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Prevalence and Correlates of Problematic Online Gaming: a Systematic Review of the Evidence Published in Chinese

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Abstract

Purpose of Review With the ongoing debate about whether problematic online gaming (POG) constitutes a genuine mental disorder, it is important for all available evidence in the field to be accessible. In this systematic review, we summarize the numerous results related to POG published in Chinese in order to make them more accessible to the international community.

Recent Findings We identified 36 relevant studies published in Chinese (7 epidemiological, 21 related to psychological factors, and 8 related to neurocognitive exploration, involving 362,328 participants in total). According to the literature, the prevalence rates of POG in China range from 3.5 to 17%, which is higher than those reported worldwide. Overall, the data published in Chinese are consistent with the international literature. Some distinctive findings emerged, however, in particular in relation to familial, scholastic, and social factors; cognitive impairments; and functional changes in neural circuits.

Summary This review is the first to render available articles on POG in Chinese for the international community, which could contribute to the current debate on the status of POG as a genuine mental health condition. Crucially, findings from the Chinese literature often resulted from studies conducted on large random or clinical samples. This is important because a repeated criticism about the recognition of POG as a genuine disorder is the fact that the evidence-based results rely heavily on convenience samples of nonclinical participants.

Keywords Problematic online gaming · Gaming addiction · Gaming disorder · Pathological gaming · Chinese · Systematic review

Introduction

Playing online games is a popular recreational activity worldwide with the number of players growing rapidly. According to Newzoo [1], a market intelligence provider, there were 2.2 billion online gamers worldwide in 2017, and revenue in the online games segment was expected to amount to US$ 109 billion in the same year. China has become the world's largest and most rapidly growing online gaming market. According to a report from the China Internet Network Information Center [2], as of December 2017, there were 583 million online game players in Mainland China. The same report also

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revealed that mobile games had become the largest sector in the Chinese online gaming market instead of computer games, driven mainly by smartphone and other handheld device sales.

However, online games are associated with negative consequences and functional impairment when played excessively [3•]. In 2013, Internet gaming disorder was included as a "condition for further study" in the DSM-5 [4], and the pending ICD-11 includes a gaming disorder condition in a section devoted to disorders that result from substance use and addictive behaviors [5]. In the existing literature, various terms have been used to describe a problematic or pathological pattern of video game use, such as Internet game addiction [6••], online game addiction [7, 8], problematic online game play [9], problematic video game use [10], and Internet gaming disorder [11]. The situation is the same in the Chinese literature, where no consensus exists for naming the condition. In the current article, we systematically use the term problematic online gaming (POG) to describe the condition in which the use of online video games is associated with tangible negative consequences (from mild problems to clinically relevant impairments).

More than 800 studies on POG have been conducted in Mainland China, but only a small fraction of them (around 10%; mainly neuroimaging studies) have been published in English [12–18]. Given the current context and continuous debates about the inclusion of gaming disorder in the ICD-11 [3•, 19–21], making all evidence on POG available to the international community has taken on a new urgency. To reach this objective in the current paper, we offer a systematic review of the POG studies published in Chinese. In particular, we sought to determine whether the Chinese POG literature is consistent with the international literature and whether new findings, not yet available to international readers, can be identified and shared.

Methods

A systematic review was conducted by using the largest scientific Chinese database, *China National Knowledge Infrastructure*. The following search terms (and their derivatives) with regard to gaming were entered in Chinese: "addiction," "disorder," "compulsion," "excessive," "problematic," and "pathological." Studies were selected in accordance with the following inclusion criteria: (1) published in a peer-reviewed journal indexed by the Chinese Science Citation Index or General Core Journals of China, (2) empirical research, and (3) available as full-text only in the Chinese language. After a systematic search, the following exclusion criteria were applied: (1) psychometric studies focused on scale development or validation only, (2) clinical studies focused on intervention or therapy only, (3) studies in which gaming time (instead of POG symptoms) was considered as the only standard for POG (e.g., gaming time ≥ 3 h equals POG), or (4) epidemiological studies reporting prevalence proportion in a sample size of less than 300. All studies published before January 2018 were included. The flowchart for article selection is displayed in Fig. 1.

