Measuring the Abuse Liability of Video Games

by

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Abstract

Video game playing has become increasingly popular since their creation in the 1970s and has received recent attention due to sharing many similarities with other addictive behaviors. Behavioral pharmacological models are commonly used in understanding drug use behaviors and may similarly inform conceptual models of video game playing. Specifically, dose-effect studies are often used to understand the abuse liability (i.e., addiction potential) of novel drugs. The current study utilized this dose-effect methodology for studying video games. Participants (N = 81) played three video games for 10 minutes (i.e., Forza Motorsport 7, Forza Motorsport 1, and OutDrive) and completed Visual Analog Scales after playing the games for one minute, five minutes, and 10 minutes. They then completed a Multiple-Choice Procedure form after 10 minutes in order to measure the abuse liability of the games. Additionally, participants completed the Video Game Dependency Scale to assess problems associated with disordered video game playing. Results from the study indicate that there were abuse liability differences between games, though relations between external behaviors (i.e., weekly participant play time and Internet Gaming Disorder scores) and in-laboratory behaviors (i.e. abuse liability scores) remain unclear. Like other behavioral addiction studies, these results support the notion that methodologies and measures commonly used in drug administration literature can be used to effectively assess variables relevant to behavioral addictions. Recommendations for future studies and implications are provided.

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Measuring the Abuse Liability of Video Games

Video games have become increasingly popular since their creation in the 1970s. Today, approximately 65% of households in the United States are home to an individual who plays video games at least three hours per week (Entertainment Software Association, 2017). Of the most frequent video game players, 53% play online at least once per week. Due to their popularity, researchers have investigated negative and positive consequences associated with playing video games. For example, several positive effects have been linked with playing video games, including benefits in motivation, cognitive abilities, social skills, affect, health, and knowledge/skill acquisition (Boyle et al., 2016; Granic, Lobel, & Engels, 2014). Beyond these benefits, video games can also function as a form of entertainment and fun. However, individuals who engage in problematic video game playing may experience a variety of negative consequences, including stress and inattention (Batthyány, Müller, Benker, & Wölfling, 2009), maladaptive cognitions and depression (Peng & Liu, 2010), sleep disturbances (Dworak, Schierl, Bruns, & Struder, 2007; Rehbein, Kleimann, Mediasci, & Mößle, 2010; Rehbein, Kliem, Baier, Mößle, & Petry, 2015), and problems with physical well-being, personal life, and academic/professional performance (Batthyány et al., 2009; Liu & Peng, 2009; Peng & Liu, 2010; Rehbein et al., 2010). Violent video games have also been linked to an increase in aggression, as well as decreases in empathy and prosocial behavior (Anderson et al., 2010). Although prevalence rate estimates vary greatly (i.e., 1.16% - 15.6%), previous research indicates that a meaningful number of individuals across cultures and genders experience various levels of impairment related to their gaming behavior (Batthyány et al., 2009; Festl, Scharkow, & Quandt, 2013; Ko, Yen, Yen, & Yang, 2007; Mentzoni et al., 2011; Peng & Li, 2009; Rehbein et al., 2010; 2015; Van Rooij, Schoenmakers, Vermulst, Eijnden, & Mheen, 2011; Wang et al., 2014). The myriad negative consequences associated with problematic video game playing, along with the number of gamers potentially affected, has created a greater need for video game research to understand the phenomenon.

The *Diagnostic and Statistical Manual* (5^{th} ed; *DSM-5*) included internet gaming disorder (IGD) as a condition that warranted further study in the Substance-Related and Addictive Disorders category in order to encourage researchers to further investigate the construct of IGD (Petry & O'Brien, 2013; Petry et al., 2014). The *DSM-5* conceptualizes IGD as "a pattern of excessive and prolonged Internet gaming that results in a cluster of cognitive and behavioral symptoms, including progressive loss of control over gaming, tolerance, and withdrawal symptoms" (American Psychiatric Association, 2013, p. 796). The proposed *DSM-5* criteria include the following: (1) preoccupation with Internet games, (2) withdrawal, (3) tolerance, (4) unsuccessful attempts to control participation in Internet games, (5) loss of interest in other hobbies, (6) continued excessive use despite knowledge of psychosocial problems, (7) deceiving others regarding amount of time spent playing, (8) using online gaming to escape or relieve negative mood, and (9) jeopardizing or loss of a significant relationship, job, or educational or career opportunity (APA, 2013). Nearly all of the proposed IGD criteria are analogous to the criteria for substance use disorders or share features of substance use disorders (Smith, Hummer, & Hulvershorn, 2015). For example, the criteria for substance use disorders, gambling disorder, and IGD include symptoms of jeopardizing relationships or jobs, as well as loss of interest in other hobbies and preoccupation with substances, gambling, or video games. Importantly, like all other addictive disorders, excessive engagement in video game playing is not enough; impairment must be present to justify a diagnosis of IGD.

Consistent with the *DSM-5* authors classifying IGD as an addictive disorder, researchers have identified similarities between IGD and substance use and gambling disorders. One similarity between IGD and other addictive disorders are the motivations to engage in those behaviors. Kuss and Griffiths (2012) conducted a systematic review of motivations to engage in IGD behaviors and identified three main themes, including dysfunctional coping (e.g., escape, dealing with stress), personal satisfaction (e.g., enjoyment, overcoming challenges), and socialization (e.g., social recognition, online relationships). Several of the specific behaviors within these themes of motivations to engage in IGD behaviors overlap with motivations for substance use (Cooper, 1994; Terry-McElrath, O'Malley, & Johnston, 2009) and gambling behavior (Lightsey Jr. & Hulsey, 2002; Neighbors, Lostutter, Cronce, & Larimer, 2002). Specifically, individuals report utilizing substances to have a good time, relax, get away from problems, and fit in with others (Terry-McElrath et al., 2009). Motivations to gamble include coping with emotions, enjoyment and competition, and interacting with family and friends or meeting new people (Lightsey Jr. & Hulsey, 2002; Neighbors et al., 2002). Collectively, these results suggest that there are overlapping motivations for engaging in each of these addictive behaviors.

Researchers have also identified several neurobiological similarities between playing video games and using substances or gambling. Studies examining brain area activation of individuals who were playing video games or exposed to video game cues revealed significant activation in regions (e.g., dorsolateral prefrontal cortex, parahippocampal gyrus, precuneus, amygdala, insula) commonly associated with reward and addiction (Franken, 2003; Hoeft, Watson, Kesler, Bettinger, & Reiss, 2008; Han, Hwang, & Renshaw, 2010; Kalivas & Volkow, 2005; Kühn, Gleich, Lorenz, Lindenberger, & Gallinat, 2014). Results from studies examining video game cue presentation have also revealed similar brain area activation to cue presentation for individuals who meet criteria for substance use or gambling disorders (Han et al., 2011; Ko et al., 2013). Weinstein and Lejoyeux (2013) provided more support suggesting that video game playing behaviors consistent with IGD have similar neural mechanisms to those underlying substance use after conducting a literature review of studies examining brain imaging, brain activation, and brain structure of individuals who meet IGD criteria.

Due to the similarities between IGD and other addictive disorders, it makes sense to turn to theoretical and methodological approaches often used to understand substance use and gambling. In the behavioral pharmacology literature, researchers have extensively examined the abuse liability of drugs, which is typically defined as the potential of a drug to cause addiction. Abuse liability varies between and within drug classes, and clinical studies are necessary to validate and better understand the nature and clinical implications of those differences (Fischman & Mellow, 1989). Abuse liability testing aids in addiction prevention efforts by making clear which drugs should be kept from individuals who would abuse them (e.g., restrictions on availability of drugs with high abuse liability). Abuse liability testing also helps curtail iatrogenic addiction and helps inform restrictions for the availability of drugs that may be vulnerable to diversion (Fischman & Mellow, 1989). Additionally, Schuster (1989) states that conducting abuse liability studies benefits basic science by providing insight into the underlying drug actions, as well as providing insight into the behavioral and biological mechanisms of addiction which then enhances our understanding of the neurobiology of mood and affect. By examining the abuse liabilities of drugs, regulating agencies, clinicians, and researchers can make decisions with the full knowledge of the drugs' addiction potential (Schuster, 1989).

In order to test for the abuse liability of drugs, researchers commonly use methodologies that allow them to compare the effects of multiple doses of one drug to the effects of multiple doses of another drug for which abuse liability is already established through clinical study (Griffiths, Bigelow, & Ator, 2003). Griffiths and colleagues (2003) describe this dose-effect comparison method as the standard for abuse liability testing. The methodology of dose-effect studies typically includes a crossover design in which participants receive multiple doses of a novel drug and a drug with abuse liability that was previously established with time intervals between test conditions (usually at least one day). The comparison drug is typically a positive control from the same pharmacological class and a placebo condition is also usually included. Researchers normally recruit between 10 to 14 participants who have a history of polydrug use. In order to investigate each drug's abuse liability, outcome measures are used to assess various aspects of the drug's effect at several points throughout each drug administration (e.g., onset, peak, and offset). Outcome measures are chosen that will help clarify the abuse liability of the drug, including subjective effects (e.g., "liking", "good" effect, mood changes, side effects) and behavioral measures (drug vs. money choice). Data collected from the outcome measures are compared between doses and drugs in order to find each drug's abuse liability. This dose-effect methodology has been used to study the abuse liability of many drugs, including several anxiolytics (Roache & Griffiths, 1987; Troisi, Critchfield, & Griffiths, 1993), sedatives (Rush, Frey, & Griffiths, 1999), antihistamines (Preston, Wolf, Guarino, & Griffiths, 1992), opioids (Duke, Correia, Walsh, Bigelow, & Strain, 2010), amphetamines (Tancer & Johanson, 2003), and stimulants (Jasinski & Krishnan, 2009).

