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Shoot at First Sight! First Person Shooter Players Display Reduced Reaction Time and Compromised Inhibitory Control in Comparison to Other Video Game Players

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**Highlights**

- The study tested inhibitory control in online gamers playing MOBA, MMORPG, or FPS.
- The study controlled for the effect of age, impulsivity, and psychopathology.
- Online FPS gamers displayed accelerated motor responses.
- Online FPS gamers displayed reduced abilities to cancel a prepotent response.
- Game genres have differential impacts on executive control.

Running Head: Inhibitory control in first person shooter gamers

Shoot at First Sight! First Person Shooter Players Display Reduced Reaction Time and  
Compromised Inhibitory Control in Comparison to Other Video Game Players

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2

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5

## Abstract

6 Studies have shown that regular video games use might improve cognitive and social skills. In  
7 contrast, other studies have documented the negative outcomes of excessive gaming vis-à-vis  
8 health and socioprofessional spheres. Both positive and negative outcomes of video game use  
9 were linked to their structural characteristics (i.e., features that make the game appealing or  
10 are inducements for all gamers to keep playing regularly). The current study tested whether  
11 active video gamers from main genres (massively multiplayer online role-playing games,  
12 online first person shooter, multiplayer online battle arena) differed in a laboratory task that  
13 measured inhibitory control. Eighty-one gamers performed the Hybrid-Stop Task, assessing  
14 restraint (go/no-go trials) and cancellation (stop-signal trials) processes of a prepotent  
15 response. They completed additional self-reported questionnaires measuring demographics,  
16 problematic video game use, impulsivity traits, and depressive symptoms. Results showed  
17 that when confounding variables were controlled for, participants whose favorite game is  
18 online first person shooter were characterized by accelerated motor responses yet reduced  
19 abilities to cancel a prepotent response. No differences between groups were identified  
20 regarding the restraint process. The findings of this pilot study might have clear implications  
21 for video gaming research by supporting the critical importance of distinguishing between  
22 video game genres when considering their specific potential benefits and detrimental effects.

23 Keywords: online video games, MMORPG, MOBA, FPS, inhibition, inhibition control

24

## 1. Introduction

25 Video games have always benefitted from technological advancements, mostly since the  
26 arrival of Internet, which allows gamers to cooperate and to compete against each other all  
27 over the world. Online gaming is nowadays a major leisure activity that enrolls millions of  
28 players on a regular (most often daily) basis. In the last two decades, a growing number of  
29 studies have explored the potential positive outcomes (e.g., improvement of social and  
30 interactive skills, promotion of positive affect and well-being, optimization of attentional and  
31 executive functions) (Griffiths, Davies, & Chappell, 2004; Zhong, 2011) and negative  
32 outcomes (e.g., social conflicts and academic disruption, loss of control, compromised health)  
33 (Achab et al., 2011; Longman, O'Connor, & Obst, 2009; Stetina, Kothgassner, Lehenbauer, &  
34 Kryspin-Exner, 2011) associated with addictive use of video games in the context of constant  
35 development and popularization of these games at a worldwide level. In 2013, Internet  
36 gaming disorder was included in Section 3 of the fifth edition of the *Diagnostic and Statistical*  
37 *Manual of Mental Disorders* as a potential new psychiatric condition (i.e., tentative condition  
38 deserving attention for future research) (American Psychiatric Association, 2013). Since then,  
39 research on Internet gaming disorder has blossomed (Kuss & Billieux, 2016).

40 A caveat about studies conducted on video game outcomes (especially those that  
41 considered negative outcomes and excessive usage) is that they largely failed to take into  
42 account game genres. Indeed, it is known that each game genre possesses its own structural  
43 characteristics (Billieux, Deleuze, Griffiths, & Kuss, 2015; King, Delfabbro, & Griffiths,  
44 2011). Accordingly, game genre can diverge in many aspects, including (but not limited to)  
45 addictive potential, underlying motives (e.g., achievement, immersion, socialization), and  
46 mobilization of distinct cognitive processes (e.g., sustained attention, inhibitory control).

47 Most studies conducted on the positive and negative effects of video games were  
48 performed with players of massively multiplayer online role-playing games (MMORPGs),

49 this game genre long being the most popular. Yet, recent years saw a growing interest in other  
50 types of online games, namely, online first person shooter (FPS) and multiplayer online battle  
51 arena (MOBA). Their growing popularity was especially supported by the development of  
52 eSport through the popularization of international events (e.g., international championships or  
53 tournaments) simultaneously broadcasted worldwide to millions of viewers (Kollar, 2015).

