Problematic Internet Use and Loneliness: How Complex Is the Relationship? A Short Literature Review

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Abstract

Purpose The Internet has become embedded into the life of billions of people worldwide. In some individuals, excessive Internet use impacts negatively on psychological and social functioning. Several studies over the last decades have focused on the relationship between Problematic Internet Use (PIU) and loneliness. The present review aims to provide an overview of the recent literature in this field and to suggest some critical questions.

Recent Findings A small-medium positive association between loneliness and PIU has been reported in several cross-sectional studies. However, the association becomes weaker when other variables are controlled for. Longitudinal studies suggest a dynamic relationship between PIU and loneliness.

Summary There is ample evidence that PIU and loneliness are positively associated, but care should be taken to control for other related variables (e.g., depression). Over time, PIU and loneliness seem to be linked in a vicious cycle, with PIU as a possible starting point.

Keywords Loneliness · Individual differences · Internet addiction · Problematic Internet use · Social isolation

Introduction

In the last two decades, the Internet has become part of our daily life, changing the way we work, communicate, shop, and so on. Despite its advantages, many people spend more time than necessary on the Internet and sometimes a psychopathological condition may result, with psychological, social, school, and/or work difficulties in a person's life [1, 2].

Psychological problems related to Internet use were first labeled as Internet Addiction Disorder, defined as an impulse-control disorder that does not involve an intoxicant [3]. Since then, several different labels have been used in the scientific literature to capture Internet-related problematic behavior, including Internet addiction, compulsive Internet use, computer addiction, pathological Internet use, and problematic Internet use [4]. In the present review, we will use the term

Problematic Internet Use (PIU) although other terms (e.g., Internet addiction) have been used in the literature. One of the most recent definition of PIU describes Internet-related problematic behavior as a condition involving excessive or poorly controlled urges and behaviors relating to Internet use that lead to subjective distress and/or interference in major areas of life functioning. It is a heterogeneous construct that may include a multitude features relating to sexual, social networking, and gaming behaviors [5]. A consensus regarding the diagnostic criteria for PIU and specific problematic online activities (i.e., pornography viewing, social networking sites use) has not been achieved yet. Indeed, many research gaps still exist, with arguably more gaps and controversies related to the mechanisms underlying the development and maintenance of Internet-related problematic behaviors.

A growing number of studies are reporting some significant adverse consequences of PIU, including reduced scholastic achievement, missing work, and mental health sequelae such as mood and anxiety disorders, social isolation, and loneliness [6–9, 10••, 11••, 12]. The relationship between loneliness and PIU has attracted a widespread and obvious interest among researchers over the last two decades. Recent studies have strived to deepen the understanding of the relationship between loneliness and Problematic Internet use. Across

studies, there are major inconsistencies in the way loneliness and PIU have been conceptualized and measured, in the type and number of constructs that have been considered besides loneliness and PIU, as well as in the approach to data analysis. Given this scenario, the present review will try to systematically examine and summarize the most recent findings on the nature of the association between loneliness and PIU.

Current Models and Proposed Mechanisms for Problematic Internet Use

In 2001, Davis [13] introduced a cognitive-behavioral model of pathological Internet use and discerned specific—from generalized pathological Internet use. Specific pathological Internet use refers to the pathological use of the Internet for a specific purpose (e.g., online sex, online gambling). This kind of overuse is content-specific and can occur even in the absence of Internet access. Generalized pathological Internet use (GPIU), instead, refers to wasting time online without a specific purpose or spending vast amounts of time in activities that are not content-specific [13]. Generalized and specific pathological Internet use can be viewed as addiction to the Internet itself and addiction on the Internet, respectively [14]. The cognitive-behavioral model of pathological Internet use [13] posits that GPIU results from social isolation or loneliness and low psychosocial well-being (e.g., mood disorders, substance use disorders). The need for social contact and the reinforcement obtained online would result in an increased desire to remain in a virtual social life [13]. Existing psychopathology would act as a distal necessary cause of symptoms of GPIU, predisposing individuals to develop maladaptive Internet-related cognitions, such as ruminating about one's overuse of the Internet, low self-efficacy, and negative self-appraisal. In turn, maladaptive Internet-related cognitions would act as proximal sufficient causes of behavioral and affective symptoms of both specific and generalized pathological Internet use, leading to difficulties with impulse control, that ultimately results in negative outcomes associated with Internet use [13].

In 2002, Davis [15] described technology-related psychological problems as a type of behavioral addictions, and referred to Internet-related problematic behaviors as Internet addiction, featuring the core components of addiction. Specifically, Internet addicts would be characterized by the attribution of greater salience to online activities, craving feelings and preoccupations when offline, mood modification, tolerance, withdrawal when reducing Internet usage, conflict, and relapsing back to Internet overuse [15]. Aiming to update Davis' model, Caplan [16] proposed a model of GPIU that incorporates some cognitive and behavioral variables that were identified by more recent research as key constructs associated with the negative outcomes of Internet use.