Results

In total, our systematic literature search identified 36 Chinese studies fulfilling the inclusion/exclusion criteria. Among them, seven studies aimed to establish the prevalence of POG (four of these also explored the psychological correlates of POG) [22–28], 21 explored the correlates (e.g., demographics, familial/scholastic/social factors, personality traits and psychological factors, game-related factors) of POG [22, 24, 25, 28–43, 44•, 45], eight explored the neurocognitive deficits in POG (four studies used event-related potentials

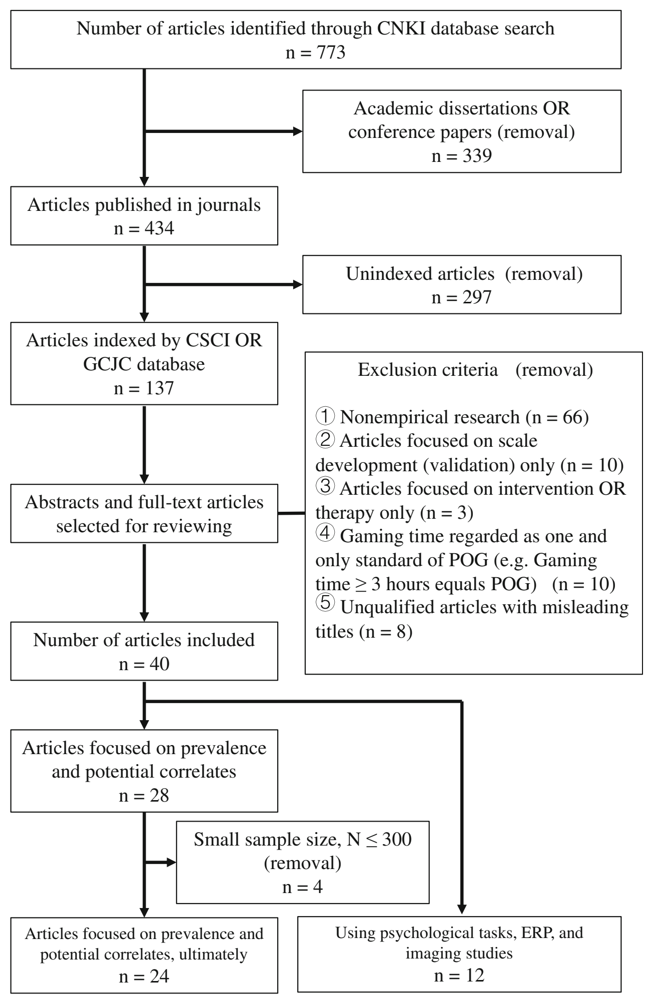

Fig. 1 Flowchart of the search strategy and selection procedure. CNKI China National Knowledge Infrastructure, CSCI Chinese Science Citation Index, GCJC General Core Journals of China, POG problematic online gaming, ERP event-related potential

(ERPs) [46–49] and four capitalized on laboratory tasks [50–53]), and four investigated whether POG is associated with functional changes in neural activities (functional magnetic resonance imaging, fMRI) [54, 55, 56•, 57•]. Overall, the 36 studies reviewed included 362,328 Chinese participants. Most studies focusing on the prevalence and correlates of POG capitalized on samples of students (50% of them were conducted in random representative samples) except for two studies that were conducted in community samples (one was conducted in a representative random sample) [27, 37]. Five studies that focused on neurocognitive deficits and cerebral correlates in POG were conducted in clinical and treatment-seeking samples [51, 53–55, 56•, 57•]. The next sections summarize (1) the prevalence data of POG, (2) the established correlates of POG, (3) the identified neurocognitive alterations in POG, and (4) the evidence of functional changes of neural activity in POG.

Prevalence Data of POG

The prevalence of POG (see Table 1) ranged from 3.5 to 17% in the studies published in Chinese [22–28]. According to international data published in English [58], the worldwide prevalence of POG varies from 0.7 to 15.6%. However, caution is required because these studies did not use standard diagnostic criteria to assess POG, which complicates the comparison of prevalence data.

In a multicenter national sample of 100,201 adolescents, the largest sample in the field to the best of our knowledge, Zuo and Ma [26] reported that the prevalence of POG among Chinese adolescents was 3.2%, and the prevalence among minors (age < 18 years) was 2.9%. Moreover, they also reported that the highest prevalence occurs among middle school and college students (both 3.2%), whereas the lowest appears among elementary school students (1.9%). In line with