#### 54 1.1. Online game genres

---

55 Insert Table 1 about here

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56 The main structural characteristics of MMORPG, MOBA, and online FPS are  
57 summarized in Table 1. MMORPGs take place in persistent virtual worlds continuing to exist  
58 independently of the player's presence. Gamer's avatar has to constantly progress (e.g., to  
59 gain levels and items) through in-game achievements, which are generally favored by  
60 successful collaborations and/or competitions with other players. The most famous  
61 MMORPG is *World of Warcraft*, reaching peaks of 12 million daily players in 2010 (Statista,  
62 2014). An important aspect of MMORPGs is that they allow different gaming styles,  
63 including competition and cooperation with other players, immersion in huge and consistently  
64 evolving virtual worlds, and role-playing components (Billieux et al., 2013; Yee, 2006).

65 In contrast, MOBA consists of intensive, short gaming sessions (30-45 minutes), in  
66 which teams of players have to destroy the opponent's "headquarters" in battles requiring  
67 both strategic abilities (e.g., knowing the strengths and weaknesses of the various game  
68 elements) and reactive skills (e.g., to attack or to avoid confrontation). The most famous  
69 MOBA is *League of Legends*, a free-to-play game that currently attracts around 100 million  
70 active gamers monthly (Statista, 2016).

71 For their part, online FPSs require motor coordination, rapidity, and reactive skills for  
72 ultimately "shooting before being shot." In FPSs, the action is generally centered on a gun (or

73 other similar weapons) and involves confrontations (fights) through a first-person perspective  
74 in which the player has to kill enemies (other players or computer generated), or perform  
75 other types of missions (e.g., controlling specific areas or territories, capturing a flag).

#### 76 *1.2. Self-control and online gaming*

77 The multidimensional construct of self-control has been extensively investigated in  
78 relation to video game involvement, mostly in relation to “dysfunctional,” “harmful,” or  
79 “addictive” video game use (D’Hondt, Billieux, & Maurage, 2015; King, Haagsma,  
80 Delfabbro, Gradisar, & Griffiths, 2013). This focus on self-control-related processes is mainly  
81 because problematic video game use has for a decade been conceptualized as a “behavioral”  
82 addiction (Lopez-Fernandez, 2015) in which impaired self-control (e.g., executive function  
83 impairment, poor decision making and delay discounting, impulsive personality traits) is a  
84 central etiological factor (Grant, Potenza, Weinstein, & Gorelick, 2010; Groman, James, &  
85 Jentsch, 2009). The available literature indeed suggests relatively similar alterations in  
86 cerebral areas underlying self-control in video gaming disorders in comparison to other types  
87 of addictive disorders (Fauth-Bühler & Mann, 2015). Case-control studies also showed that  
88 problematic online gamers display poor decision-making abilities (Bailey, West, & Kuffel,  
89 2013; Pawlikowski & Brand, 2011) and impaired prepotent response inhibitory control (Littel  
90 et al., 2012). An important finding is that impulsivity traits also have a predictive role in the  
91 onset and perpetuation of the disorder (Gentile et al., 2011).

92 Nevertheless, the types of games in which participants were involved were generally not  
93 considered in existing studies. Notable exceptions comprised reports that showed impaired  
94 decision making under risk in a case-control study involving MMORPG problematic gamers  
95 (Pawlikowski & Brand, 2011), impaired inhibitory control (assessed with a go/no-go task) in  
96 another case-control study conducted with problematic FPS players (Metcalf & Pammer,  
97 2014), and a tendency toward compromised reward discounting in excessive MOBA gamers



98 (Nuyens et al., 2016). Moreover, violent video games, especially FPSs, have for some time  
99 been targeted in studies that challenge the idea that these games favor violent and aggressive  
100 behaviors, with, to date, mixed and controversial conclusions (Anderson et al., 2010;  
101 Ferguson, 2011).

