

Delineating adaptive esports involvement from maladaptive gaming: a self-regulation perspective

Damien Brevers¹, Daniel L King² and Joël Billieux^{3,4}

The last decade has witnessed the rise of electronic sports (esports), yet little is known about how involvement in intensive esports relates to self-regulatory processes, such as executive functioning (EF). In this paper, we review the evidence on EF in problematic and non-problematic video-game use. We also consider research on EF in traditional sports athletes, as well as in 'exercise addiction'. The focus of the review is on two core components of EF, namely response inhibition and cognitive flexibility. The available evidence suggests that EF is a reliable marker for indexing specific types of sport and video-gaming expertise, but does not appear to consistently delineate maladaptive from adaptive video-game involvement. Future research avenues on EF that characterize esports players are suggested to advance this area.

Addresses

¹ Institute for Health and Behaviour, Department of Behavioural and Cognitive Sciences, University of Luxembourg, Esch-sur-Alzette, Luxembourg

² College of Education, Psychology, & Social Work, Flinders University, Australia

³ Institute of Psychology, University of Lausanne, Lausanne, Switzerland

⁴ Centre for Excessive Gambling, Lausanne University Hospitals (CHUV), Lausanne, Switzerland

Corresponding author: Brevers, Damien (damien.brevers@uni.lu)

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Introduction

Electronic sports, or *esports*, refer to organized, competitive forms of video-games that can be played individually or in a team and viewed by spectators either in-person or via streaming services [1]. With the advance in digital technologies, there has been an exponential worldwide increase in the popularity of esports and an increased number of national and international tournaments [1,2]. Along with this increased involvement in esports, the world has been introduced to a new generation of esports players, including some who, like elite athletes, receive

(high) income through prize monies, sponsorship, and celebrity endorsements [2].

There have been some claims that the development of esports may promote dysfunctional gaming practices (i.e., gaming disorder, GD [3]). In 2019, GD was recognized as a condition by the World Health Organization and included in the 11th edition of the International Statistical Classification of Diseases and Related Health Problems (ICD-11). As defined in the ICD-11, one of the central features of GD is loss of control over gaming, which involves an inability to regulate the duration of gaming sessions or the context in which they take place [4–6]. Nevertheless, it has been suggested that GD criteria may not distinguish harmful from adaptive esports involvement [7•]. Moreover, little is known about how esports practice (e.g., strenuous training, disappointment after low performances, boredom [8•,9]) relates to players' self-regulation capacities. In particular, intensive esports involvement might impact on daily-life executive functioning (EF), which plays a pivotal role in the voluntary pursuit and attainment of life goals [10].

The present paper aims to discuss how EF has the potential to delineate GD from adaptive esports involvement. Indeed, while both adaptive and problematic gaming may involve intensive video-game use (e.g., in terms of time commitment), one is adaptive (peak esports performance) and one is maladaptive and constitutes a mental condition (GD). Here we focused on two core EF processes, namely response inhibition (i.e., the ability to stop a response that has been initiated but has become inappropriate or unwanted; [11•]) and cognitive flexibility (i.e., the ability to successfully adapt to a constantly changing environment; [12]). We selected these two constructs from the available evidence that advances their crucial role in the characterization of impulsive (a failure to suppress addiction-related behaviors) and compulsive (an inability to shift behaviors toward healthy and functional areas of life) components of addictive disorders [13,14]. We start by reviewing the evidence regarding EF in problematic and non-problematic video-game use. We next review the evidence regarding EF in sport athletes and in the debated construct of 'sport addiction' or 'exercise addiction'. In light of these findings, we then propose research avenues for a better understanding of EF in esports players and to avoid the conflation of adaptive and maladaptive intensive video-game involvement.

EF in GD population, gamers, and athletes

Response inhibition

GD population

In GD research, response inhibition has been measured by using the Stroop task, the go/no-go task (GNGT), and the stop-signal task (SST). Meta-analyses have highlighted that individuals with GD exhibit lower inhibitory control in the Stroop task and the GNGT [15,16]. Nevertheless, the main literature on the GNGT shows that between-group differences do not necessarily hold when controlling for response speed [17]. Put differently, response inhibition can be affected by response speed (i.e., 'go' trials for GNGT, 'congruent' trials for the Stroop task; for a brief task description, see Table S1 in Supplementary material). This aspect is especially relevant because significant reaction time differences (increased or decreased speed) have been frequently observed between individuals with IGD and matched-control participants (e.g., Refs. [18–20]). However, to the best of our knowledge, none of these studies controlled (at an individual or a group level) for the effect of reaction time on response inhibition outcomes.