One specific example of the dose-effect methodology being utilized in an abuse liability study of intramuscular and sublingual buprenorphine and buprenorphine/naloxone is demonstrated in a study conducted by Duke and colleagues (2010). Participants were administered 15 drug conditions (4, 8, and 16 mg buprenorphine and 4/1, 8/2, 16/4 mg buprenorphine/naloxone were administered sublingually and intramuscularly; 2 and 4 mg hydromorphone administered intramuscularly; and a placebo) in a residential drug treatment facility. Participants and observers completed several outcome measures, including six visual analog scales to assess drug effect, liking, high, good effects, bad effects, and sickness via self-report, as well as a 37-item measure of adjectives associated with morphine-like effects and opioid withdrawal-like effects. These measures were each completed at baseline and then 12 more times every 15 minutes following each drug administration. This study was a part of a series of studies on the abuse liability of buprenorphine and buprenorphine/naloxone via both sublingual and intramuscular routes, and the results informed the clinical use of suboxone and other medications used to treat opiate addiction.

To aid in further understanding the abuse liability of novel drugs, authors have argued for the inclusion of behavioral economics measures in abuse liability research (Bickel, Snider, Quisenberry, & Stein, 2017; Griffiths et al., 2003). One measure that has been used as a complementary assessment of abuse liability in several dose-effect studies (e.g., Vansickel, Weaver, & Eissenberg, 2012; Zacny & Gutierrez, 2009) is the Multiple-Choice Procedure (MCP). The MCP is a behavioral economics measure of relative reinforcing value that was initially developed as a measure for efficiently investigating drug reinforcement by providing drug vs. money choices (Griffiths, Troisi, Silverman, & Mumford, 1993). The MCP provides choices between a drug reinforcer with a constant quantity and money that gradually increases from one choice to the next. The datum of interest from the MCP is the point at which participants switch from choosing the drug reinforcer to the monetary reinforcer, which is called the crossover point. This crossover point is conceptualized as the relative reinforcing value of the drug compared with a monetary reinforcer. Past research suggests that the initial laboratory version of the MCP is a reliable and valid measure for assessing the relative reinforcing value of several drugs (Benson, Little, Henslee, & Correia, 2008; Griffiths et al., 1993; Griffiths, Rush, & Puhala, 1996; Little & Correia, 2006; Rousseau, Irons, & Correia, 2011). In addition, a survey-based version of the MCP using hypothetical choices has also shown evidence of validity for gambling (Butler, Irons, Bassett, & Correia, 2018) and video game playing (Bassett, Irons, Schultz, & Correia, 2018). An example of the MCP being used in an abuse liability study of electronic cigarettes was conducted by Vansickel and colleagues (2012). Participants completed four sessions of electronic cigarette and cigarette puffing and were then asked to complete the MCP five times after each session, during which they chose between 10 minutes of smoking the electronic cigarette and money or cigarette and money. The crossover point for the electronic cigarettes was $1.06 and the crossover point for the cigarettes was $1.50, indicating that cigarettes were more reinforcing than electronic cigarettes. This successful use of the MCP in a dose-effect abuse liability study suggests it may also be useful for examining the abuse liability of other types of reinforcers.

Methodologies commonly used to assess the abuse liability of drugs have also been applied to behavioral addictions. A gambling study conducted by Dixon and colleagues (2014) investigated the abuse liability of “losses disguised as wins (LDW)” in a modern electronic gaming machine. Modern gaming machines celebrate the wins of gamblers by animating symbols and playing sounds. A LDW occurs when a gambler spins the slot machine and despite winning less than their original wager, the machine still celebrates the “win” with sights and sounds. Participants in this study played two slot games, one with a single line for wagering and another with multiple lines for wagering, making LDWs possible. For the single line, participants wagered one credit per spin, but in the multi-line game, players wagered one credit per line. Therefore, any credit gain less than 20 represented a loss. Investigators tracked post reinforcement pauses (PRPs) to assess whether LDWs and wins would be equally rewarding. Participants also completed questionnaires to assess their gaming experience after each game, in which they rated their excitement and arousal during each session. At the end of the experiment, players were asked to identify whether they preferred the multi-line or single-line game. To assess the abuse liability of the two game types, investigators compared the PRPs of single slot games with multi-line slot games that provide the ability to reinforce gamblers despite a net loss of credits. They also compared regular and high-risk/problem gamblers' arousal and excitement outcome measure data. Results indicated that regular gamblers preferred the multi-line game and appear more susceptible to the deceptive reinforcement provided by LDWs (i.e., the multi-line games had higher abuse liability). This study provides evidence that the concept of abuse liability is not solely a construct that applies to drugs within behavioral pharmacology literature, but can also be applied to gambling and may be useful for other behavioral addictions.

Similar to drugs and gambling games, it is likely that abuse liability varies between video games and video games genres. Indeed, previous research has identified particular structural characteristics more prevalent in some games than others that can influence video game playing behavior and the chance of developing IGD, including playing online (Thomas & Martin, 2010), positive reinforcement (e.g., rewarding efforts by obtaining rare in-game items; Chumbley & Griffiths, 2006; Kuss & Griffiths, 2012), as well as adult content and attachment to in-game avatars (Kuss & Griffiths, 2012). Though each of these structural characteristics can be found in a wide range of games, they are extremely common in Massive Multiplayer Online Role-Playing

Games (MMORPGs). MMORPGs are one of the most popular video game genres played worldwide (Billieux, Deleuze, Griffiths, & Kuss, 2015). Individuals who play MMORPGS are more likely than other game players to experience negative consequences associated with video game playing (Kuss, Louws, & Wiers, 2012) and are also more likely to meet criteria for IGD (Müller et al., 2015; Stetina, Kothgassner, Lehenbauer, & Kryspin-Exner, 2011). Collectively these studies suggest that specific structural characteristics that are more common in some games than others, may increase the abuse liability of those games.

In addition to abuse liability of drugs, researchers have examined individual differences in addiction liability, or vulnerability to develop substance use disorders. Researchers have argued that the concept of abuse liability attributes too much influence to the drug itself rather than characteristics of the individual taking the drug or the environment (Anthony & Trinkoff, 1989). Beyond class- and drug-specific mechanisms, individual differences of genetic, neurochemical, physiological, behavioral, and environmental origin can contribute to the development of substance use disorders (Vanyukov et al., 2003). Specific traits more common in some individuals than others that can also contribute to the development of addiction, include impulsivity (Moreno et al., 2012), novelty-seeking (Cloninger, 1986), and sensation-seeking (Zuckerman & Kuhlman, 2000). Researchers have also identified sex differences in the diagnosis of substance use disorders; men are almost twice as likely to meet criteria as women (Merikangas & McClair, 2012). In the context of video games, it is also important to consider the effect of individual differences. Several survey-based studies have been conducted to investigate risk factors associated with the development of IGD. Several personality traits were identified to be associated with IGD, including impulsivity, introversion, neuroticism, or individuals who have low agreeableness or conscientiousness (Kuss & Griffiths, 2012; Müller, Beutel, Egloff, &

Wölfling, 2014; Rehbein et al., 2010). Initial surveys of IGD prevalence rates also indicates higher prevalence rates of IGD for males, during adolescence, and in Asian countries (Festl et al., 2013; Ko, Yen, Yen, & Yang, 2007; Peng & Li, 2009; Rehbein et al., 2010; 2015; Van Rooij, Schoenmakers, Vermulst, Eijnden, & Mheen, 2011; Wang et al., 2014). Abuse liability studies of video game playing may aid in understanding what individual characteristics make people more likely to develop IGD beyond what survey-based studies have provided.

To the author's knowledge, no previous studies investigating the abuse liability of video games have been conducted. Thus, the current study aimed to build upon current video game literature by testing for abuse liability differences in video games. Applying methodology commonly applied in behavioral pharmacology research to investigate drugs may elucidate whether different structural characteristics of video games impact abuse liability. Specifically, the current study utilized dose-effect methodology to investigate differences in abuse liability between video games. To do so, game quality was conceptualized as the "dose" of a video game and three different quality games were compared, including a newer and high-quality game (Forza Motorsport 7), a much older version of the same game which is characterized as lower quality (Forza Motorsport 1), and a game with very low quality conceptualized as the placebo (OutDrive). The current study assessed the abuse liability of the games by using measures commonly used in the behavioral pharmacology literature. We hypothesized that there would be abuse liability differences between the three game quality conditions, such that subjective ratings and relative reinforcing value would increase as a function of game quality. The abuse liability measures used within the dose-effect methodology have not been tested with video games, thus we were interested in exploring the relationships between several video game variables with abuse liability. We hypothesized that measures of abuse liability would correlate with participants' self-reported frequency of playing video games and with IGD scores. Finally, we hypothesized that IGD scores and self-reported frequency of playing video games will contribute to the prediction of abuse liability scores.

Method

Participants

Six hundred and twenty-two undergraduate students enrolled in psychology and statistics courses at a large, southern university, who were age 18 or older, completed the online survey in exchange for extra credit in their courses. Of those 622 participants, 165 participants who met inclusion criteria were invited to participate in the laboratory session. In total, 82 participants then completed the laboratory session. However, some participant data were excluded from analyses. One participant's data were excluded from all analyses due to the English language proving to be a barrier to understanding any of the laboratory measures. Additionally, two participants did not follow directions while completing one measure each, leaving their data for that measure uninterpretable. Therefore, each analysis conducted included a total of 80 to 81 participants. Finally, one participant endorsed playing video games at an average amount each week that was identified as an extreme outlier. This was addressed according to the Tabachnik and Fidell (2013, p. 77) strategy for handling outliers, such that the outlying case was assigned a raw score of one unit larger than the next most extreme score. Specifically, this participant's total minutes of play time was changed from 2,461 minutes of average weekly game play to 1,891 minutes.