102 In contrast, a growing body of evidence converged in demonstrating that video game  
103 use is susceptible to improvement of specific cognitive processes (Anguera et al., 2013),  
104 which notably opens up promising avenues for developing game-based interventions in  
105 various populations, including elderly individuals, conditions marked by impaired self-control  
106 (e.g., neuropsychological, impulse control, or addictive disorders) (Thorens et al., 2016), and  
107 psychiatric disorders characterized by severe cognitive alterations (e.g., schizophrenia;  
108 Amado et al., 2016). To date, among the video game genres described above, demonstrated  
109 cognitive benefits were limited to studies conducted on FPSs. More precisely, several reports  
110 highlighted that FPS players, in comparison to individuals with little or no gaming experience,  
111 display improved top-down guidance of attention (Wu & Spence, 2013), optimized  
112 monitoring and updating of working memory (Colzato, van den Wildenberg, Zmigrod, &  
113 Hommel, 2013), improved visuomotor controls (Li, Chen, & Chen, 2016), faster reaction  
114 times (Colzato et al., 2013), and better cognitive flexibility (Colzato, van Leeuwen, van den  
115 Wildenberg, & Hommel, 2010). It is, however, worth noting that a study focusing on  
116 inhibitory control (measured with a stop-signal task) showed identical inhibition capacities  
117 between experienced and non-experienced FPS players (Colzato et al., 2013). Nevertheless, to  
118 date, no study has compared the effect of regular use of different types of video games on  
119 cognitive performances.

120

121 *1.3. Current study*

122 The current study was designed as a pilot study that aimed at testing whether video  
123 gamers favoring different game genres (i.e., MMORPG, MOBA, or online FPS) differed in  
124 terms of (1) reaction time and (2) inhibitory control, defined as the capacity to refrain or  
125 suppress prepotent motor responses (Friedman & Miyake, 2004). We decided to focus on  
126 inhibitory control, as this executive mechanism is a key aspect of self-control involved in the  
127 proactive control of goal pursuit (Braver, Gray, & Burgess, 2008; Strack & Deutsch, 2004)  
128 and advantageous decision making (Billieux, Gay, Rochat, & Van der Linden, 2010).  
129 Moreover, inhibitory control impairment is a hallmark of addictive and impulsive disorders  
130 (Groman et al., 2009; Smith, Mattick, Jamadar, & Iredale, 2014). On the basis of previous  
131 studies that showed a potential positive effect of FPS use on a wide range of cognitive  
132 processes, we postulated that FPS gamers would present reduced reaction time compared to  
133 MOBA and MMORPG gamers. This impact on reactivity could be encouraged by the nature  
134 (and structural characteristics) of FPSs, which promotes impulsive choices, i.e., “shooting”  
135 more quickly and more accurately than the opponent’s players. We also expected reduced  
136 inhibitory controls among online FPS gamers because of a compromised trade-off between  
137 speed and accuracy (Heitz, 2014). To test these hypotheses, we decided to control for  
138 confounding variables (i.e., variables known to influence reaction time and/or inhibitory  
139 control), namely, age, gender (only males were included in the study), symptoms of  
140 disordered video game use, impulsive personality traits, and depressive symptoms (Billieux et  
141 al., 2010; Cross, Copping, & Campbell, 2011; d’Acromont & Van der Linden, 2007).

142

## 2. Method

143

### *2.1. Participants and procedure*

144

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146

Inclusion criteria for this study were being 18 years or over, a native or fluent French speaker, and currently and regularly (i.e., almost every day) playing either MMORPGs, MOBAs, or online FPSs. The sample was composed of 86 volunteer gamers recruited on the

147 campus of Université catholique de Louvain (in the city of Louvain-la-Neuve), through a  
148 Facebook announcement, and by word of mouth. They were all males, aged between 18 and  
149 39 years ( $M = 21.91$ ,  $SD = 3.84$ ). Participants were informed about the anonymity of the study  
150 and gave their prior consent. They received an incentive of 10 euros at the end of the  
151 experiment. The ethical committee of the Psychological Science Research Institute of the  
152 Université catholique de Louvain (Belgium) approved the study protocol.