Table 1 Summary of prevalence data

Study	Sample	Sample characteristics	Age range (years)	Measure(s)	Identification	Prevalence (%)
Yu et al. (2009) [22]	845	① Southern China ② 5 middle and high schools ③ Cluster random sampling	NR	IGAS	IGAS score ≥ 7 of 10	4.90
Ye et al. (2009) [23]	546	① Southern China ② 7 colleges and universities ③ Gamers only ④ Simple random sampling	17–24	IGAS	IGAS score ≥ 7 of 10	4
Zhao et al. (2009) [24]	471	① Southwestern China ② 4 colleges ③ Gamers only ④ Simple random sampling	20 ± 1.84	IGAS	Mild addiction: IGAS score > $\bar{x}$ ± S Severe addiction: IGAS score > $\bar{x}$ ± 2S	Mild addiction 15.5 Severe addiction 1.5
Yu et al. (2010) [25]	Total 1334 Male 649 Female 685	① Southern China ② 7 middle and high schools ③ Simple random sampling and purposive sampling	NR	IGADS	IGADS score ≥ 7 of 10	Total 3.5 Male 5.4 Female 1
Zuo and Ma (2010) [26]	100,201 (73,529 adolescents)	① Eastern China, central China, western China ② Multiple centers (10 provinces) ③ Elementary school, middle school, high school, vocational school, and college students; unemployed youth; parents; Internet service managers ④ Stratified random sampling	NR	IGAS	IGAS score ≥ 7 of 10	Adolescents 3.2 Minors 2.9
Chen et al. (2012) [27]	862	① Southeast China ② 5 cities, urban residents ③ Community participants ④ Simple random sampling	Total 7–62 Retiree group 52.33 ± 5.35 Student group 15.22 ± 7.01	YDQ	YDQ score ≥ 5 of 10	Student group 8.4 White collar 5.5 Blue collar 6.1 Retiree 1.0
Pan et al. (2013) [28]	1876	① Southeast China ② 4 professional high schools ③ Stratified cluster sampling	17.55 ± 2.15	IGAS	IGAS score > 25	7.70

NR not reported, *IGAS* Internet Gaming Addiction Scale, *IGADS* Internet Gaming Addiction Diagnosis Scale, *YDQ* Young's Diagnostic Questionnaire another study published in Chinese [25] and most studies published in the English literature [59••], this large sample study also verifies the increased prevalence of POG among males (males 4.9%; females 1.1%).

In addition, the Chinese literature adds to the available knowledge by providing prevalence rates that are stratified by profession [27]. More precisely, in this study, the highest prevalence of POG was found in students (8.4%), followed by blue-collar workers (6.1%), white-collar employees (5.5%), and retirees (1%). These findings support the possibility that socioeconomic status might constitute a risk factor for POG.

Established Correlates of POG

Table 2 lists the studies published in Chinese that have reported various correlates of POG in community samples. The following sections describe their findings regarding (1) demographic factors; (2) personality and psychological factors; (3) familial, scholastic, and social factors; and (4) game-related factors (game genres and gaming experience).

Demographic Factors

Similar to what has repeatedly been shown in the international literature [59••], the reviewed studies identified male gender as a predictor of POG in several large random samples of students (the largest sample size = 30,260) [22, 24, 25, 28, 29, 35, 42, 45]. Regarding the effect of grade level (i.e., academic years), one study found that junior-grade students were more vulnerable to POG in a random sample of vocational school students (secondary education designed to provide vocational education, or technical skills required to perform the tasks of a particular and specific job for middle-school graduates, commonly with few admission requirements) [28], whereas another study indicated that senior-grade students were more vulnerable in a mixed random sample that included middle, high, and vocational school students and unemployed youth [29]. Furthermore, it also reported that vocational school students and unemployed youth are more vulnerable to POG than are their peers [29].

Personality and Psychological Factors

POG has been consistently reported to be associated with a series of personality variables such as impulsivity, extraversion, neuroticism, or agreeableness [59••]. Kuss and Griffiths [60] argued that introversion, neuroticism, and impulsivity consist of three core characteristics of POG. Studies published in Chinese confirmed these results by showing that impulsivity and extraversion are linked to POG in large student samples (including random samples; see Table 2 for details) from vocational colleges and high schools [28, 45]. Moreover, other psychological risk factors identified in the international literature [59••], such as low self-esteem [61], psychopathological symptoms (depression and anxiety) [10, 62], low self-efficacy [63], and elevated perceived stress [64], were also linked to POG in large samples (see Table 2 for details). In line with the numerous studies showing that addictive use of video games is often an uncontrolled behavior displayed to reduce or alleviate aversive states [65, 66], several studies published in Chinese related POG to escapism [30, 34], poor self-control [32], and maladaptive emotion regulation strategies (e.g., tendency to blame others, ruminate, or catastrophize when facing stressors) [31, 36, 37]. Unfortunately, and similar to what has been characterized in the international literature, no longitudinal data are available in Chinese that would allow support of the existence of a causal pathway between maladaptive coping and the onset of POG.