The 81 participants included in analyses were 53.1% female with an average age of 19.15. Participants identified their racial and ethnic background by selecting one or more racial categories. The sample was 82.7% White, 11.1% Black or African American, 3.7% White/Black or African American, and 2.5% Asian. Participants additionally reported whether they were of Hispanic or Latino descent; 8.6% of the sample identified as Hispanic or Latino. Approximately 34.6% of participants reported being a member of a fraternity or sorority. Participants were mostly split between living in an off-campus house or apartment (46.9%) or in a campus dormitory (45.7%).

Measures

Participants first completed a brief demographics questionnaire that included sex, age, ethnicity, year in school, current residence, and Greek affiliation.

Daily Gaming Questionnaire (*DGQ*; Appendix A). The DGQ is adapted from the Daily Drinking Questionnaire (DDQ; Collins, Parks, & Marlatt, 1985), a commonly used measure for assessing drinking behaviors over the past month. The DGQ assesses the amount of time participants typically play video games each day of the week for the past month. Video games are defined as any game that is played on a computer, a console (e.g. PlayStation, Xbox), a tablet, a phone, or any other mobile device. Examples of videos games would include World of Warcraft, Player Unknown's Battlegrounds, League of Legends, sports-based games, and games that are primarily played on mobile devices, such as Clash of Clans, Words with Friends, and Candy Crush. In addition, participants were asked to report how many days they played any video games, how many days they played games on specific gaming machines (i.e., PC, console, mobile device), what video game they played the most, what genre of video game they played the most, and how many days they played longer than two hours during the past 28 days. Participants were also asked to identify their favorite video game and if they identify as a "hardcore gamer."

Video Game Dependency Scale (*VGDS*; adapted from Computerspielabhängigkeitsskala; Rehbein et al., 2015; Appendix B). The VGDS was initially adapted from the Internet Addiction Scale by Rehbein and colleagues (2010), and updated to assess each of the nine IGD *DSM-5* criteria. Each criterion is assessed by two items, resulting in an 18-item, 4-point Likert-type scale (1 'strongly disagree', 2 'somewhat disagree', 3 'somewhat agree', 4 'strongly agree'). The VGDS has exhibited evidence of validity and reliability (King et al, 2013). In the current study the VDGS demonstrated adequate internal consistency (α = .917).

Multiple Choice Procedure (MCP; Griffiths, Troisi, Silverman, & Mumford, 1993; Appendix C). The MCP is a behavioral economics measure of relative reinforcing value that was initially developed as a measure for efficiently investigating drug reinforcement. Participants were asked to make choices between 10 minutes to play each of the three video games and ascending amounts of money ranging from $0.00 to $15.00. Dollar values started at $0 and increased by $0.25 up to $2.00. After $2.00, the dollar values increased by $0.50 up to $10.00, and then increased by $1.00 up to $15.00 for a total of 30 choices. Participants were instructed that once they selected money to continue to do so for the remainder of that MCP administration. Each version of the MCP yielded a single crossover point, which was conceptualized as the relative reinforcing value of playing video games compared to a monetary reinforcer.

Visual Analog Scales (VASs). VASs are measures designed to assess for subjective ratings and have been utilized extensively in abuse liability studies (e.g., Duke et al., 2010; Jasinski & Krishnan, 2009). There were a total of three VASs to assess participants' ratings of liking, fun, and novelty of the three video games. Each item resembled a continuous line with two end points, which were anchored at the beginning and the end by descriptors (e.g., not at all fun, and very fun). Additionally, the line was with equidistant numbers ranging from '0' at the far left of the line to '10' at the far right. Participants were instructed to circle a number to indicate their level of agreement with the question and anchored statements.

Procedure

All study procedures were approved by the university's Institutional Review Board. Participants first logged in to Sona Systems to complete a screening process, which included informed consent as well as several measures (i.e., the demographics questionnaire, the DGQ, and the VGDS). Participants who had played a video game in the past 28 days, who had played a vehicle racing game at least once, and who expressed interest were invited to participate in the laboratory portion of the study. After presenting to the laboratory, participants read and signed an informed consent form. They were then read a brief statement describing the activities they would be completing in the laboratory and were familiarized with the VASs and the MCP. They then completed each of the three video game playing conditions (Forza Motorsport 7, Forza Motorsport 1, and OutDrive) in counter-balanced order. The six condition orders were completed between thirteen and fifteen times each. For each condition, participants played the video game for 10 minutes. Participants were instructed to pause the game and complete the three VAS questions after playing for one minute, five minutes, and 10 minutes. After playing for the full 10 minutes, participants then completed an MCP for that game. Each of the choices on the MCP forms were labeled 1-90. After each of the three gaming conditions were completed, a random drawing took place in order to consequent participants' choices (i.e., 10 minutes to play video games or money) from each of the three MCP forms. Participants pulled a random number (i.e., 1-90) from a cup and that number was then matched to the corresponding choice on the MCP form. If participants selected money for that specific choice, they were instructed to sit quietly in a chair without access to their phone or any other entertainment for 10 minutes and then given the money. If the number corresponded to a choice on the MCP where participants chose 10 more minutes to play the game, then they were allowed to play the video game for an additional 10 minutes uninterrupted and with no restrictions. In total, participants completed the VASs nine times (i.e., three times for each video game condition) and they completed the MCP three times (i.e., once for each video game condition). The laboratory where participants played games was a plain, well-lit room with chairs and a desk against a wall. Participants played OutDrive on the PC on this desk. On the adjacent wall, a 42-inch television was on a table with an Xbox One X attached to play Forza Motorsport 7 and an original Xbox attached to play Forza Motorsport 1.

Results

Each of the 81 included participants answered several frequency-related questions regarding their video game playing behavior via the DGQ. Participants reported the number of minutes they typically played video games each week (*M* = 486.33, *SD* = 505.98, *Mdn* = 390). Participants also reported the number of days they played a video game on several gaming devices in the past 28 days; 38.27% of participants played video games at least one day on a personal computer (*M* = 3.42, *SD* = 6.97), 62.96% of participants played video games at least one day on a video game console (e.g., PlayStation, Xbox; *M* = 7.12, *SD* = 8.53), 76.54% of participants played video games at least one day on mobile devices (*M* = 7.90, *SD* = 9.19). Participants also reported the number of days that they played video games for longer than two hours (*M* = 4.67, *SD* = 6.26).

In order to test for abuse liability differences, multiple two-way 3x3 repeated measures ANOVAs were conducted utilizing video game condition (i.e., Forza Motorsport 1, Forza Motorsport 7, and OutDrive) as one independent variable and time of VAS administration (i.e., 1 minute, 5 minutes, and 10 minutes after starting the game) as the second independent variable.

The three VAS questions (liking, fun, and novelty) were used as the dependent variables for a total of three two-way repeated measures ANOVAs. To further test for abuse liability differences, a one-way repeated measures ANOVA utilizing video game condition as the independent variable and MCP crossover point as the dependent variable was conducted. Mean VAS ratings and MCP crossover points are presented in Table 1, Figure 1, Figure 2, Figure 3, and Figure 4.

VAS-Liking ANOVA

For the dependent variable of liking, Mauchly's test of sphericity indicated that the assumption of sphericity had been violated for both main effects of video game condition, $\chi^2(2)$ = 11.68, p = .003, and time of VAS administration, $\chi^2(2)$ = 56.13, p < .001, as well as the interaction effect, $\chi^2(9)$ = 58.51, p < .001. Therefore, degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity (ε = .88 for the main effect of game condition, ε = .66 for the main effect of time of VAS administration, and ε = .69 for the interaction effect).

There was a statistically significant main effect of video game condition, F(1.76, 138.72) = 42.97, p < .001, η_p^2 = .352. In order to clarify the differences in liking between game conditions, contrast analyses were conducted comparing each of the game conditions. Contrasts revealed participants liked Forza Motorsport 7 (M = 6.65) significantly more than both Forza Motorsport 1 (M = 4.94), F(1, 79) = 95.58, p < .001 and OutDrive (M = 4.83), F(1, 79) = 55.31, p < .001. There was no significant difference in liking between Forza Motorsport 1 and OutDrive. The repeated measures ANOVA also tested for the main effect of time of VAS administration, but this effect was not statistically significant.