153 A series of items were used to measure video gaming preferences (listing of video games  
154 played, preferred type of video game genre). Group attribution was determined from self-  
155 reported preferred video games. Participants were also asked to estimate the mean time (in  
156 hours) spent playing their preferred genre on a weekly basis. One subject failed to report a  
157 preferred type of video game and was thus excluded from the analyses. The proportion of  
158 participants playing MOBA was 52% ( $n = 45$ ), whereas online FPS and MMORPG games  
159 were practiced by 41% ( $n = 35$ ) and 29% ( $n = 25$ ) of the participants, respectively. Part of the  
160 sample (15%,  $n = 13$ ) also reported playing video games that do not fall under the above-  
161 mentioned categories (e.g., online simulation or real-time strategy game). Regarding the  
162 favored video game genre, the majority of participants (43%,  $n = 37$ ) indicated MOBA as  
163 their preferred genre, whereas 32% ( $n = 27$ ) indicated that it was FPS and 25% ( $n = 21$ ) that it  
164 was MMORPG. Part of the sample played more than one genre at the time of the experiment  
165 (38% among MOBA players, 11% among FPS players, and 43% among MMORPG players).

166 After signing the consent form and reading the accompanying information, participants  
167 performed a laboratory task that measured different aspects of inhibitory control: The Hybrid-  
168 Stop Task (Schachar, Forget-Dubois, Dionne, Boivin, & Robaey, 2011). After completing the  
169 task, participants filled self-reported scales in the following fixed order: The Problematic  
170 Online Gaming Questionnaire (POGQ; Demetrovics et al., 2012), the UPPS-P Impulsive  
171 Behavior Scale (UPPS-P; Billieux, Rochat, et al., 2012), and the Beck Depression Inventory-

172 II (BDI-II; Beck, Steer, & Brown, 1998). Table 2 defines the various constructs measured by  
173 the self-reported scales and reports their internal consistencies. Participants also completed  
174 other measures unrelated to the current study and will be described elsewhere.

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175 Insert Table 2 about here

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## 176 *2.2. Behavioral task*

177 The Hybrid-Stop Task is a computerized task developed by Schachar et al. (2011) to  
178 assess two distinct components of inhibitory control: cancellation (i.e., interrupting an  
179 ongoing automatized action) and restraint (i.e., preventing an action when required). The  
180 Hybrid-Stop Task comprises three types of trials: (1) go trials (a measure of reaction time),  
181 (2) no-go trials (a measure of the restraint process), and (3) stop-signal trials (a measure of the  
182 cancellation process). An initial training session composed of 16 trials aims at automatizing  
183 the association between target stimuli and response keys. The task then begins, composed of  
184 320 trials divided into five blocks. In go trials (160 trials), the participant has to indicate as  
185 quickly as possible the direction in which a white arrow points as it appears in the middle of  
186 the screen by pressing specific key buttons. In no-go trials (80 trials), the arrow appears blue,  
187 requiring the participant to avoid answering (process of restraint). In stop-signal trials (80  
188 trials), the arrow first appears black before turning blue after a varying quick delay, requiring  
189 the participant to interrupt the ongoing action (process of cancellation). The first stop-signal  
190 delay of the Hybrid-Stop Task is based on the mean reaction time measured during the  
191 training session. A dynamic algorithm continuously modifies the delay on the basis of the  
192 participant's performance in each stop-signal trial: 50 ms shorter in the case of failed  
193 inhibition (making the next trial easier to inhibit) and 50 ms faster in the case of successful  
194 inhibition (making the next trial harder to inhibit).

195 Participants were instructed to answer as quickly as possible, no matter the type of trial,  
196 and to avoid answering when a blue arrow appears. In the instructions, participants were  
197 warned that they must not anticipate the potential appearance of the stop signal, which implies  
198 that making errors is inevitable. The efficiency of the restraint process is measured through  
199 the percentage of errors at go/no-go trials. The cancellation process is measured through the  
200 number of stop-signal errors and the calculation of the stop-signal reaction time (SSRT)  
201 (Logan, 1994), which represents the mean time in which the participant is able to perceive a  
202 stop signal and to interrupt his/her answer. The integration method was used to determine the  
203 SSRT (Logan & Cowan, 1984), this method being recognized as the most accurate SSRT  
204 estimation (Verbruggen, Chambers, & Logan, 2013). Items in which participants made errors  
205 were removed before the calculation of the mean reaction time. To limit the impact of late  
206 responses, we suppressed every no-stop trial that was longer than the mean for no-stop trials  
207 plus 2.5 standard deviations on a subject-by-subject basis and did not take it into account in  
208 the analyses.