A finding reported only in the Chinese literature is that lack of gratitude (defined as a general tendency to recognize and respond with grateful emotion to other people's benevolence) was associated with POG in left-behind children [35, 36, 38]. Left-behind children generally refer to children who remain in rural regions of China under the care of kin members while their parents leave to work in urban areas, mainly for occupational reasons. The status of left-behind children in China was notably related to increased vulnerability to both physical and psychological challenges, including substance abuse (tobacco and alcohol) and behavioral problems [67, 68]. Accordingly, the authors [35, 36, 38] argued that greater gratitude toward others acts as a protective factor against the development of POG.

Familial, Scholastic, and Social Factors

In comparison to most other research on POG, studies in East Asian countries have focused more on the relationship between POG and familial factors [69••]. It was thus reported in the Chinese literature that POG in students is related to family economic status (either extremely rich or poor) [22, 25], poor parental educational background [22, 25], dysfunctional parent–child relationships [22, 40], unconstructive parenting styles (including parental emotional and/or physical abuse) [29, 44, 45], and parental gaming behavior [28]. This type of data underscores an urgent need for further research (including longitudinal) that aims to specify the role of familial factors in the onset and maintenance of POG.

Regarding scholastic factors, POG was found to be associated in Chinese studies with poor teacher-student relationships [29], poor schoolmate relationships [29], poor scholastic attainment [28, 29, 42], destructive school atmosphere [38], and low levels of perceived school climate [43]. Concerning social factors, POG was linked to limited social support [22, 35], insufficient interpersonal communication [28], peer victimization [45], and more gamers among friends' networks [37]. Besides the abovementioned Chinese studies, another team

Table 2 Summary of POG correlates

Study	Sample characteristics	Demographic factors	Personality and psychological factors	Family factors	School-related factors	Social factors	Gaming-related factors
Yu et al. (2009) [22]	① 845 (participants) ② Age range: NR ③ Middle and high school students ④ Cluster random sampling	① Male		① Poor educational backgrounds ② Family economic status (either rich or poor) ③ Dysfunctional parent-child relationship		① Poor social support	
Zhao et al. (2009) [24]	① 471 ② Age range 20 ± 1.8 ③ College and university students ④ Simple random sampling	① Male	① Low level of self-esteem ② Low level of self-efficacy				
Zhang and Ruan (2009) [29]	① 3050 ② Age range 11–30 ③ Middle and high school students, vocational students, and unemployed youth ④ Stratified random sampling	① Male ② Senior grade ③ Vocational students ④ Unemployed youth	① Escapism	① Dysfunctional parenting style ② Parental bad habits (e.g., substance abuse)	① Poor teacher-student relationship ② Poor schoolmate relationship ③ Poor scholastic attainment		① Game genre
Yu et al. (2010) [25]	① 1334 ② Age range: NR ③ Middle and high school students ④ Simple random sampling	① Male		① Poor educational background (their parents) ② Family economic status (either too rich or poor)			① Role-playing games ② Games with aggressive plots
Yu et al. (2010) [30]	① 471 ② Age range 20 ± 1.8 ③ College and university students ④ Gamers only ⑤ Simple random sampling		① Escapism ② Self-affirmation and self-efficacy during gaming				
Zhou et al. (2011) [31]	① 400 ② Age range: disorder group 22.5 ± 2.5 Control group 21.8 ± 0.96 ③ College students ④ Convenience sampling		① Negative mood states ② Negative cognitive strategies (e.g., blame others)				
He et al. (2012) [32]	① 453 ② Age range: NR ③ College and university students ④ Male only ⑤ Cluster random sampling		① Low self-control ② Low self-esteem				
Wei et al. (2012) [33]	① 491 ② Age range: NR ③ University students ④ Male gamers only ⑤ Convenience sampling						① High level of flow experience ② High level of challenge ② High level of mastery and control
Pan et al. (2013) [28]	① 1876 ② Age range 17.6 ± 2.2 ③ Vocational college students ④ Stratified cluster random sampling	① Male ② Junior grade	① Extraversion ② Lack of life goal	① Poor family satisfaction ② High parental gaming frequency ③ Poor parental supervision	① Poor scholastic attainment	① Poor interpersonal communication	

Table 2 (continued)