There was a statistically significant interaction effect between video game condition and time of VAS administration, F(2.78, 219.29) = 8.19, p < .001, η_p^2 = .094, indicating that time of

VAS administration had different effects on video game liking depending on the game being played. In order to further investigate this interaction and ensure that the main effect of video game condition was interpretable, simple effects analyses were conducted at each time point. At the first minute time point, there were statistically significant differences between the liking of Forza Motorsport 7 (M = 6.25) and Forza Motorsport 1 (M = 5.11), $F(1, 79) = 37.60$, $p < .001$, as well as Forza Motorsport 7 and OutDrive (M = 4.80), $F(1, 79) = 36.53$, $p < .001$. There was no significant difference between the liking of OutDrive and Forza Motorsport 1 at the first minute. Similar results were identified at the second and third time points of VAS administration (i.e. 5 and 10 minutes). At the fifth minute, there were statistically significant differences between the liking of Forza Motorsport 7 (M = 6.78) and Forza Motorsport 1 (M = 5.01), $F(1, 79) = 71.52$, $p < .001$, as well as Forza Motorsport 7 and OutDrive (M = 4.91), $F(1, 79) = 47.10$, $p < .001$. At the tenth minute, there were statistically significant differences between the liking of Forza Motorsport 7 (M = 6.91) and Forza Motorsport 1 (M = 4.69), $F(1, 79) = 101.60$, $p < .001$, as well as Forza Motorsport 7 and OutDrive (M = 4.78), $F(1, 79) = 60.99$, $p < .001$. There was no significant difference between the liking of OutDrive and Forza Motorsport 1 at the fifth or tenth minute. These simple effect analyses indicate that the main effect of video game condition is interpretable; participants liked Forza Motorsport 7 significantly more than both Forza Motorsport 1 and OutDrive. Simple effects analyses were also conducted to compare liking scores from each game across VAS administration time points to further explain the interaction effect. Participant liking for Forza Motorsport 1 significantly decreased over time. Specifically, contrasts revealed significant differences between the first VAS administration (M = 5.11) and third VAS administration (M = 4.69), $F(1, 79) = 5.25$, $p = .025$, as well as the second VAS administration (M = 5.01) and third administration, $F(1, 79) = 6.71$, $p = .011$. There was no significant difference between the first and second VAS administration for participant liking of Forza Motorsport 1. In contrast, participant liking for Forza Motorsport 7 significantly increased over time. Contrasts revealed significant differences between the first VAS administration (*M* = 6.25) and second VAS administration (*M* = 6.78), $F(1, 79) = 17.09$, $p < .001$, as well as the first and third VAS administrations (*M* = 6.91), $F(1, 79) = 16.72$, $p < .001$. There was no significant difference between the second and third VAS administration time points for participant liking of Forza Motorsport 7. Participant liking of OutDrive remained very similar over VAS administrations (i.e., 1 minute (*M* = 4.80); 5 minutes (*M* = 4.91); 10 minutes (*M* = 4.78)) and did not significantly differ from each other. The significant interaction and contrasts suggest that participant liking over time depends upon the video game they are playing.

VAS-Fun ANOVA

For the dependent variable of fun, Mauchly's test of sphericity indicated that the assumption of sphericity had been violated for both main effects of video game condition, $\chi^2(2) = 12.89$, $p = .002$ and time of VAS administration, $\chi^2(2) = 60.38$, $p < .001$, as well as the interaction effect, $\chi^2(9) = 52.69$, $p < .001$. Therefore, degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon = .87$ for the main effect of game condition, $\varepsilon = .65$ for the main effect of time of VAS administration, and $\varepsilon = .78$ for the interaction effect).

There was a statistically significant main effect of video game condition, $F(1.74, 137.11) = 35.89$, $p < .001$, $\eta_p^2 = .312$. In order to clarify the differences in fun between game conditions, contrast analyses were conducted comparing each of the game conditions. Contrasts revealed participants rated Forza Motorsport 7 (*M* = 6.58) as significantly more fun than both Forza Motorsport 1 (*M* = 5.26), $F(1, 79) = 57.26$, $p < .001$ and OutDrive (*M* = 4.76), $F(1, 79) = 55.31$, $p < .001$. Additionally, participants rated Forza Motorsport 1 significantly more fun than

OutDrive, $F(1, 79) = 4.50$, $p = .037$. The repeated measures ANOVA also tested for the main effect of time of VAS administration, but this effect was not statistically significant.

There was a statistically significant interaction effect between video game condition and time of VAS administration, $F(3.13, 247.36) = 10.18$, $p < .001$, $\eta_p^2 = .114$, indicating that time of VAS administration had different effects on participant ratings of video game fun depending on the game being played. In order to further investigate this interaction and ensure that the main effect of video game condition was interpretable, simple effects analyses were conducted at each time point. At the first minute time point, participant ratings of fun were significantly different between Forza Motorsport 7 ($M = 6.29$) and Forza Motorsport 1 ($M = 5.51$), $F(1, 79) = 13.66$, $p < .001$, as well as Forza Motorsport 7 and OutDrive ($M = 4.79$), $F(1, 79) = 31.05$, $p < .001$. There was also a significant difference between OutDrive and Forza Motorsport 1, $F(1, 79) = 9.33$, $p = .003$. Similar results were identified at the second time point of VAS administration (i.e. 5 minutes). At the fifth minute, there were statistically significant differences in reported fun between Forza Motorsport 7 ($M = 6.66$) and Forza Motorsport 1 ($M = 4.85$), $F(1, 79) = 38.92$, $p < .001$, as well as Forza Motorsport 7 and OutDrive ($M = 4.85$), $F(1, 79) = 48.49$, $p < .001$. Participant ratings of fun also significantly differed between OutDrive and Forza Motorsport 1 at the fifth minute, $F(1, 79) = 5.31$, $p = .024$. In slight contrast to the previous VAS administration time points, at the tenth minute, there were statistically significant differences in reported fun between Forza Motorsport 7 ($M = 6.79$) and Forza Motorsport 1 ($M = 4.88$), $F(1, 79) = 89.46$, $p < .001$, as well as Forza Motorsport 7 and OutDrive ($M = 4.65$), $F(1, 79) = 62.57$, $p < .001$, but there was not a significant difference between OutDrive and Forza Motorsport 1. These simple effect analyses indicate that the main effect of video game condition is interpretable, such that participants rated Forza Motorsport 7 as significantly more fun than both Forza Motorsport 1 and

OutDrive. However, there was no significant difference between Forza Motorsport 1 and OutDrive at the third VAS administration time point, indicating that the interaction effect is more meaningful when considering the relation between these two variables.

Simple effects analyses were also conducted to compare fun ratings from each game across VAS administration time points to further explain the interaction effect. Participant fun ratings for Forza Motorsport 1 significantly decreased over time. Specifically, contrasts revealed significant differences between fun ratings at the first VAS administration ($M = 5.51$) and third VAS administration ($M = 4.88$), $F(1, 79) = 11.14$, $p = .001$, as well as the second VAS administration ($M = 5.39$) and third administration, $F(1, 79) = 16.28$, $p < .001$. There was no significant difference between the first and second VAS administration for participant fun rating of Forza Motorsport 1. In contrast, participant ratings of fun for Forza Motorsport 7 significantly increased over time. Contrasts revealed significant differences in fun ratings between the first VAS administration ($M = 6.29$) and second VAS administration ($M = 6.66$), $F(1, 79) = 4.52$, $p = .035$, as well as the first and third VAS administrations ($M = 6.79$), $F(1, 79) = 7.75$, $p = .007$. There was no significant difference between the second and third VAS administration time points for participant ratings of fun for Forza Motorsport 7. Fun ratings for OutDrive also depended upon the time of VAS administration. Specifically, there was a significant decline of fun ratings between the second VAS administration ($M = 4.85$) and third VAS administration ($M = 4.65$), $F(1, 79) = 5.64$, p = .02. There was not a significant difference between VAS administrations one and three, or one and two. The significant interaction and contrasts suggest that participant ratings of fun over time also depends upon the video game they are playing.

VAS-Novelty ANOVA

For the dependent variable of novelty, Mauchly's test of sphericity indicated that the assumption of sphericity had been violated for the main effect of time of VAS administration, $\chi^2(2) = 13.60$, $p = .001$, as well as the interaction effect, $\chi^2(9) = 39.10$, $p < .001$. Therefore, degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon = .86$ for the main effect of time of VAS administration and $\varepsilon = .85$ for the interaction effect).

There was a statistically significant main effect of video game condition, $F(2, 158) = 7.13$, $p = .001$, $\eta_p^2 = .083$. In order to clarify the differences in participant ratings of novelty between game conditions, contrast analyses were conducted. Contrasts revealed participants rated Forza Motorsport 7 ($M = 4.31$), $F(1, 79) = 10.31$, $p = .002$, and Forza Motorsport 1 ($M = 4.15$), $F(1, 79) = 9.51$, $p = .003$, as significantly more novel then OutDrive ($M = 3.43$). There was no significant difference in novelty ratings between Forza Motorsport 1 and Forza Motorsport 7. The repeated measures ANOVA revealed no significant difference between VAS time administrations and no significant interaction effect.

MCP ANOVA

In order to further test for abuse liability differences, a one-way repeated measures ANOVA using MCP crossover points as the dependent variable was conducted to identify any differences in relative reinforcing value between video game conditions. Mauchly's test of sphericity indicated that the assumption of sphericity was violated, $\chi^2(2) = 19.37$, $p < .001$. Therefore, degrees of freedom were corrected utilizing Greenhouse-Geisser estimates of sphericity ($\varepsilon = .82$). The ANOVA revealed a significant difference in MCP crossover points between video game conditions, $F(1.64, 129.52) = 15.82$, $p < .001$, $\eta_p^2 = .167$. Contrast analyses were utilized to clarify this significant difference and revealed significant differences between

Forza Motorsport 7 (*M* = 4.97) and Forza Motorsport 1 (*M* = 3.58), $F(1, 79) = 41.74$, $p < .001$, as well as a significant difference between Forza Motorsport 7 and OutDrive (*M* = 3.68), $F(1, 79) = 15.31$, $p < .001$. There was no significant difference in MCP crossover points between Forza Motorsport 1 and OutDrive. The contrast analyses suggest that participants' relative reinforcing values for Forza Motorsport 7 were significantly higher than for either Forza Motorsport 1 or OutDrive and that they made no significant distinction between Forza Motorsport 1 and OutDrive.

