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Neurobiological correlates of internet gaming disorder: Similarities to pathological gambling

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HIGHLIGHTS

- Overview of neurobiological underpinnings of internet gaming disorder (IGD)
- Main focus on impulsivity, compulsivity and sensitivity to reward and punishment
- Comparison to findings in pathological gambling (PG)
- Neurobiological similarities between IGD and PG but more research needed

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ABSTRACT

The number of massively multiplayer online games (MMOs) is on the rise worldwide along with the fascination that they inspire. Problems occur when the use of MMOs becomes excessive at the expense of other life domains. Although not yet formally included as disorder in common diagnostic systems, internet gaming disorder (IGD) is considered a “condition for further study” in section III of the DSM-5. The current review aims to provide an overview of cognitive and neurobiological data currently available on IGD, with a particular focus on impulsivity, compulsivity, and sensitivity to reward and punishment. Additionally, we also compare these findings on IGD with data from studies on pathological gambling (PG)-so far the only condition officially classified as a behavioral addiction in the DSM-5.

Multiple similarities have been observed in the neurobiology of IGD and PG, as measured by alterations in brain function and behavior. Both patients with IGD and those with PG exhibited decreased loss sensitivity; enhanced reactivity to gaming and gambling cues, respectively; enhanced impulsive choice behavior; aberrant reward-based learning; and no changes in cognitive flexibility.

In conclusion, the evidence base on the neurobiology of gaming and gambling disorders is beginning to illuminate the similarities between the two. However, as only a few studies have addressed the neurobiological basis of IGD, and some of these studies suffer from significant limitations, more research is required before IGD's inclusion as a second behavioral addiction in the next versions of the ICD and DSM can be justified.

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1. Introduction

Internet use is part of everyday life, extending into both recreational and work domains. Although the internet has countless benefits, problems nonetheless occur if computer use becomes excessive, difficult to control, or interferes with daily life. Since the internet is only the medium, and users are addicted to different forms of content it facilitates access to, it is crucial to study those contents separately. Internet gaming disorder (IGD) is currently the best-studied domain. There are approximately 1.78 billion gamers worldwide as of August 2014 (http://www.statista.com/statistics/293304/number-video-gamers/; Accessed: 17th August 2015). Massively multiplayer online games (MMOs) allow users to play simultaneously alongside many other players through the internet. MMOs can be considered as perpetual environments that continue to evolve even when the player is not “in-game”. MMOs come in various forms that can be distinguished according to their content; the most common MMO types are role-playing games (MMORPG), in which players assume the roles of characters and act out fantastical adventures within the game's imaginary world, first-person shooters, and real-time strategy games (Kuss, 2013). Although not yet a formal disorder in common diagnostic systems (ICD-

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Table 1
Overview, characteristics and main results of neurobiological studies included in this review.