Study	Sample characteristics	Demographic factors	Personality and psychological factors	Family factors	School-related factors	Social factors	Gaming-related factors
Wei et al. (2014) [34]	① 384 ② Age range: NR ③ College and university students ④ Male game players only ⑤ Convenience sampling		① High level of perceived pressure ② Escapism				
Wei et al. (2014) [35]	① 498 ② Average age 14.65 ③ Left-behind children (middle students) ④ Cluster random sampling	① Male	① Weak gratitude disposition			① Poor social support	
Wei et al. (2014) [36]	① 482 ② Average age 14.60 ③ Left-behind children (middle students) ④ Cluster random sampling		① Weak gratitude disposition ② Dysfunctional coping strategies				
Wang et al. (2015) [37]	① 1906 ② Age range: NR ③ Community participants ④ Male gamers only ⑤ Convenience sampling		① Maladaptive cognitions			① Larger proportion of gamers in the social network	
Wei et al. (2015) [38]	① 835 ② Age range 10.6 ± 1.0 ③ Left-behind children (high school students) ④ Cluster random sampling		① Weak gratitude disposition		① Disharmonious school atmosphere		
Zhang and Lei (2015) [39]	① 380 ② Average age 13.91 ③ Middle and high school students ④ Convenience sampling						① High level of perceived usefulness ② High level of perceived usability ③ High level of perceived game quality ④ High level of game experience ⑤ Positive attitude toward game
Su et al. (2016) [40]	① 4105 ② Age range 13.7 ± 2.7 ③ Elementary, middle, and high school students ④ Cluster random sampling			① Poor parental supervision ② Poor parenthood		①Deviant peer affiliation	
Wei et al. (2016) [41]	① 465 ② Age range: NR ③ College and university students ④ Convenience sampling						① High level of perceived competition, cooperation, and flow experience
Li et al. (2017) [42]	① 30,260 ② Age range 15.1 ± 1.9 ③ Middle and high school students ④ Stratified random sampling	① Male	① Anxiety ② Depression ③ Loneliness		① Poor scholastic attainment ② High level of academic pressure		

Table 2 (continued)

Study	Sample characteristics	Demographic factors	Personality and psychological factors	Family factors	School-related factors	Social factors	Gaming-related factors
Ma et al. (2017) [43]	① 1368 ② Age range 12.9 ± 0.5 ③ Middle school students ④ Convenience sampling				① Low level of learning engagement ② Low level of perceived school climate		
Yu et al. (2017) [44•]	① 1389 ② Age range 12.9 ± 0.5 ③ Middle school students ④ Convenience sampling			① Parental corporal punishment (e.g., spankings by parents)	① Low level of school connectedness		
Zhang et al. (2017) [45]	① 875 ② Average age 20.63 ③ High school students ④ Convenience sampling	① Male	① Impulsivity	① Parents' authoritarianism		① Peer victimization	

NR not reported, *POG* problematic online gaming

[70] in China reported (in English) that teacher support of autonomy might be an important protective predictor of POG in adolescents and that school engagement might have a mediating influence. Lo et al. [71] further reported that the quality of interpersonal relationships decreased as the amount of time spent playing online games increased.

Game Genres and Gaming Experience

In the literature on POG published in English, it was reported that massive multiplayer online role-playing games, first-person shooter games, fighting games, and real-time strategy games were preferred by youths displaying POG [59••] and that different game genres can have specific potential benefits and detrimental effects for individuals [72]. Yu et al. [25] reported that Chinese undergraduates engaged in role-playing games were more likely to present addictive use of video games. Furthermore, the same study also highlighted a link between POG and extremely violent plots.

Flow experience usually refers to a mental state in which a person performing a specific activity experiences the subjective state of being totally immersed in a feeling of energized focus, full involvement, and enjoyment. Such an experience has been reported to have the potential to exert a strong impact on the reward system in gamers [73]. Chinese literature not only reported similar findings, but it also extended them by showing in a sample of students that the flow state mediates the link between POG and three key gaming experiences: a sense of control, a sense of challenge, and a sense of competition [33, 41].

Identified Neurocognitive Alterations in POG

Table 3 lists the studies published in Chinese that reported neurocognitive alterations in POG. The following sections report their findings regarding (1) cognitive biases and (2) executive function.

Cognitive Biases

The international literature on executive control (e.g., inhibitory control) impairment has reported mixed results. A more consistent finding is the fact that POG participants display poorer executive performances (e.g., inhibition difficulties) when faced with game-related stimuli [74]. Similarly, Zhang [47] found that POG participants had a shorter reaction time toward game-related pictures in a dot probe detection task. The existence of this type of cognitive bias was also supported by ERP studies. Dai and his colleagues [49] found that game-related words elicited significantly increased P200 and P300 amplitudes (P200 being mostly related to higher order perceptual processing, modulated by attention, and P300 reflecting

Table 3 Summary of neurocognitive alterations in POG (EEG and/during laboratory tasks)

