord, C., Rutter, M., & Le Couteur, A. (1994). Autism Diagnostic Interview-Revised: A revised version of a diagnostic interview for caregivers of individuals with possible pervasive developmental disorders. *Journal of Autism and Developmental Disorders, 24*(5), 659–685.
- Mazurek, M. O., & Engelhardt, C. R. (2013). Video game use and problem behaviors in boys with autism spectrum disorders. *Research in Autism Spectrum Disorders, 7*(2), 316–324.
- Morey, R. D., & Rouder, J. N. (2014). BayesFactor: Computation of Bayes factors for common designs. R package version 0.9.7. <http://CRAN.R-project.org/package=BayesFactor>
- Przybylski, A. K., Deci, E., Rigby, C. S., & Ryan, R. M. (2014). Competence-impeding electronic games and players' aggressive feelings, thoughts, and behaviors. *Journal of Personality and Social Psychology, 103*(3), 441–457.

- Roid, G. H. (2003). Stanford Binet intelligence scales (5th ed.). Itasca, IL: Riverside Publishing.
- Rosenthal, R., & Rubin, D. B. (2003). R equivalent: A simple effect size indicator. *Psychological Methods*, 8(4), 492–496.
- Rosnow, R. L., & Rosenthal, R. (1989). Statistical procedures and the justification of knowledge in psychological science. *American Psychologist*, 44(10), 1276–1284.
- Rouder, J. N., Morey, R. D., Speckman, P. L., & Province, J. M. (2012). Default Bayes factors for ANOVA designs. *Journal of Mathematical Psychology*, 56(5), 356–374.
- RWW Blog. (2013, February 20). Beck: Video Games Were Responsible For Sandy Hook Massacre. [Video file]. Retrieved from https://www.youtube.com/watch?v=Wd_Z6TwC704
- Sherry, J. L. (2007). Violent Video Games and Aggression: Why Can't We Find Effects? In R. W. Preiss, B. Gayle, N. Burrell, M. Allen, J. Bryant (Eds.), *Mass media effects research: Advances through meta-analysis* (pp. 245-262). Mahwah, NJ, US: Lawrence Erlbaum Associates Publishers.
- Spielberger, C. D, Jacobs, G, Russell, S., & Crane, R. S. (1983). Assessment of anger: The State-Trait Anger Scale. In J. N. Butcher & C. D. Spielberger (Eds.), *Advances in personality assessment* (pp. 161-189). Hillsdale, NJ: Erlbaum.
- Wagenmakers, E.-J. (2007). A practical solution to the pervasive problems of p values. *Psychonomic Bulletin & Review*, 14(5), 779–804.

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