Correlation Analyses

In order to test the hypothesis that abuse liability scores would correlate with each other, with participant's frequency of playing video games, and with VGDS total scores, multiple bivariate correlation tests were conducted utilizing liking, fun, and novelty ratings for each game averaged across time of VAS administrations, MCP crossover points for each game, average weekly participant video game play time (in minutes), and total VGDS scores. See Table 1 for all Pearson correlation coefficient and *p* values. Significant variable relations varied from weak to strong. All Forza Motorsport 1 VAS variables and MCP crossover point were significantly positively correlated with each other (*ps* < .05). Similarly, all Forza Motorsport 7 VAS variables were significantly positively correlated (*ps* < .05) and the MCP crossover point was significantly positively correlated with participant ratings of liking ($p < .05$). For OutDrive, all three VAS variables were significantly positively correlated (*ps* < .001) and the MCP crossover point was significantly positively correlated with participant ratings of liking and fun (*ps* < .001). Additionally, all MCP crossover points were significantly positively correlated with each other, (*ps* < .001). Average participant weekly play time was significantly positively correlated with all three Forza Motorsport 1 VAS variables (*ps* < .05), with participant ratings of liking for Forza

Motorsport 7 ($p < .05$), with MCP crossover points for Forza Motorsport 1 ($p = .001$) and Forza Motorsport 7 ($p < .001$), and with total scores on the VGDS ($p < .001$). Total VGDS scores were additionally significantly positively correlated with participant ratings of Forza Motorsport 1 novelty ($p < .05$) and MCP crossover points for Forza Motorsport 7 ($p < .001$).

Regression Analyses

Finally, in order to test the hypothesis that IGD symptoms (i.e., VGDS total score) and weekly video game play time will contribute to the prediction of abuse liability (i.e., VAS ratings and MCP crossover points), several hierarchical multiple regression analyses were conducted by entering gender, followed by average weekly participant video game play time, followed by VGDS total scores as the predictor variables. Average liking, fun, and novelty VAS ratings as well as MCP crossover points from each of the three games were used as the dependent variables (i.e., 12 total analyses with four analyses for each video game; see Tables 2, 3 and 4). The hierarchical multiple regression analyses of the Forza Motorsport 1 abuse liability variables revealed significant Model R^2 utilizing all three independent variables for liking $R^2 = .118$, $p < .05$, novelty $R^2 = .167$, $p < .001$, and MCP crossover points, $R^2 = .129$, $p < .05$. However, VGDS did not produce a significant change in R^2 above what gender and weekly participant play time predicted in any of the analyses, though weekly play time was a significant predictor of the three dependent variables. Similar results were found with the Forza Motorsport 7 analyses. There were significant Model R^2 utilizing all three independent variables for liking, $R^2 = .135$, $p <.05$ and MCP crossover points, $R^2 = .184$, $p <.001$. However, VGDS did not produce a significant change in R^2 above what gender and weekly participant play time predicted in any of the analyses, though weekly play time was a significant predictor of MCP crossover points. There were no regression models that significantly predicted abuse liability in any of the OutDrive analyses except for participant sex significantly predicting participant ratings of fun, $R^2 = .051$, $p < .05$.

Discussion

The current study represents the first attempt to establish differences in abuse liability between video games. Though the methodology utilized in the current study is novel within the video game literature, researchers have been using dose-effect methodology to investigate abuse liability differences between drugs and drug doses for several decades (e.g., Roache & Griffiths, 1985; Schoedel, Stockis, & Sellers, 2018). The methodology is well-established and recognized as a very effective approach for identifying abuse liability differences between drugs and drug doses (Griffiths et al., 2003). In order to test for abuse liability differences in video games, subjective ratings of liking, fun, and novelty, as well as relative reinforcing value of each video game were assessed. Relations between abuse liability, average video game play time, and video game dependency were also assessed. Finally, the utility of average video game play time and IGD scores for predicting abuse liability were examined.

As hypothesized, abuse liability differed between the three video game conditions. Specifically, Forza Motorsport 7 was rated as significantly more fun and likeable than both Forza Motorsport 1 and OutDrive, but Forza Motorsport 1 and OutDrive ratings were not significantly different on those two VAS items. Further, Forza Motorsport 7 and Forza Motorsport 1 were both rated significantly more novel than OutDrive, but were not significantly different from one another. Additionally, Forza Motorsport 7 had significantly higher crossover points on the MCP from both Forza Motorsport 1 and OutDrive, but Forza Motorsport 1 and OutDrive MCP crossover points were not significantly different from each other. These findings suggest that, in general terms, as the quality (“dose”) of the game increased, ratings and MCP scores also tended to increase. Though some drug administration studies show dose-dependent differences between all doses and across all measures (Foltin & Fischman, 1991), it is much more typical for results to match those obtained in the current study. For example, in a study conducted by Mumford, Rush, & Griffiths (1995) to evaluate the abuse liability of two sedative drugs (abecarnil and alprazolam), there were clear dose-related differences on most, but not all measures. In addition, while the highest doses of the drugs were significantly different than placebo doses, subjective ratings and choice behavior did not always differ across the placebos and three active doses. Similar results were also demonstrated in a study of triazolam and pentobarbital (both sedatives), where a significant main effect of drug dose was found for participant liking, but graphical inspection revealed that ratings of participant liking of drug doses did not significantly differ from each other at many of the measured time points (Roache & Griffiths, 1985). Thus, for both previously conducted drug administration studies and the current study on video games, abuse liability studies often show a pattern of dose-dependent results but fail to demonstrate differences across all doses. For the current study the results strongly suggested that measures of abuse liability vary as a function of the dose or quality of the video game being assessed.

The hypothesis that measures of abuse liability would correlate with each other, with participants' video game play time, and with IGD scores was partially supported. Within each of the three games, the three VAS scales were significantly positively correlated with each other. Ratings of liking and fun were strongly correlated, whereas ratings of novelty were only weakly to moderately correlated with liking and fun. Additionally, each of the three MCP crossover points exhibited weak positive correlations with participant ratings of liking for each game respectively. Beyond ratings of liking, however, there were inconsistent relations between VAS variables and MCP crossover points. Specifically, all Forza Motorsport 1 VAS variables were weakly positively correlated with MCP crossover point, OutDrive ratings of fun were also weakly positively correlated with MCP crossover point, and no additional Forza Motorsport 7 VAS variables were significantly correlated with the MCP crossover point. VGDS scores were only significantly positively correlated with two of the twelve abuse liability variables (Forza Motorsport 1 novelty and Forza Motorsport 7 MCP crossover points) and participant play time was only correlated with six of the twelve variables (Forza Motorsport 1 MCP crossover point, liking, fun, and novelty as well as Forza Motorsport 7 MCP crossover point and liking ratings). Additionally, VGDS scores were moderately positively correlated with average participant weekly play time. In general, it appears that abuse liability variables measured in the lab are robustly related with each other and that measures of external behaviors (i.e., participant play time and IGD scores) are similarly related. However, external behaviors did not show clear relations with abuse liability measures.

Similarly, the results partially supported the hypothesis that VGDS scores and participant play time would contribute to the prediction of abuse liability. No regression analyses utilizing either variable predicted abuse liability scores of OutDrive. Several regression analyses did reveal both VGDS scores and participant play time to be significant predictors of abuse liability scores for Forza Motorsport 1 and Forza Motorsport 7. However, VGDS scores did not contribute to the variance accounted for in abuse liability scores beyond what gender and participant play time already explained in any of the twelve regression analyses, despite it being a significant predictor in several models. This finding mimics the correlation analyses, which revealed VGDS scores to only be significantly related to two measures of abuse liability. This may partially be explained by the environment where participants played the games and completed measures, in that it was not similar to the environment they typically play in. In the laboratory, participants did not have their typical setup (e.g., chair, controller, ruleset) and they were out of their usual routine, which may have affected how they responded to in-laboratory abuse liability measures. More specifically, the different playing environments may have limited the likelihood that video game playing in the natural environment would correlate with or predict behavior in the laboratory. Additionally, the sample was restricted, such that the majority of participants endorsed very few symptoms of IGD, thus further limiting the predictive power of VGDS scores. Additional research will be needed to determine the conditions (e.g., laboratory procedures, measure of natural and laboratory behavior, sample) that would allow for measures of abuse liability to relate to important behaviors that occur outside of the laboratory environment.

This study represents another example of successfully utilizing methodology and measures commonly used within drug administration research with behavioral addictions. Two recent studies investigating relative reinforcing value differences between video games (Bassett et al., 2018) and money to gamble (Butler et al., 2018) also utilized the MCP to account for the relative reinforcing value of behavioral addictions. As with the current study, those results demonstrate that the MCP can be used to effectively measure relative reinforcing value differences between reinforcers relevant to behavioral addictions. Additionally, the differences between MCP crossover points identified in these studies supports calls from prominent substance abuse researchers (i.e., Bickel, Snider, Quisenberry, & Stein, 2017; Griffiths et al., 2003) to utilize behavioral economics measures in abuse liability research. For the current study, MCP crossover points contributed to explaining the pattern of abuse liability differences between video games, such that for three of the four abuse liability dependent variables, Forza Motorsport 7 was significantly higher rated than both Forza Motorsport 1 and OutDrive.

In the current study, the video game conditions differed in graphics quality, difficulty, reinforcement schedule, gameplay, controls, soundtrack, and in several other ways. Each of these structural characteristics may have impacted abuse liability. Indeed, previous research indicates that video games likely differ in their addiction potential due to specific structural characteristics common in some games (Chumbley & Griffiths, 2006; Kuss & Griffiths, 2012; Thomas & Martin, 2010). One of the identified structural characteristics, attachment to in-game avatars, may have been relevant for the three video game conditions in the current study. In Forza Motorsport 7, players are shown their driver as race tracks are loading and after finishing races. The other two video games did not show an in-game avatar. Though attachment to these avatars is unlikely very high in the 10 minutes they played the game, it’s possible that this could have contributed to the higher abuse liability scores identified for Forza Motorsport 7.