### 209 3. Results

#### 210 3.1. Data reduction

211 Four participants were excluded from the analyses: three were considered outliers in  
212 terms of time spent playing video games and one had technical problems with the stop-signal  
213 task (two FPS gamers, one MOBA gamer, and one MMORPG gamer). The final sample was  
214 thus composed of 81 male volunteer gamers aged between 18 and 39 years ( $M = 22.07$ ,  $SD =$   
215  $3.83$ ).

#### 216 3.2. Control variables

217 Before comparing the groups (MOBA, online FPS, MMORPG) on the Hybrid-Stop Task  
218 measures, we ran a set of analyses of variance to identify potential group differences within

219 the control variables retained, namely (1) demographics, (2) time spent playing per week, (3)  
220 impulsivity traits (UPPS-P), (4) video game excessive use symptoms (POGQ), and (4)  
221 depressive symptoms (BDI-II), using Bonferroni-corrected post hoc tests when significant  
222 differences were identified. On the basis of recent data questioning the utility of  
223 distinguishing between positive and negative urgency (Berg, Latzman, Bliwise, & Lilienfeld,  
224 2015) and the high correlation between these two constructs in the current study ( $r = .53, p <$   
225  $.001$ ), we used a unique score of general urgency. Demographics for the final sample are  
226 reported in Table 3. A significant difference appeared regarding the mean hours of playtime  
227 (online FPS players reported less weekly time spent playing than did MMORPG and MOBA  
228 gamers). However, this variable is not significantly correlated with the Hybrid-Stop Task  
229 variables and was thus not considered as a covariate.

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230 Insert Tables 3 and 4 about here

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### 231 *3.3. Inhibitory control*

232 One-way analyses of variance were computed to compare performances in the Hybrid-  
233 Stop Task (reaction time, cancellation process, and restraint process) between groups, while  
234 applying Bonferroni-corrected post hoc tests. All results are reported in Table 4. Post hoc  
235 comparisons revealed that gamers favoring online FPS displayed faster reaction times to go  
236 trials and presented a reduced ability to cancel an automatic motor response (higher SSRT)  
237 than did gamers favoring MOBA. Although the result was marginally significant ( $p = .068$ ),  
238 gamers favoring online FPS also displayed reduced reaction time in comparison to gamers  
239 who preferred MMORPG. Gamers favoring online FPS also made more errors in stop-signal  
240 trials compared with those who preferred to play MOBA and MMORPG. No difference in  
241 reaction time and inhibitory control was demonstrated between gamers whose preferred genre

242 was either MOBA or MMORPG. No group differences were highlighted regarding the  
243 restraint process (go/no-go trials).

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244 Insert Figure 1 about here

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#### 245 4. Discussion

246 This study was designed as a pilot study devoted to the comparison of inhibitory control  
247 performances in regular video game players based on their preferred game genre (MMORPG,  
248 MOBA, or online FPS) while controlling the influence of potential confounding factors  
249 (demographics, weekly hours of playing, symptoms of disordered gaming, impulsivity traits,  
250 and depressive symptoms). A Hybrid-Stop Task was used to measure reaction time, along  
251 with two components of inhibition: the cancellation and the restraint processes. On the whole,  
252 the results showed that individuals favoring online FPS games were characterized by  
253 accelerated reaction times and reduced abilities to cancel a prepotent motor response in  
254 comparison to individuals favoring MOBA or MMORPG games. Although it clearly appeared  
255 that individuals who preferred online FPS made more errors than did gamers who favored  
256 MOBA and MMORPG, the picture seems a bit more nuanced when it comes to reaction time,  
257 as gamers favoring online FPS are faster than MOBA gamers but not faster than MMORPG  
258 gamers. Notably, however, the difference in reaction time between gamers favoring online  
259 FPS and MMORPG can be considered a nonsignificant trend ( $p = .068$ ). Regarding SSRT (an  
260 index of inhibitory restraint depending on both reaction time and errors), it appears that  
261 gamers favoring online FPS present lower inhibition control than do gamers favoring MOBA.  
262 An important finding is that 20% of the gamers who indicated that they favor MMORPG also  
263 play online FPS, whereas only about 11% of gamers who favor MOBA also play online FPS,  
264 which could explain why the differences observed between MMORPG and online FPS are

265 less marked than those observed between MOBA and online FPS. No differences between  
266 groups were identified regarding the restraint of a prepotent motor response.