Study	Participants (age: $\bar{x} \pm$ S)	Scale	Identification	Laboratory measures	Main findings in participants with POG compared with controls
He et al. (2008) [46]	14 participants with POG/14 healthy controls (21.5 ± 1.3/20.6 ± 1.6) Male only	IAT and IAPS	NR	ERP during auditory discrimination task	- Shorter reaction time - Reduced P300 amplitude - Increased N1 amplitude
Zhang (2008) [47]	6 participants with POG/6 healthy controls (whole sample range 18–25)	M-YDQ	NR	ERP during a dot probe detection task	- Shorter reaction time toward game-related pictures - Lower P200 amplitude evoked by game-related pictures - Shorter P100 latency elicited from the dot stimulus that emerged on the same side of the game-related pictures
Xu et al. (2010) [48]	15 participants with POG/15 non-gamer controls (17.5 ± 2.7/16.9 ± 2.9)	IAT	① IAT ≥ 60, ② self-reported gaming as their major online activity, ③ at least 2 years of Internet use experience	ERP (CNV)	- Prolonged CNV latency - Lower average amplitude of CNV and PINV
Dai et al. (2011) [49]	12 participants with POG/12 healthy controls (19.5 ± 2.8/20.1 ± 3.5) Male only	YDQ	① YDQ ≥ 5, ② self-reported gaming as their major online activity, ③ prominent impairment caused by gaming	ERP during a game Stroop task	-Larger amplitudes of P200 and P300 evoked by game-related words for participants with POG (compared with neutral words)
Zhang and Wang (2012) [50]	26 participants with POG/24 healthy controls (21.7 ± 2.0/21.2 ± 2.4)	IAT	① IAT ≥ 50, ② self-reported gaming as their major online activity	Color Trail Test and Stroop test	-Shorter reaction time in CTT-II and CTT trial interference effects -Shorter reaction time in Stroop-B and Stroop-C and Stroop interference effects
Zhang et al. (2013) [51]	21 participants with POG*/21 non-gamer controls (20.90/20.76) Male only	YDQ	① YDQ ≥ 5, ② self-reported gaming as their major online activity, ③ clinical evaluation	Task switching paradigm	-Greater cognitive switching cost
Li et al. (2014) [52]	16 participants with POG/15 healthy controls (whole sample 21 ± 2) Male only	IAII and IAS	① IAII ≥ 40 ② IAS > 5	Go/no-go task	-Lower accuracy rate for Internet-related stimuli -No such differences for neutral stimuli
Zhang et al. (2014) [53]	14 participants with POG*/14 non-gamer controls (21.36/21.43) Male only	YDQ	① YDQ ≥ 5, ② self-reported gaming as their major online activity, ③ clinical evaluation	Attentional focus task	-Lower accuracy rate -Greater attentional switching in the visuospatial sketchpad task

POG problematic online gaming, *EEG* electroencephalography, *NR* not reported, *IAT* Internet Addiction Test, *IAPS* Internet Addiction Pattern Scale, *YDQ* Young's Diagnostic Questionnaire, *IAII* Internet Addiction Impairment Index, *IAS* Internet Addiction Scale, *ERP* event-related potential, *M-YDQ* modified Young's Diagnostic Questionnaire for Internet addiction, *CNV* contingent negative variation, *PINV* postimperative negative variation, *CTT* Color Trail Test

*Clinical and treatment-seeking sample

processes involved in stimulus evaluation or categorization) in POG participants, suggesting greater responsiveness to game-related cues in these individuals. However, Zhang [47] identified a lower P200 amplitude in POG participants than in healthy controls when faced with game-related pictures. One possible explanation might be that pictures are related to lower attentional processing in gamers because they are perceptively used in this type of stimulation (i.e., they are used for such stimuli), which is not the case for words (gamers might not see game-related words more often than non-gamers do in real-life situations). Furthermore, a study published by Li et al. [52] found a prepotent response inhibition deficit toward game-related stimuli for POG in a Go/No-Go task, but a preserved performance for neutral trials (i.e., game-unrelated stimuli), suggesting that attentional bias toward game-related stimuli may also influence executive control.