The finding that there were abuse liability differences between racing video games also supports the notion that there may be abuse liability differences between video game genres. That is, if video games that are relatively similar differ in their abuse liability, it is also possible that video games from completely different genres also differ in abuse liability. Past research has indicated that video gamers who play MMORPGs have a greater change of experiencing negative consequences and meeting IGD criteria (Kuss et al., 2012; Müller et al., 2015; Stetina, Kothgassner, Lehenbauer, & Kryspin-Exner, 2011). It is possible that games in the MMORPG genre have higher abuse liabilities, which would help to explain these previous findings.

Though this is the first exploratory study of video game abuse liability, if the differences hold true for other video games and genres, there are several implications for clinicians, regulatory boards, and parents. First, if a client endorses playing video games, particularly in a disordered manner, these results would indicate that it would be important for the clinician to know which video game and genre the client is playing. If the client is playing games with high abuse liability, it would be very important for formulating treatment plans and for prognostic indicators. To the author's knowledge, no current measures of IGD assess for the specific video game or genre of video game being played. Results from the current study suggest that knowing the specific game being played may yield useful clinical information due to differences in abuse liability between games. Second, the regulatory board for video games (i.e., Entertainment Software Rating Board; ESRB) may need to incorporate abuse liability into video game ratings. The ESRB currently rates games in five different categories, which consider age appropriateness and also provide content descriptors (ESRB, 2018). If games differ in their abuse liability, researchers, game developers, and policy makers could work together to provide consumers the information via more detailed ratings. Third, research on abuse liability could help parents make decisions about which games they allow their children to be exposed to. With information about not just the content of game, but also the abuse liability, parents could decide to avoid games with higher abuse liabilities.

Future research should build upon the current study in order to continue refining the methodology for testing video games. For example, the current study assessed for participant ratings of video game liking, fun, and novelty, as well as relative reinforcing value. Dose-effect studies also frequently assess for physiological effects (e.g., heart-rate, blood pressure, skin temperature), mood changes, and utilize observer-rated measures (Griffiths et al., 2003). Researchers could also consider additional VAS questions, such as assessing for participant ratings of video game challenge and avatar attachment. Researchers should also consider adding VAS questions related to social aspects of video games. Several studies have revealed evidence suggesting socialization as an important motivator for individuals who engage in IGD behaviors

(Kuss & Griffiths, 2012). Relatedly, researchers could also investigate how social interaction (e.g., with confederates, with online players, with other participants in the laboratory) affects abuse liability scores.

Data from the current study suggest that dose-effect methodology can be used effectively to measure abuse liability differences between video games, however, limitations of the design must also be considered when interpreting the results. First, the current study's methodology focused on maximizing internal validity at the expense of external validity. This likely contributed to the study being less successful at predicting how external behaviors affected in-laboratory behaviors. Typical dose-effect studies do not attempt to utilize external behaviors for predictors or as dependent variables, as the focus of the study is internal validity for determining abuse liability differences (Griffiths et al., 2003; Fischman & Foltin, 1991). Therefore, the current study may not be utilizing the correct battery of measures or methodology to find external behaviors predictive of in-laboratory abuse liability scores. Second, the operationalization of video game "dosage" utilizing game quality is more subjective than in drug administration studies utilizing dose-effect methodology. Specifically, doses of drugs are easily operationalized with objective differences between conditions (e.g., 5 mg vs. 10 mg). However, game quality is a more subjective operationalization. Third, participants played each video game condition for only ten minutes. Ten minutes to play a video game may give players a general impression of the game, but it is not enough time to experience the game as a whole. Past studies have revealed that players of a casual game (Happy Farm) played games for approximately 10 minutes before stopping (Hou, 2011). However, individuals who play a more involved and complex video game (World of Warcraft) had average game-playing sessions of close to 3 hours (Tarng, Chen, & Huang, 2008). It is possible that with more time to play the games, participants' abuse liability scores may change. Drug-administration dose-effect studies typically hold sessions for one drug dose over an entire day, and then have multiple day breaks between sessions and drug doses (Griffiths, 2003). Future research should consider providing participants more time to play each video game over the course of multiple days as that methodology may give a more complete picture of the abuse liability of video games. Fourth, the sample was composed entirely of college students between the ages of 18 and 22, apart from one participant who was 27, and few participants met diagnostic criteria for IGD as assessed by the VGDS. Recruiting a more diverse sample, including individuals of all ages and with more severe video game playing behaviors would improve the generalizability of the results.

Many of the studies investigating the IGD construct and video games have focused on the individual playing video games. In contrast, the current study provides evidence of differences between video games themselves that contribute to addiction and represents the first attempt to utilize dose-effect methodology with video games to assess abuse liability. Results suggest that abuse liability differences exist between video games and future studies should continue investigating these differences. Refinements to the methodology should be investigated in order to improve the ability to show abuse liability differences between games, if they exist, and to show relations between external behaviors and in-laboratory abuse liability scores.

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Table 1

Correlations, Means, and Standard Deviations of the VAS, MCP Crossover Points, and Selected Independent Variables

Correlations, Means, and Standard Deviations of the VAS, MCP Crossover Points, and Selected Independent Variables

Variable	*M*	*SD*	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. F1Liking	4.94	1.71	---													
2. F1Fun	5.26	1.57	.91**	---												
3. F1Novelty	4.15	2.29	.38**	.45**	---											
4. F7Liking	6.65	1.68	.58**	.50**	.30*	---										
5. F7Fun	6.58	1.59	.58**	.51**	.27*	.93**	---									
6. F7Novelty	4.31	2.02	.25*	.26*	.53**	.34*	.34**	---								
7. OLiking	4.83	1.92	.34*	.31*	.15	.27*	.23*	.18	---							
8. OFun	4.76	2.00	.37**	.33*	.18	.27*	.24*	.17	.95**	---						
9. ONovelty	3.43	2.14	.23*	.19	.57**	.27*	.25*	.30*	.39**	.38**	---					
10. F1_MCP	3.58	2.73	.32*	.37**	.25*	.29*	.22	.24*	.03	.02	.15	---				
11. F7_MCP	4.97	3.12	.11	.21	.23*	.25*	.18	.06	-.008	-.03	.15	.79**	---			
12. O_MCP	3.68	2.89	.09	.14	.07	.15	.08	.13	.35**	.34**	.14	.63**	.53**	---		
13. VGDS	25.99	8.67	.02	.09	.35*	.03	.02	.11	-.13	-.16	.07	.21	.29**	-.03	---	
14. Week Freq	479.30	481.55	.28**	.23*	.32*	.27*	.19	.04	-.12	-.13	.13	.36**	.41**	.08	.58**	---

Note. $N = 80$ for all analyses except correlation between VGDS and Week Freq, where $N = 81$. F1 = Forza 1; F7 = Forza 7; O = OutDrive; Liking = Liking VAS Question; Fun = Fun VAS Question; Novelty = Novelty VAS Question; e.g. F1Liking = Forza 1 Liking VAS Question; MCP = MCP Crossover Point; VGDS = Video Game Dependency Scale. Week Freq = reported weekly number of minutes playing video games.

*$p < .05$. ** $p < .001$.

Table 2

Hierarchical Multiple Regression Analyses Predicting Forza 1 Abuse Liability Scores

F1Liking	*B*	*SE B*	β	*T*	Model R^2	R^2 Change	*F* Change
Model 1					.033	.033	2.67
Sex	-.620	.379	-.182	-1.64			
Model 2					.082*	.049	4.07*
Sex	-.260	.413	-.076	-.630			
Week Freq	.001	.000	.244	2.02*			
Model 3					.118*	.036	3.11
Sex	-.356	.411	-.104	-.867			
Week Freq	.001	.000	.374	2.67**			
VGDS	-.047	.027	-.238	-1.76			
F1Fun	*B*	*SE B*	β	*T*	Model R^2	R^2 Change	*F* Change
Model 1					.022	.022	1.73
Sex	-.460	.350	-.147	-1.32			
Model 2					.057	.036	2.92
Sex	-.177	.383	-.057	-.461			
Week Freq	.001	.000	.210	1.71			
Model 3					.062	.004	.339
Sex	-.207	.388	-.066	-.532			
Week Freq	.001	.000	.254	1.76			
VGDS	-.015	.025	-.081	-.583			
F1Novelty	*B*	*SE B*	β	*T*	Model R^2	R^2 Change	*F* Change
Model 1					.088**	.088	7.52**
Sex	-1.35	.493	-.297	-2.74**			
Model 2					.134**	.046	4.12*
Sex	-.881	.536	-.193	-1.64			
Week Freq	.001	.001	.239	2.03*			
Model 3					.167**	.033	2.99
Sex	-.759	.534	-.166	-1.42			
Week Freq	.001	.001	.115	.845			
VGDS	.060	.035	.227	1.73			
F1MCP	*B*	*SE B*	β	*T*	Model R^2	R^2 Change	*F* Change
Model 1					.037	.037	2.97
Sex	-1.042	.605	-.191	-1.72			
Model 2					.129**	.093	8.18*
Sex	-.287	.636	-.053	-.451			
Week Freq	.002	.001	.334	2.86**			
Model 3					.129*	.00	.000
Sex	-.288	.648	-.053	-.445			
Week Freq	.002	.001	.335	2.46*			
VGDS	-.001	.042	-.002	-.016			

Note. $N = 80$. Week Freq = reported average weekly number of minutes playing video games. VGDS = Video Game Dependency Scale. All significance testing for Model R^2 are for the full model.
*$p < .05$. **$p < .01$. *** $p < .001$.