Internet gaming disorder (IGD)				Pathological gambling (PG)			
Study	Task & method	Sample/study size	Main results IGDp > HCs	Study	Task & method	Sample/study size	Main results PGs > HCs
Impulsivity							
Ding et al. (2014)	Go/no-go task (fMRI)	N = 17 IGDp N = 17 HCs	–No behavioral differences –Hyperactivation in no-go trials: superior/middle frontal gyrus; SMFG, ACC, IPC, PCG, precuneus, cuneus –Hypoactivation in no-go trials: SPC, middle/inferior TG	Smith et al. (2014)	Meta-analysis of go/no-go tasks (behavior)	3 go/no-go studies in PGs	–No behavioral differences
Chen et al. (2015)	Go/no-go task (fMRI)	N = 17 IGDp N = 17 HCs	–No behavioral differences –Hypoactivation in no-go trials: SMA/pre-SMA				
Ko et al. (2014)	Go/no-go task (fMRI)	N = 26 IGDp N = 23 HCs	–Hyperactivation in no-go trials: OFC, caudate nucleus				
Liu et al. (2014)	Go/no-go task under gaming-cue distraction (fMRI)	N = 11 IGDp N = 11 HCs	*Gaming cues*: –More commission errors –Hypoactivation in no-go trials: DLPFC, SPC	van Holst et al. (2012)	Go/no-go task under gaming cue distraction (fMRI)	N = 16 PGs N = 15 HCs	*Neutral cues*: –Slower but similar accuracy –Hyperactivation in no-go trials: DLPFC, ACC *Gambling cues*: –Better performance –Hypoactivation in no-go trials: DLPFC, ACC
Lin et al. (2015)	Probability discounting task (fMRI)	N = 19 IGDp N = 21 HCs	–Shorter RT; preference of probabilistic to fixed options –Hypoactivation when choosing probabilistic options: IFG, PCG	Madden et al. (2009)	Probability discounting task (behavior)	N = 19 PGs N = 19 HCs	–Less steep discounting of probabilistic rewards
				Miedl et al. (2012)	Probability discounting task (fMRI)	N = 16 PGs N = 16 HCs	–Trend towards discounting of delayed rewards –Corr. between VS and OFC activity; subjective values attenuated for risky rewards
Compulsivity							
Zhou et al. (2012)	Cue-related go/no-go switching task (behavior)	N = 46 IGDp N = 46HCs	–Inhibition deficits, shifting deficits and cognitive bias towards gaming cues	Boog et al. (2014)	Reward and non-reward based probabilistic reversal learning task (behavior)	N = 19 PGs N = 19 HCs	–Impaired performance for reward-based but not non-reward-based cognitive inflexibility
Dong et al. (2014)	Color-word Stroop task (fMRI)	N = 15 IGDp N = 15 HCs	–Hyperactivation: –Switching conditions: STG –Easy-to-difficult conditions: insula –Difficult-to-easy conditions: precuneus	Goudriaan et al. (2005)	Card playing task; reward perseveration (behavior)	N = 48 PGs N = 49 HCs	–Impaired performance
Choi et al. (2014)	Intra-extra dimensional shift task (behavior)	N = 15 IGDp N = 15 HCs	–No behavioral differences				
Sensitivity to reward and punishment							
Ko et al. (2009)	Cue reactivity task (fMRI)	N = 10 IGDp N = 10 HCs	–Hyperactivation: OFC, NAc, ACC, MFC, DLPFC, caudate nucleus	Crockford et al. (2005)	Cue reactivity task (fMRI)	N = 10 PGs N = 10 HCs	–Hyperactivation: DLPFC, PFC with IFG and medial frontal gyrus, OC with FuG, PHC
Ko et al. (2013b)	Cue reactivity task (fMRI)	N = 15 IGDp N = 15 IGDp -in rem. N = 15 HCs	–Hyperactivation: DLPFC, precuneus, PHC, PCC, ACC IGDp > IGDp rem.: –Hyperactivation: DLPFC, PHC	Goudriaan et al. (2010)	Cue reactivity task (fMRI)	N = 17 PGs N = 17 HCs	–Hyperactivation: PHC, PC, amygdala, occipitotemporal areas
Sun et al. (2012)	Cue reactivity task (fMRI)	N = 10 IGDp N = 10 HCs	–Hyperactivation: DLPFC, ACC IFC, ITG, insular and angular gyrus, cerebellum	Van Holst et al. (2012)	Go/no-go task under gaming cue distraction (fMRI)	N = 16 PGs N = 15 HCs	–Hyperactivation: DLPFC, ACC, VS
Dong et al. (2011)	Monetary card guessing task (fMRI)	N = 14 IGDp N = 13HCs	–Hyperactivation in gain trials: OFC –Hypoactivation in loss trials: ACC	Meng, Deng, Wang, Guo and Li (2014)	Meta-analysis of cue reactivity studies (fMRI)	13 fMRI cue-reactivity studies	–Hyperactivation: putamen, globus pallidus, MOG
Dong et al. (2013)	Monetary card guessing task — extreme win/lose situations (fMRI)	N = 16 IGDp N = 15 HCs	–Hyperactivation in gain trials: SFG –Hypoactivation in loss trials: PCC	Reuter et al. (2005)	Monetary card guessing task (fMRI)	N = 12 PGs N = 12 HCs	–Hypoactivation in win vs. loss trials: striatum, VMPFC
				De Greck et al. (2010)	Monetary card guessing task (fMRI)	N = 16 PGs N = 12 HCs	–Hypoactivation in win vs. loss trials (due to weaker deactivation during lose-events): VS, ventral putamen

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