In contrast to the Stroop task and the GNGT, the SST allows for the estimation of response inhibition independently of categorization speed on 'go' trials through the computation of the stop-signal reaction time (SSRT; slower SSRT indicates lower efficiency of response inhibition; see also Table S1). When relying on the effect sizes reported by two recent meta-analyses (studies undertaken before May 2016 in Ref. [15]; before October 2017 in Ref. [16]), it appears that GD is linked to a decrease in SST performance. However, one meta-analysis focused on SST response accuracy (e.g., 'go' response on 'stop' trials) rather than on SSRT [15]. The other reported SST performance across five studies, but it is not clear which SST index was used to compute effect sizes [16]. Specifically, one study did not report SSRT [21]; two studies reported lower response inhibition (i.e., slower SSRT), but in a sample of individuals with problematic Internet use (i.e., not GD-specific [22]), or in a sample of problem gamblers with problematic Internet use (again, not GD-specific [23]); and the two remaining studies did not observe a significant response inhibition (i.e., SSRT) difference between GD and matched-controls (playing Internet games less than 2 hour/day [24,25]).

We found four additional studies that reported response inhibition (indexed by SSRT on the SST) in individuals with GD [26–28,29*], which were not included in the above-mentioned meta-analyses. Three studies did not observe a significant difference between the GD (treatment seeking in Ref. [28]) and the control groups (non-gamers in Ref. [27,28]; frequent gamers in Ref. [26]). Only Wang *et al.* [29*] reported lower response inhibition in a sample of treatment-seeking adolescents with GD compared with that in matched non-gamer controls.

Overall, when reviewing the effect size and statistical power of studies that have reported SSRT (see Table S2), it is unclear whether GD is associated with a decrease in response inhibition.

Gamers

Two studies did not observe a significant SSRT difference between highly involved players in 'first-person shooter' games (FPS; this game type requires the player to rapidly react to fast-moving visual/auditory stimuli) and non-gaming matched controls ([30,31]; see Table S2). Interestingly, when comparing different groups of video-game players, Deleuze *et al.* ([32*]; see Table S2) highlighted that FPS players exhibited lowered response inhibition on the SST compared with players who favored massively multiplayer online role-playing games and with multiplayer online battle arena players. These results remained significant when taking into account the potentially confounding effect of demographics, time played per week, impulsivity traits, depression, and IGD symptoms. Hence, these findings suggest that regular video-game practice may modulate response inhibition ability.

Athletes

Elite athletes (i.e., young athletes who perform at high-levels of competition or professional adult athletes) exhibit higher response inhibition (i.e., faster SSRT on the SST) than do non-athletes (see Table S2). Notably, these enhanced patterns of response inhibition vary according to the level of sport expertise, with elite-level athletes displaying better response inhibition than amateur or recreational athletes do (see Table S2). Interestingly, better response inhibition has been highlighted in sports that involve direct contact with an opponent (soccer, handball, fencing, taekwondo; [33–37]), but not in sports that do not involve direct physical contact with the opponent (volleyball, badminton; [38–40]). Hence, response inhibition ability seems to differ according to the type of sport expertise.

Few studies have been reported on inhibitory control in exercise and sport 'addiction', possibly because this addiction construct is poorly operationalized and defined [41,42], or because there are few treatment-seeking cases, as compulsive physical exercise is mostly viewed as a by-product of eating disorders [43]. Yet, we identified a study that provides preliminary evidence that 'exercise addicts' present decreased inhibitory control (but as assessed with a go/no-go task) when compared with regular exercisers and non-exercisers [44].

Cognitive flexibility

GD population

Cognitive flexibility may be operationalized as the ability to shift response sets to a previously irrelevant dimension (i.e., attentional set-shifting), or to adjust choices with changes in contingencies (i.e., reversal learning). The

most widely used neuropsychological tasks for the evaluation of attentional set-shifting are the Wisconsin Card Sorting Test (WCST) and the Intra-/Extra-Dimensional Set-Shifting Task (ID/ED; see Table S1 for an overview). Reversal learning can be assessed with the Probabilistic Reversal Learning Task (see also Table S1).

Attentional set-shifting and reversal learning have been examined in GD by Banca *et al.* [45]. Their study found that individuals with GD were less effective in reversal learning, but not in attentional set-shifting compared with matched-control participants. Another case-control study did not observe a significant difference in attentional set-shifting performance between individuals with GD and matched-control participants [25]. Han *et al.* [46] examined attentional set-shifting in a group of individuals with GD with comorbid major depressive disorder, a GD group without depressive symptoms, and a group of controls. These authors found that performance on ID/ED was lower in the GD group with a major depressive disorder compared with that in the GD group without depression and the control group, signaling the importance of taking into account the impact of a comorbid depressive disorder on EF.

Gamers

Numerous studies have shown that video-game players (especially FPS players) are faster than non-players in switching between tasks (i.e., decreased ‘switch cost’ during response mapping tasks; for a review, see Refs. [47,48]. Yet, these results should be considered cautiously because they might have been overestimated and subjected to publication bias [49]. However, no study has specifically examined attentional set-shifting and reversal learning across different levels or types of video-game expertise.

Athletes

A decreased ‘switch cost’ effect has also been consistently reported in elite athletes (for a meta-analysis, see Ref. [50]). Surprisingly, little is known regarding reversal learning and attentional set-shifting abilities among elite athletes. The two only studies that we identified report that attentional set-shifting ability (measured with the WCST in Ref. [51], and with the ID/ED in Ref. [52]) increases in terms of sport expertise.

We failed to identify any study that has investigated cognitive flexibility in individuals who are ‘exercise addicts’. As explained earlier, this might be due to controversies and inconsistencies regarding the operationalization of this condition and/or the reduced number of treatment-seeking cases.