Table 3

Hierarchical Multiple Regression Analyses Predicting Forza 7 Abuse Liability Scores

F7Liking	*B*	*SE B*	β	*T*	Model R^2	R^2 Change	*F* Change
Model 1					.074*	.074	6.19*
Sex	-.909	.365	-.271	-2.49*			
Model 2					.101*	.028	2.39
Sex	-.640	.401	-.191	-1.59			
Week Freq	.001	.000	.185	1.55			
Model 3					.135*	.034	2.98
Sex	-.731	.400	-.218	-1.83			
Week Freq	.001	.000	.311	2.24*			
VGDS	-.045	.026	-.231	-1.73			
F7Fun	*B*	*SE B*	β	*T*	Model R^2	R^2 Change	*F* Change
Model 1					.054*	.054	4.47*
Sex	-.735	.347	-.233	-2.12*			
Model 2					.064	.010	.791
Sex	-.586	.386	-.186	-1.52			
Week Freq	.000	.000	.109	.889			
Model 3					.082	.019	1.54
Sex	-.650	.388	-.206	-1.68			
Week Freq	.001	.000	.202	1.41			
VGDS	-.031	.025	-.171	-1.24			
F7Novelty	*B*	*SE B*	β	*T*	Model R^2	R^2 Change	*F* Change
Model 1					.013	.013	1.03
Sex	-.457	.451	-.114	-1.01			
Model 2					.013	.000	.013
Sex	-.482	.504	-.120	-.958			
Week Freq	.000	.001	-.014	-.115			
Model 3					.022	.009	.693
Sex	-.426	.509	-.106	-.837			
Week Freq	.000	.001	-.079	-.533			
VGDS	.028	.033	.118	.832			
F7MCP	*B*	*SE B*	β	*T*	Model R^2	R^2 Change	*F* Change
Model 1					.074*	.074	6.20*
Sex	-1.68	.676	-.271	-2.49*			
Model 2					.181***	.107	10.11**
Sex	-.755	.703	-.122	-1.08			
Week Freq	.002	.001	.360	3.18**			
Model 3					.184**	.003	.239
Sex	-.702	.715	-.113	-.982			
Week Freq	.002	.001	.328	2.48*			
VGDS	.023	.046	.063	.489			

Note. $N = 80$. Week Freq = reported average weekly number of minutes playing video games. VGDS = Video Game Dependency Scale. All significance testing for Model R^2 are for the full model.
*$p < .05$. **$p < .01$. *** $p < .001$.

Table 4

Hierarchical Multiple Regression Analyses Predicting OutDrive Abuse Liability Scores

OLiking	*B*	*SE B*	β	*T*	Model R^2	R^2 Change	*F* Change
Model 1					.045	.045	3.67
Sex	.811	.424	.212	1.91			
Model 2					.046	.001	.083
Sex	.752	.473	.196	1.59			
Week Freq	.000	.000	-.036	-.288			
Model 3					.048	.002	.145
Sex	.728	.479	.190	1.52			
Week Freq	.000	.001	-.007	-.045			
VGDS	-.012	.031	-.053	-.381			
OFun	*B*	*SE B*	β	*T*	Model R^2	R^2 Change	*F* Change
Model 1					.051*	.051	3.74*
Sex	.901	.449	.226	2.05			
Model 2					.053	.001	.116
Sex	.829	.490	.208	1.69			
Week Freq	.000	.001	-.042	-.340			
Model 3					.059	.006	.500
Sex	.782	.496	.197	1.58			
Week Freq	.000	.001	.012	.082			
VGDS	-.023	.032	-.099	-.707			
ONovelty	*B*	*SE B*	β	*T*	Model R^2	R^2 Change	*F* Change
Model 1					.006	.006	.487
Sex	-.335	.481	-.079	-.698			
Model 2					.018	.012	.959
Sex	-.109	.534	-.026	-.205			
Week Freq	.001	.001	.123	.979			
Model 3					.019	.000	.030
Sex	-.122	.542	-.029	-.225			
Week Freq	.001	.001	.136	.919			
VGDS	-.006	.035	-.025	-.173			
OMCP	*B*	*SE B*	β	*T*	Model R^2	R^2 Change	*F* Change
Model 1					.000	.000	.018
Sex	.088	.652	.015	.135			
Model 2					.008	.008	.640
Sex	.326	.718	.057	.454			
Week Freq	.001	.001	.100	.800			
Model 3					.016	.007	.551
Sex	.243	.729	.042	.334			
Week Freq	.001	.001	.154	1.06			
VGDS	-.035	.047	-.105	-.742			

Note. *N* = 80. Week Freq = reported average weekly number of minutes playing video games. VGDS = Video Game Dependency Scale. All significance testing for Model R^2 are for the full model.
$^*p < .05$. $^{**}p < .01$. $^{***}p < .001$.

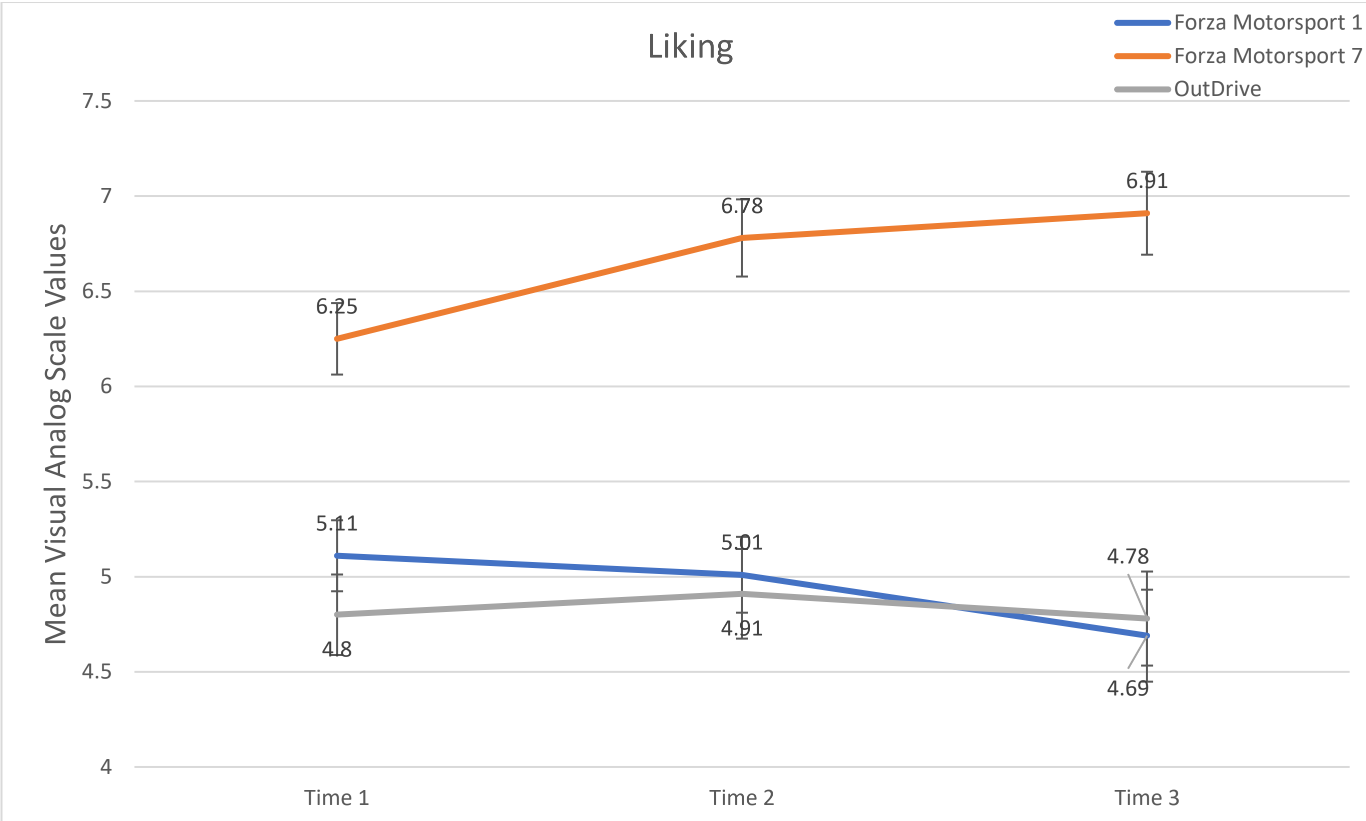

Figure 1. Mean Visual Analog Scale (VAS) participant ratings of video game liking across time of VAS administration.