According to Caplan's model, individuals with a preference for online social interactions are more likely to use computer-mediated communication for alleviating the affective distress associated with face-to-face interactions. Using online interactions to regulate mood would be associated with deficient self-regulation, manifested as obsessive thought patterns related to Internet use and compulsive use of the Internet. In turn, deficient self-regulation would lead to negative outcomes in daily life [16].

In 2014, Brand, Young, & Laier [17] proposed a model on the development and maintenance of generalized and specific Internet addiction which combines the cognitive-behavioral model of GPIU [13] with a model of healthy Internet usage, and a global model of specific types of Internet addiction. Here, control processes and executive functions play a significant role on the person's coping style and Internet use expectancies. Specifically, reduced prefrontal control processes would underlie reduced coping and self-regulation abilities to deal with daily challenges, thus leading users to turn to the Internet. The experienced reinforcement when using the Internet (e.g.., reducing feelings of emotional or social loneliness) may increase positive Internet-related expectancies, making Internet usage the only way to cope with negative mood [17]. In this way, Internet users may engage in a loop where online activities increase the individual's focus on maladaptive general and Internet-related cognitions that, in turn, are reinforced by using the Internet.

A recently updated version of the Interaction of Person-Affect-Cognition-Execution (I-PACE) model of addictive behaviors [18••, 19] considers the interactions among predisposing variables, affective and cognitive responses to internal or external stimuli, executive and inhibitory control, decision-making behavior resulting in the use of certain Internet applications/sites, and consequences of using the Internet applications/sites of choice. Specifically, Brand et al. [19] have proposed that in the early stages of PIU, gratification is the main driving force that triggers changes in affective and cognitive responses to PIU-related stimuli. With the progression of the addiction process, the level of subjective gratification would decrease, and the level of compensating effects would increase. While losing control over the use of specific Internet applications/sites, there may be an increase in negative consequences, e.g., social isolation and loneliness, and other negative emotions and experiences. These feelings and losses of social contacts or other problems may be further exacerbated by repeatedly using the Internet applications/sites of choice, with compensation becoming more important than gratification [19].

While several models of PIU have been proposed, many research gaps still exist, with arguably more gaps and controversies related to the mechanisms underlying the development and maintenance of Internet-related problematic behaviors and their relationship with negative affect (e.g., loneliness).

Loneliness Is Linked Differently to Internet Use and to Problematic Internet Use

Loneliness has been defined as the unpleasant subjective feeling of the lack or loss of companionship, of missing certain relationships as well as a certain level of quality in one's relationships (see [20]). Two types of loneliness have been theorized: social loneliness, i.e., the feeling of boredom and marginality due to the lack of meaningful friendships or a sense of belonging to a community, and emotional loneliness, i.e., a feeling of emptiness and restlessness due to the lack of a network of social relationships [21].

Loneliness appears to be a hallmark of modern society. Surveys conducted in Europe, the USA, and Asia highlight that loneliness is common not only in the adult population, with higher prevalence (around 20–30%) among people 60 years and older (e.g. [22, 23],), but also in youth under 25 years (5–10%; see [24, 25]).

The relationship between loneliness and social Internet use has attracted a widespread and obvious interest among researchers over the last two decades. It has been suggested that new social technologies may contribute to increasing loneliness in modern society by replacing face-to-face interactions with superficial online communication, that lacks the intimacy and quality of human relationships [26]. Specifically, the displacement hypothesis suggests that people who engage in social Internet use experience higher loneliness levels because they displace offline relationships and activities with online ones [27]. In contrast, the stimulation hypothesis suggests that social Internet use works as a negative reinforcement, reducing loneliness by enhancing existing relationships and promoting new ones [28, 29]. More recently, a theoretical model has been proposed, where the relationship between loneliness and social Internet use would be bidirectional and dynamic, i.e., when social Internet use is a way to escape the offline social world, loneliness levels would increase; whereas when social Internet use is a way to expand one's social connections/strengthen existing ones, loneliness levels would decrease [30•].

Loneliness and Internet Use

In accordance with the displacement hypothesis, in a study on Belgian adolescents, emotional loneliness was positively related to both active Facebook use (using Facebook in a manner that facilitates interactions with other Facebook users, e.g., directed communication, broadcasting) and passive Facebook use (monitoring other users' content on Facebook, without communicating with the content owners about it). Moreover, greater passive Facebook use predicted lower perception of friend support. Lastly, emotional loneliness had an effect on depressed mood through passive Facebook use, public Facebook use, and other factors [31]. Notably, however, the

β coefficients were small. As reported in Table 1, similar effects were also obtained by Blachnio et al. [32] on Polish participants. Here, greater Facebook use (i.e., standard Facebook use and Facebook entertainment) and Facebook addiction were associated with higher loneliness, with the effect of loneliness on Facebook addiction being greater than that on Facebook use. Also similarly, in a study on Chinese students, the association between loneliness and preference for online social interaction was positive and small-medium when included in a path model with subjective well-being and external locus of control [47].