Executive Function

Using laboratory neuropsychological paradigms (see Table 3), several investigators highlighted executive function impairments in case-control studies. Most studies indicated that participants with POG had a lower level of executive functioning than non-gamers did [51, 53]. Using the task switching paradigm developed by Monsell et al. [75], Zhang et al. [51] showed that POG participants are slower when performing cognitive switching, which suggests a compromised ability in individuals displaying POG to shift attention away from gaming-related thoughts. Using the attentional focus task developed by Kübler et al. 2005 [76] in another study, Zhang et al. [53] reported an attention-shifting deficit in visuospatial working memory in treatment-seeking problematic gamers. In the same vein, He et al. [46] conducted an ERP study in which POG participants presented a reduced P300 amplitude and an increased N100 amplitude when processing neutral auditory stimuli. For these authors, the reduced P300 amplitude suggests that high-level cognitive and decisional abilities might be impaired in persons displaying POG. Finally, Xu et al. [48] found that POG participants are characterized by prolonged latency and lower average amplitude in the contingent negative variation ERP component, which is often interpreted in terms of deficits in higher order cognitive processes, such as decision-making. It is worth noting that only one Chinese study [50] reported a positive association between POG and executive functioning efficiency. In this study, better performances (shorter reaction time) on the Color Trail Test (a language-free version of the Trail Making Test assessing sustained and divided attention) and the Stroop test were found in a sample of POG participants. Although these results are surprising, the possibility cannot be excluded that they are partly related to the type of gaming that participants were engaged in, as it was reported that specific game genres (e.g., first-person shooter) were associated with shorter reaction times in cognitive tasks [72]. Unfortunately, the study did not consider the potential effect of game genre on the results.

Evidence of Functional Changes of Neural Activity in POG

Several functional magnetic resonance imaging studies identified some functional changes in neural activity in clinical POG samples (see Table 4). Adopting arterial spin labeling, Li et al. [56•] found that treatment-seeking adolescent gamers showed significantly higher global cerebral blood flow in brain areas that are crucial for sensory functions (temporal gyrus), learning and memory (parahippocampal gyrus), executive functioning (cingulate cortex, orbitofrontal gyrus), or reward processing (putamen). These results suggest a wide range of alterations in neural activity in POG. By investigating the resting state in clinical gamers, Du et al. [55] also found functional changes in several cerebral areas related to sensory functions (temporal gyrus), executive functioning (dorsolateral prefrontal cortex, medial prefrontal cortex, and anterior cingulate cortex), memory (parahippocampal gyrus), and reward processing (posterior cingulate cortex). These studies consistently demonstrated that POG may share similar neural mechanisms with substance use disorder and pathological gambling at the neural level (e.g., decreased loss sensitivity, enhanced cue reactivity, increased impulsive choices, and aberrant reward-based learning) [77–79].

The amygdala is known as a critical brain area associated with emotion regulation, memory, and learning, and it plays a pivotal role in craving of psychoactive substances [80]. Using functional connectivity analysis in a sample of treatment-seeking gamers, Han et al. [57•] found that clinical gamers have lower resting-state functional connectivity (rsFC) between the left amygdala and the right rectal gyrus, and that the rsFC level is negatively correlated with POG severity (indexed by total scores on the Chinese Internet Addiction Scale). Regarding dynamic functional connectivity (dFC), clinical gamers displayed lower left amygdala dFC with the postcentral gyrus and with the right inferior parietal lobe. Although both dFCs were associated with POG severity, the association with the postcentral gyrus was positive, whereas that with the right inferior parietal lobe was negative. These findings suggest that impaired functional connectivity of the amygdala with other areas related to memory and mood-related circuits might be important for the occurrence of POG [81].

Ding et al. [54] collected fMRI data during a probabilistic guessing task. Their study showed that the right anterior cingulate cortex, the right frontal lobe medial orbital cortex, and the left temporal pole were hyperactivated in clinical gamers in win trials. In loss trials, however, the left temporal pole was hyperactivated, whereas the right lingual gyrus and the right brainstem were hypoactivated in clinical gamers. The reaction times of clinical gamers were significantly shorter than those of control participants in both conditions. For the authors, these results confirm that adolescents with clinically relevant POG are more likely to show heightened preferences for immediate reward but tend to neglect the long-term adverse consequences because of enhanced reward sensitivity and decreased loss sensitivity, a phenomenon that has been documented in a wide range of addictive behaviors [82, 83].

Conclusion

In this systematic review, we examined the findings of numerous POG studies that were to date available only in Chinese