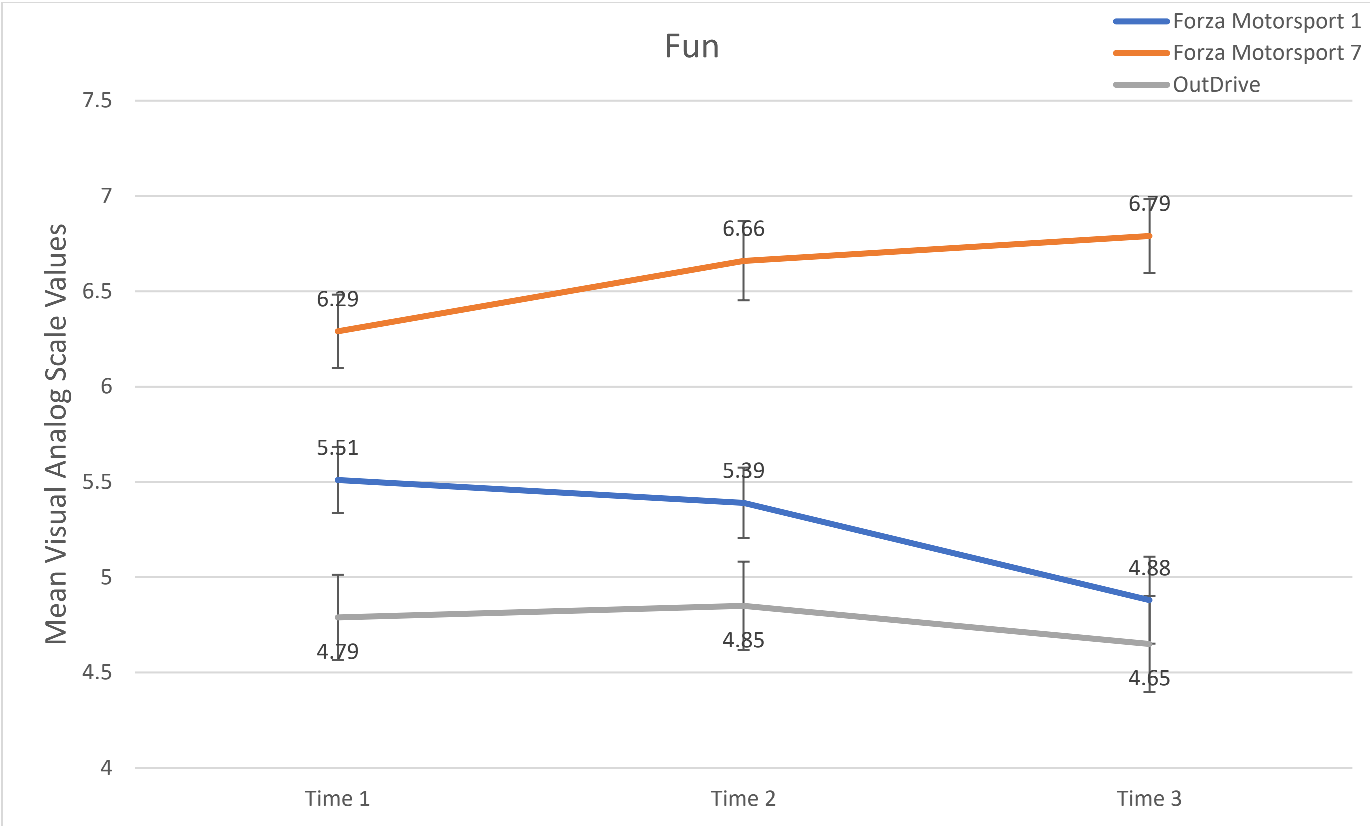

Figure 2. Mean Visual Analog Scale (VAS) participant ratings of video game fun across time of VAS administration.

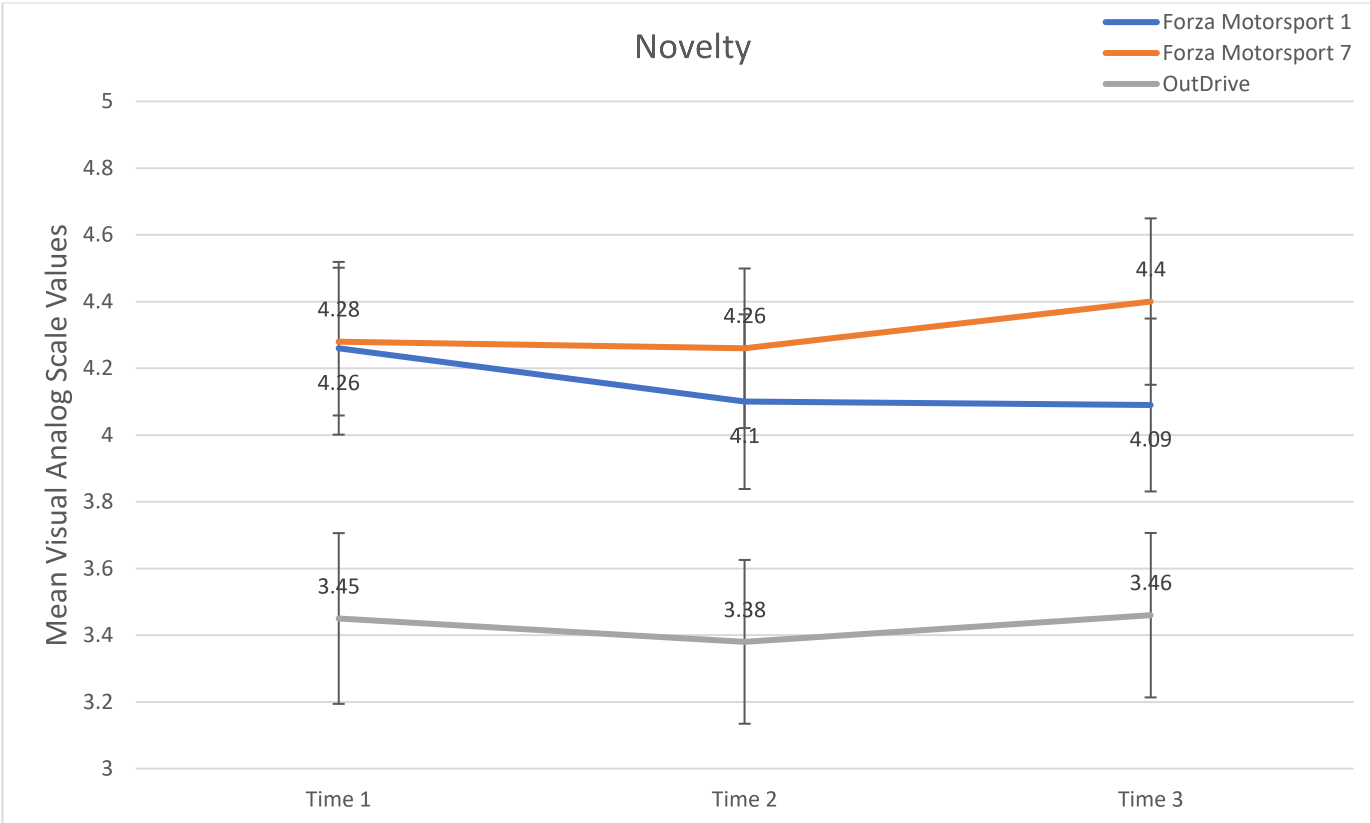

Figure 3. Mean Visual Analog Scale (VAS) participant ratings of video game novelty across time of VAS administration.

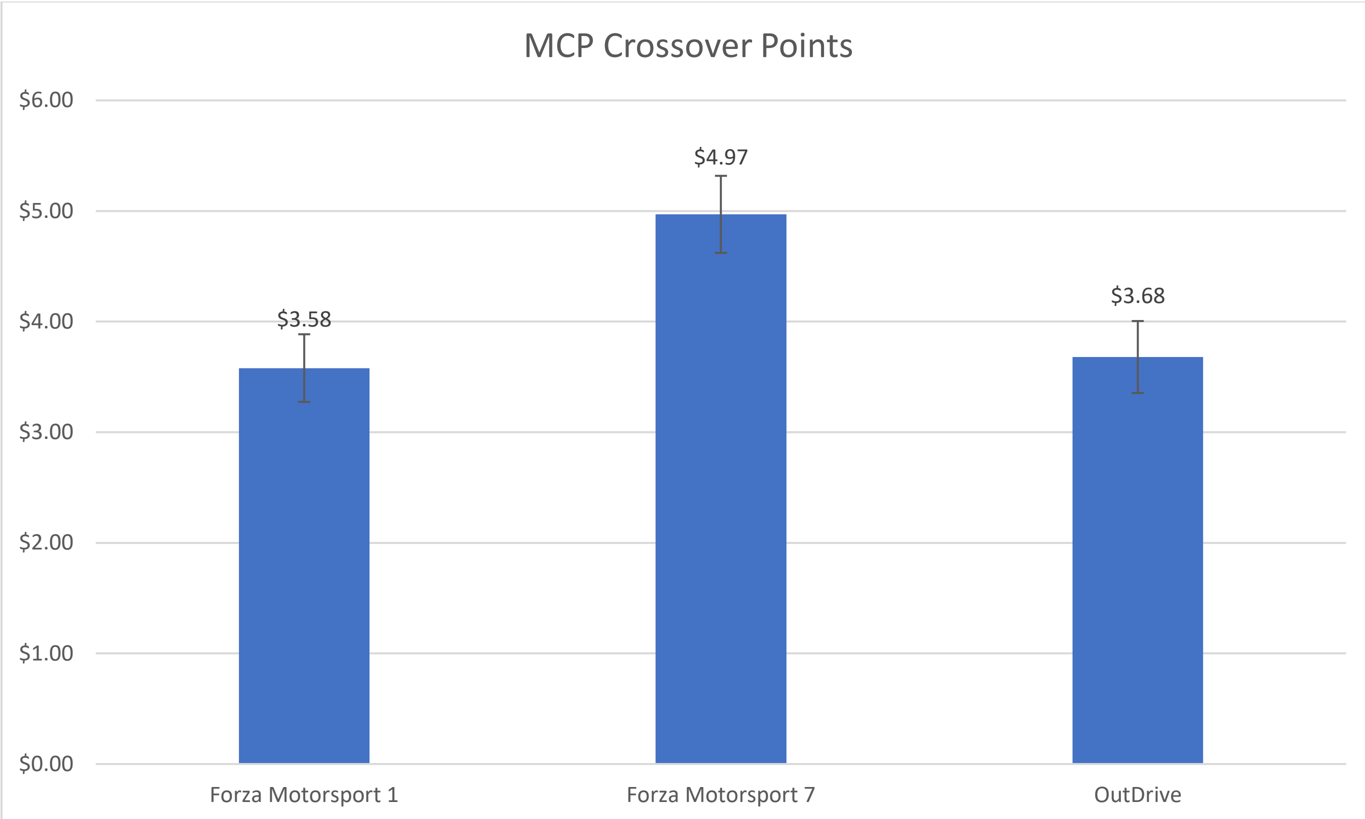

Figure 4. Mean Multiple-Choice Procedure crossover points for each of the three video games.