These results seem to suggest that engaging in Internet use may lead to higher loneliness levels. However, the cross-sectional nature of most of the studies does not allow to infer cause-effect associations here. Indeed, some findings rather seem to lend support to the stimulation hypothesis. Specifically, a study on social network site use in young American adults [48] and a study on Internet use on older adults in Israel [49•] found small and negative associations between loneliness and social network site use, and Internet users to be less lonely than non-Internet users. Of note, in a study on young Americans, higher Instagram use for interaction and browsing was associated with lower loneliness [50]. In contrast, higher Instagram broadcasting was associated with higher loneliness, with overall medium effects [50].

These findings could be viewed as supporting a dynamic nature of the relationship between loneliness and Internet use [30•], where loneliness could be increased or decreased based on whether one uses the Internet in a way that replaces offline social interactions with online ones, or to build up new friendships and enhance existing ones.

Loneliness and Problematic Internet Use

Most of aforementioned studies focused on the use of the Internet without including a measure of problematic Internet use. In this condition, the relationship between problematic Internet/social network site use and loneliness is expected to be consistently positive. Indeed, this expected positive association emerged in the study by Blachnio et al. [32]. Moreover, it has been observed in young Turkish participants [35], in Indian post-graduate students [36•], in Chinese adolescents [37•], in Chiang Mai medical students [38•], in Chinese adolescents [40], in Iranian adolescents [41•], in Portuguese adolescents and young adults [42•], and in more than 1000 Americans, South Koreans, and Finnish [45••]. The same positive relationship has also been found in Chinese left-behind middle-school students [43•] and in individuals with and without Attention-Deficit/Hyperactivity Disorder [44]. A study on American older adults reported that problematic social media use is associated with higher perceived social isolation [39•]. In contrast with these findings, a study on Turkish adolescents did not report a statistically significant association

Table 1 Journal articles that have examined the relationship between Problematic Internet Use (PIU) and loneliness in the last 5 years (an article published in 2014 has been also included because of its relevance for addressing this topic)

Authors	Sample characteristics	Study design	Measure of PIU	Measure of loneliness	Relationship between PIU and loneliness
Błachnio et al. [32]	551 individuals; age range = 15–29 years; 29% males	Cross-sectional	The Facebook Usage Questionnaire. It included three factors labeled Standard Facebook Use (19 items); Facebook Addiction (12 items); Facebook Entertainment (7 items). Cronbach's alpha was .88 for the first factor, .85 for the second one, and .69 for the third one	The Polish version of the Loneliness Scale (11 items). The items are rated on a five-point Likert scale. Cronbach's α was .86	Association between Facebook addiction and loneliness net of gender, age, self-presentation style (self-promotion and self-depreciation), and the need for privacy: $\beta = .24$, $p < .001$
Karakose et.al [33].	712 individuals; age range = 14–18 years; 41.6% males	Cross-sectional	The Turkish version of the Bergen Facebook Addiction Scale (BFAS; 6 items). The items are rated on a five-point Likert scale (very rare, rarely, sometimes, often, very often). Cronbach's α was .84	The Turkish version of the shortened form of the UCLA (University of California, Los Angeles) Loneliness Scale (7 items). The items are rated on a four-point Likert scale (never, rarely, sometimes, always). Cronbach's α was .73	Association between Facebook addiction and loneliness $r = .13$, $p = .083$
Ostovar et al. [34]	1052 individuals; mean age = 32.3 ± 3.30 years; 59% males; Internet addicted = 632 (68% males); Controls = 420 (37% males)	Cross-sectional	The Persian version of the Internet Addiction Test (IAT; 20 items). The items are rated on a five-point Likert scale (from 1 = rarely to 5 = always). Cronbach's α was .92	The Persian version of the Loneliness Scale (LS; 38 items). The items are rated on a five-point Likert scale (from 1 = very strongly to 5 = not at all). Cronbach's α was .98	Association between Internet addiction and loneliness $r = .67$, $p < .01$ Internet addicted showed higher loneliness levels than controls (F = [5, 1047] = 58.83, $p < .001$) net of stress, depression, and anxiety
Ozsaker et al. [35]	459 individuals; mean age = 20.92 ± 2.15 years; 41% males	Cross-sectional	The Problematic Internet Use Scale (PIUS; 33 items). Cronbach's α was .95	The UCLA Loneliness Scale (Version 3, 20 items). The items are rated on a four-point Likert scale (never, seldom, sometimes, often). Cronbach's α was not reported	Association between PIU and loneliness $r = .31$, $p < .01$
Shettar et al. [36•]	100 individuals; mean age = 27.55 ± 2.88 years; 54% males	Cross-sectional	The BFAS (six items). The items are rated on a five-point Likert scale (very rare, rarely, sometimes, often, very often). Cronbach's α was not reported	The UCLA Loneliness Scale (Version 3, 20 items). The items are rated on a four-point Likert scale (never, seldom, sometimes, often). Cronbach's α was not reported	Association between severity of Facebook addiction and loneliness $r = .24$, $p < .05$
Shi et al. [37•]	3289 individuals; age range = 10.9–18 years; 41% males Internet addicted = 679 individuals	Cross-sectional	The Chinese version of the Internet Addiction Diagnostic Questionnaire (IADQ; 10 items). The participants answered either "Yes" (recorded as 1) or "No" (recorded as 0) to each item. Cronbach's α was .79	The Loneliness in Children Scale (20 items). The items are rated on a four-point Likert scale (from 1 = very strongly disagree to 4 = very strongly agree). Cronbach's α was .94	Association between Internet addiction and loneliness $r = .22$, $p < .001$ Association between Internet addiction and loneliness $\beta = .15$, $p < .001$ net of gender, age, family functioning, and self-esteem
Simcharoen et al. [38•]	330 individuals; mean age = 20.88 ± 1.81 years; 43% males	Cross-sectional	The Thai version of the IAT (20 items). The items are rated on a five-point Likert scale (from	The Thai short version of the UCLA (seven items). The items are rated on a four-point Likert scale	Association between Internet addiction and loneliness $\beta = .27$, $p < .001$ net of amount of