267 Confirming our hypotheses and the work of Colzato et al. (2013), online FPS gamers  
268 displayed decreased mean reaction times. Interestingly, the observation in Table 4 of the  
269 standard deviations for reaction times revealed a very small variability within online FPS  
270 gamers, giving further support to the view that regular involvement in this particular game  
271 genre boosts the reactivity of motor responses. This effect can reasonably be attributed to the  
272 nature of FPSs (i.e., their structural characteristics reported in Table 1), which puts players  
273 into the perspective of fighters who need to react more quickly than their opponents to  
274 survive, and eventually win, in the game. In contrast, MMORPGs are more contemplative and  
275 less demanding in terms of attention focus and reactivity, alternating between strategic action  
276 (combats) and immersive exploration, and MOBAs instead mobilize quick and strategic  
277 decision making and collaborative playing,

278 The analyses also revealed that gamers favoring online FPS make more errors when they  
279 need to restrain an automatized prepotent response. It is thus likely that when playing online  
280 FPS, an impulsive gamer who is characterized by increased reactivity and diminished  
281 inhibition will perform well, with limited direct associated risks (e.g., a failed cancellation  
282 process resulting in “friendly fire” will not have consequences in the real life of gamers). Yet,  
283 we cannot exclude the possibility that in the real life, this impulsive style is susceptible to  
284 engendering negative outcomes. Indeed, reduced efficacy of the cancellation process reflects a  
285 poor capacity to inhibit prepotent (or automatic) motor responses (Friedman & Miyake,  
286 2004), which is a core etiological factor of many psychiatric disorders, including addictive  
287 disorders (Billieux, Lagrange, et al., 2012; Lawrence, Luty, Bogdan, Sahakian, & Clark,  
288 2009; Noël et al., 2009). Individuals with impaired inhibition of prepotent response have also  
289 been shown to be more prone to making detrimental decisions in the long term to obtain



290 immediate gratification (Billieux et al., 2010). Beyond this risk, reduced inhibitory control has  
291 also been linked to other hazardous or problematic behaviors, including aggressive and  
292 antisocial behaviors (Plutchik & Van Praag, 1995). Our study findings are also congruent with  
293 Dickman's conceptualization of impulsivity (Dickman, 1990), which posits that depending on  
294 the context, an impulsive behavior can be either functional or dysfunctional. Indeed, from the  
295 evidence presented above, the impulsive style displayed by online FPS players in our study is  
296 probably adaptive in the gaming context, but likely dysfunctional to a certain extent in the  
297 context of real-life daily living.

298 Several limitations have to be acknowledged. First, we did not include a non-gamers  
299 group as required in any attempt to document an inhibitory control impairment in certain  
300 types of video game players. This choice was, however, deliberate, as our aim was to test the  
301 influence of game genre on inhibitory control, not to show impairments in video gamers  
302 versus non-gamer participants, as in traditional case-control studies. Second, even though all  
303 but one participant successfully identified a preferred type of video game, the study design did  
304 not allow us to consider that some participants might be involved in more than one type of  
305 video game genre, and we measured only the time spent playing weekly for the preferred  
306 gaming genre. Accordingly, subsequent studies either should be conducted with "pure  
307 gamers" (i.e., gamers involved in only one type of video game genre), or should control for  
308 the involvement in each type of gaming genre by using techniques such as tracking- or diary-  
309 based methods. Finally, future studies should also consider individuals who play "casual  
310 games" (i.e., simple and short video games playable on smartphones or web browsers, such as  
311 *Candy Crush* and *Pokémon GO*), which were not considered here, despite their growing  
312 popularity. Nonetheless, we can suppose that these games, because of their simple and  
313 repetitive nature, will not engender an effect on attentional and executive processes.

314 In conclusion, although preliminary, our results revealed neuropsychological differences  
315 among gamers that can be understood on the basis of the heterogeneous structural  
316 characteristics of online video games. These findings may have clear implications for video  
317 gaming research and support the critical importance of distinguishing between video games  
318 genres, whether focusing on their benefits (e.g., development of “games for health” or use in  
319 neuropsychological rehabilitation) or on their detrimental effects (e.g., development of  
320 addictive patterns of use, promotion of maladaptive impulsive behaviors).