Perspectives and research avenues

The need for individualized approaches

The above findings suggest a number of research directions to examine how EF operates among esports players.

Of particular importance is the observed modulatory effects of comorbid GD psychopathology (e.g., depressive symptoms), as well as of the types of video-game and sport expertise on EF.

Overall, these findings call for applying a person-centered analytic approach to the study of EF in esports. Such an approach would allow one to map patterns of EF to specific profiles of esports players (e.g., differing in esports subgenre, level of performance, or motives to play; [53]). For example, a study by Wang *et al.* [29] used cluster analysis to show that, despite significant between-group differences, more than 70% of a sample with GD symptoms presented intact inhibitory control (assessed by the SST). A similar approach also allowed improvement in the understanding of the complex links and interrelations between specific patterns of problematic video-game use (e.g. Refs. [54,55]). Another method is to combine case-control studies (intergroup approach) with complementary profile analyses (intragroup approach). By using such a method in a sample of treatment-seeking gamblers, Billieux *et al.* [56] showed that only 40% of the patients presented with an *abnormally low* pattern of response inhibition, despite significant between-group differences with non-gamblers. Hence, such an analytic approach will allow matching of practical indexes of EF that characterize esports players (e.g., using quintiles to identify levels of performance: impaired, low, mild, high, outstanding) to GD symptoms.

Using an ecological index of EF

Although laboratory tasks offer sensitive measures of EF, they are also characterized by limited ecological validity. For instance, these tasks present a low correlation with EF performance in natural settings among patients with neurological and developmental disorders [57]. Another potential methodological issue is that the response modalities pertaining to computerized EF tasks mimic those of video gaming (e.g., to push left/right computer keys on go trials of the SST), implying a potential transfer from video-game expertise to the computerized assessment of EF. For instance, lower response inhibition performance in FPS players [32] might reflect adaptive adjustment to video-game expertise, but not a decreased ability in response inhibition *per se*. This aspect is of key importance for esports, which links strategic actions to fast, accurate finger-key actions under stressful competitive environments.

Laboratory tasks should thus not serve as the sole source for estimating EF in video-gamers and esports players. For instance, in individuals with attention-deficit/hyperactivity disorder, EF can be reliably assessed with the Barkley Deficits in Executive Functioning Scale (BDEFS [58]; see Table S3 for examples of items from each subdimension of the scale). Potential advantages to self-rating of EF include the ecological validity and

predictive capacity in relation to daily life impairment [59]. Indeed, the BDEFS correlates with measures of comorbid disorders (e.g., major depression) and predicts impairment or deviant behaviors in daily living (e.g., antisocial acts), as well as occupational functioning, better than EF tasks do [59]. Another interesting aspect of the BDEFS is that it can also be completed by someone who knows the individual well. Hence, applying this procedure to esports players should allow parents and/or trainers to help their children/athletes in self-regulating their video-game use on a daily life basis (see also Ref. [60]).

The examination of EF in esports would thus benefit from a comparable line of research aiming to offer a more comprehensive understanding of both the maladaptive and adaptive features of competitive video-gaming. This goal could be operationalized through the creation of items that tap into daily-life self-regulatory challenges encountered by esports players (e.g., personal hygiene, screen time, sleep, diet, esports betting; [61,62]) and by examining their ability to face such situations (see Table S3 for an illustration). Comparable front-loaded phenomenological approaches have already been used to better grasp key psychological processes involved in sport performance (e.g., precompetitive emotional states [63]), or to provide qualitative understandings of engagement in new types of digital conduct (e.g., binge-watching of TV series [64], social media use [65]). These ratings of EF should also be particularly relevant when adopted throughout the stages of the esports career (e.g., initiation, development, mastery, and discontinuation) in order to inform about the main pathways and challenges encountered during a career in esports [8,66].

Conclusion

Given the constantly growing popularity of esports and related activities, it is urgent to identify markers that delineate adaptive high involvement in video games from problematic involvement. Yet, based on our review of the literature, pathological involvement in video gaming is a heterogeneous condition that is not necessarily associated with EF deficits. Moreover, available research shows that specific games (and sport expertise) differentially impact EF, which raises questions regarding whether the studies have taken game genre into account. Our view is that the similarities and specificities of video-gaming and rule-based competitive sports call for new lines of research on EF. Exploring this question is crucial if we are to develop a gaming-specific theoretical and practical understanding of how these key self-regulatory processes unfold among esports players. This line of research should lead to the development and funding of innovative educational and intervention programs and to the spread of these actions to parents, young adult peers or siblings, teachers, and esports coaches.

Authors' contributions

DB and JB wrote the manuscript. DLK provided critical input and revisions. The manuscript's content was discussed and approved by all authors.

Conflicts of interest statement

Nothing declared.

CRediT authorship contribution statement

Damien Brevers: Conceptualization, Methodology, Writing - original draft. **Daniel L King:** Writing - review & editing. **Joël Billieux:** Conceptualization, Writing - review & editing.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:<https://doi.org/10.1016/j.copsyc.2020.07.025>.

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