Table 4 Summary of neuroimaging studies on POG

Study	Participants (age: $\bar{x}$ ± S)	Scale	POG identification	Research design	Main findings in participants with POG compared with controls
Ding et al. (2013) [54]	17 participants with POG*/17 healthy controls (16.4 ± 3.2/16.3 ± 3.0)	CIAS	Beard's diagnostic criteria [84]	fMRI (during a probabilistic guessing task)	-Shorter reaction time in both win and loss conditions -Overactivation of right anterior cingulate cortex, right medial orbital frontal cortex, and left temporal pole in win condition -Overactivation of left temporal pole and underactivation of right lingual gyrus and right brainstem in loss condition
Du et al. (2014) [55]	17 participants with POG*/19 healthy controls (17.2 ± 1.9/18.9 ± 0.8)	NA	Criteria of IGD in DSM-5	fMRI (fALFF)	-Increased activation in the bilateral dorsal lateral prefrontal cortex, right medial prefrontal cortex, right anterior cingulated cortex, bilateral posterior cingulated cortex, right parahippocampal gyrus, right inferior temporal gyrus, and right precuneus -Decreased activation in the right temporal lobes, bilateral lingual gyrus, bilateral occipital lobes, and right splenium of corpus callosum and of bilateral cerebellum
Li et al. (2015) [56•]	18 participants with POG*/17 healthy controls (18.2 ± 3.5/18.9 ± 1.7) Male only	CIAS	Beard's diagnostic criteria [84]	fMRI (ASL)	-Higher global CBF in the right superior temporal gyrus, right orbitofrontal gyrus, right putamen, left cingulate gyrus, left putamen/parahippocampal gyrus, left middle temporal gyrus, left precentral gyrus, left brainstem, and left rectal gyrus -Negative correlation between CBF values in the right superior temporal gyrus and the CIAS scores in the POG group
Han et al. (2017) [57•]	30 participants with POG*/30 healthy controls (21.2 ± 2.7/20.8 ± 2.9)	CIAS	Beard's diagnostic criteria [84]	fMRI (FCA)	-Hypoactive rsFC between the left amygdala and the right rectal gyrus -Hypoactive dFC between the left amygdala and the right parietal inferior lobe/left postcentral gyrus associated with the CIAS scores

POG problematic online gaming, *ASL* arterial spin labeling, *CBF* cerebral blood flow, *CIAS* Chinese Internet Addiction Scale, *fALFF* fractional amplitude of low-frequency fluctuation, *FCA* functional connectivity analysis, *fMRI* functional magnetic resonance imaging, *IGD* Internet gaming disorder, *NA* not applicable, *rsFC* resting-state functional connectivity, *dFC* dynamic functional connectivity

*Clinical and treatment-seeking sample

(36 studies conducted on 362,328 participants were included in the current review) to make them accessible to the international community. Moreover, we showed that the findings from the Chinese literature often resulted from studies conducted in large random or clinical samples. This result could address the concern that too many studies in the field are from convenience samples of nonclinical participants [3•, 19–21]. Crucially, the current article not only reported results that are consistent with those published in English in the international literature, but it also made known several original results that were previously available in Chinese only.

Epidemiological studies published in Chinese and conducted in large and representative samples emphasize relatively high prevalence rates, which is in line with the reported tendency of a higher prevalence of POG in Asian countries [59••]. Furthermore, data published in Chinese also suggest that familial, scholastic, and social factors could play a pivotal role in the onset and maintenance of POG. Moreover, neuroimaging studies (mostly conducted in clinical samples) published in Chinese provide additional support to the view that POG shares similarities with addictive behaviors in terms of several neural circuitries (sensory, executive function, memory, and reward).

Some limitations of the studies reviewed should, however, be acknowledged. First, similar to the case in the international literature, the Chinese literature on POG may be jeopardized by inappropriate identification of POG because there is no consensus or gold standard regarding its diagnostic criteria. From the definition of gaming disorder provided in the latest draft of the ICD-11, it is hoped that common screening and diagnostic instruments can be developed to further facilitate research in this field. Moreover, like international research, Chinese research on POG lacks longitudinal designs that allow causality statements (e.g., to identify some correlates as potential risk or etiological factors; to decide whether some metabolic and functional changes are direct manifestations of POG or the consequences of compensatory responses to impairments associated with POG in neuroimaging studies). To further ascertain whether POG is a manifestation of errant coping strategies or a genuine behavioral addiction caused by psychological and biological dysfunctions, longitudinal research with valid diagnostic criteria and measures is warranted.

In conclusion, one of the domains of POG research that has received much more attention in the Chinese literature than in the international literature pertains to the impact of familial, scholastic, or social factors. Critically, as most of these factors are relatively adjustable and modifiable, this opens up new avenues for prevention strategies and clinical interventions. For example, family therapy performed by psychological therapists might be an easy and effective intervention for POG, as supported by initial evidence [85]. Moreover, these results also put into question the implementation of "boot-camp"-based interventions, which tend to largely ignore familial, scholastic, or social factors as being an important part of the treatment. Accordingly, further studies on these factors should be initiated at the international level, given the importance of cultural differences in characterizing them.

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Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest. This article has been edited by Editor-in-Chief Marc Potenza instead of Joël Billieux, as Joël Billieux is the Section Editor of the "Technological Addictions" topical collection.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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