321

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324

325

**Author Disclosure statement**

326 No competing financial interests exist.

327

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Table 1. Comparison of structural characteristics of the three main online video game genres

Massively multiplayer online role-playing game ( <b>MMORPG</b> )	Multiplayer online battle arena ( <b>MOBA</b> )	Online first person shooter ( <b>online FPS</b> )
Persistent virtual worlds	Achievement (with rankings)	Action, precision, reflexes
Advancement system	Social aspects (cooperation and battles	Competition and cooperation
Achievement (quests, battles, events)	PvP)	Achievement (defeating the enemy, accomplishing missions, reaching objectives)
Exploration and immersion (virtual worlds, lore, stories)	Short and intense play sessions	Rewards (better items and weapons)
Social aspects (competition, cooperation, creation of guilds, virtual life)	Necessity to play regularly (to maintain level/ranking)	
	e-Sport (broadcast of international tournament, millions of viewers)	

*Note:* PvP = player versus player.

Table 2. Study variables

Questionnaire	Scale	Scale description	Cronbach's $\alpha$
Problematic Online Gaming Questionnaire	Total score	Symptoms of problematic online video game use	.82
Short UPPS-P Impulsive Behavior Scale	Urgency	Tendency to act rashly in intense positive or negative emotional contexts	.83
	Lack of premeditation	Difficulties taking into account the consequences of an action	.87
	Lack of perseverance	Difficulties remaining focused on a boring and/or difficult task	.91
Beck Depression Inventory-II	Sensation seeking	Preference for new experiences and potentially risky activities	.78
	Total score	Dimensional score of depressive symptoms	.79
Hours of playtime per week	Mean estimation	Reported estimation of the mean hours devoted to play the preferred genre per week	-
Hybrid-Stop Task	GO RTs	Mean reaction time for go trials	-
	SSRTs	Mean stop-signal reaction times	-
	SST errors	Percentage of errors for stop-signal trials	-
	GNG errors	Percentage of errors for go/no go trials	-

Table 3. Comparison of demographics and questionnaires between genres of favorite online game

	MMORPG	MOBA	Online FPS	<i>F</i>	<i>p</i>
	( <i>N</i> = 20, 24.7%)	( <i>N</i> = 36, 44.4%)	( <i>N</i> = 25, 30.9%)		
	<i>M</i> ( <i>SD</i> )	<i>M</i> ( <i>SD</i> )	<i>M</i> ( <i>SD</i> )		
Demographic measures					
Age	22.90 (3.39)	21.06 (1.79)	22.88 (5.69)	2.366	.101
Hours/week	15.50 (9.22)	16.82 (6.74)	9.98 (5.21) <sup>a</sup>	7.309	.001**
Online video game use					
POGQ-Total	42.25 (9.46)	46.36 (8.53)	44.52 (6.82)	1.597	.209
Psychopathological measures					
UPPS-Total urgency	18.15 (5.35)	20.75 (4.03)	19.80 (3.85)	2.307	.106
UPPS-Lack of premeditation	6.35 (2.18)	7.78 (2.47)	7.08 (2.23)	2.463	.092
UPPS-Lack of perseverance	7.30 (2.56)	8.25 (3.00)	6.92 (2.29)	1.966	.147
UPPS-Sensation seeking	11.75 (2.65)	11.50 (2.32)	11.76 (2.63)	.104	.901
BDI-II	7.20 (3.59)	8.56 (5.70)	7.80 (6.08)	.428	.653

*Note.* Hours/week = mean hours of online game per week; MMORPG = massively multiplayer online role-playing game; MOBA = multiplayer online battle arena; online FPS = online first person shooter; POGQ = Problematic Online Gaming Questionnaire; UPPS = UPPS-P Impulsive Behavior Scale; BDI-II = Beck Depression Inventory - II. \*\* $p < .005$ .

<sup>a</sup>Statistically significant in comparison to MMORPG and MOBA players at  $p < .05$  using Bonferroni post hoc tests.

Table 4. ANOVAs on Hybrid-Stop Task scores of online video game genres

	MMORPG	MOBA	Online FPS		
	<i>M (SD)</i>	<i>M (SD)</i>	<i>M (SD)</i>	<i>F</i>	<i>p</i>
GO RTs	501.71 (220.88)	525.04 (243.42)	363.85 (43.81) <sup>a</sup>	5.259	.007*
SSRTs	259.54 (51.82)	249.83 (53.28)	291.86 (59.21) <sup>b</sup>	4.477	.014*
SST errors	59.62 (15.23)	59.23 (14.62)	72.95 (16.44) <sup>c</sup>	6.765	.002**
GNG errors	3.06 (3.15)	2.64 (6.78)	3.55 (5.37)	.192	.825

*Note.* ANOVAs = one-way analyses of variance; MMORPG = massively multiplayer online role-playing game; MOBA = multiplayer online battle arena; online FPS = online first person shooter; GO RTs = mean reaction time for go trials; SSRTs = mean stop-signal reaction times; SST errors = percentage of errors for stop-signal trials; GNG errors = percentage of errors for go/no go trials. \* $p < .05$ ; \*\* $p < .005$ .

<sup>a</sup>Statistically significant in comparison to MOBA players at  $p < .05$  using Bonferroni post hoc tests. The difference between online FPS and MMORPG can be considered a nonsignificant trend at  $p = .068$ .

<sup>b</sup>Statistically significant in comparison to MOBA players at  $p < .05$  using Bonferroni post hoc tests.

<sup>c</sup>Statistically significant in comparison to MOBA and MMORPG players at  $p < .05$  using Bonferroni post hoc tests.

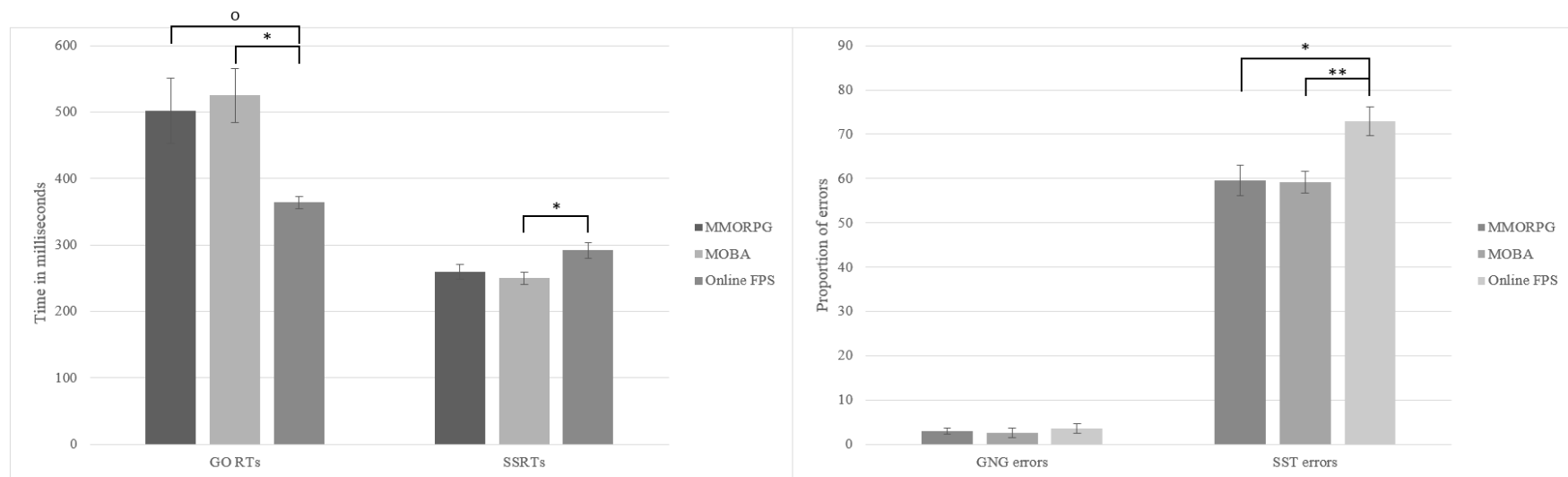


Fig. 1. Mean reaction times, SSRTs, and errors in the Hybrid-Stop Task.  $*p < .05$ ;  $**p < .005$ ;  $^{\circ}p = .068$ . Error bars represent standard errors of the mean. GO RTs = mean reaction times for go trials; SSRTs = mean stop-signal reaction times; GNG errors = go/no-go errors; SST errors = stop-signal task errors; MMORPG = massively multiplayer online role-playing game; MOBA = multiplayer online battle arena; online FPS = online first person shooter.