Table 1 (continued)

Authors	Sample characteristics	Study design	Measure of PIU	Measure of loneliness	Relationship between PIU and loneliness
			1 = rarely to 5 = always). Cronbach's α was .90	(never, rarely, sometimes, always). Cronbach's α was .82	time daily spent using the Internet, objectives of negative coping, being accepted, curiosity, activities of work, entertainment, social connection, studying, and indulgence; association between Internet addiction and loneliness $\beta = .05$, $p < .001$ net of amount of time daily spent using the Internet, objectives of negative coping, being accepted, curiosity, activities of work, entertainment, social connection, studying, indulgence, and interpersonal problems
Meshi et al. [39•]	213 individuals; mean age = 62.6 ± 8.3 years; 20.2% males	Cross-sectional	The Bergen Social Media Addiction Scale (BSMAS; 6 items). The items are rated on a five-point Likert scale (from 1 = very rarely to 5 = very often). Cronbach's α was .70	The Patient-Reported Outcomes Measurement Information System (PROMIS) social isolation scale (four items). The items are rated on a five-point Likert scale (from 1 = never to 5 = always). Cronbach's α was .87	Association between Problematic Social Media Use and perceived social isolation $\beta = .16$, OR = 1.17 net of demographic variables, depressive symptoms, and estimated daily minutes on social media
Zeng et al. [40]	624 individuals; mean age = 16.19 ± 2.05 years; 49.7% males	Cross-sectional	The Chinese version of the IAT (20 items). The items are rated on a five-point Likert scale (from 1 = rarely to 5 = always). Cronbach's α was .90	The Chinese version of the UCLA Loneliness Scale (Version 3, 20 items). The items are rated on a four-point Likert scale (from 1 = never to 4 = often). Cronbach's α was .85	Association between Pathological Internet use and loneliness $r = .29$, $p < .01$ Association between Pathological Internet use and loneliness $\beta = .29$, $p < .001$ net of explicit self-esteem
Parashkouh et al. [41•]	581 individuals; mean age = 16.2 ± 1.2 years; 47% males	Cross-sectional	The IAT (20 items). The items are rated on a five-point Likert scale (from 1 = rarely to 5 = always)	The UCLA Loneliness Scale (Version 3, 20 items). The items are rated on a four-point Likert scale (never, seldom, sometimes, often)	Association between Internet addiction and loneliness $r = .20$, $p = .0001$, OR = 1.005–1.034
Costa et al. [42•]	548 individuals; age range = 16–26 years; 57.3% males	Cross-sectional	The Generalized Pathological Internet Use Scale-2 (GPIU-2, 15 items). The items are rated on a five-point Likert scale (from 1 = never to 5 = always)	The UCLA Loneliness Scale (Version 3, 20 items). The items are rated on a four-point Likert scale (never, seldom, sometimes, often)	Association between Internet addiction and loneliness in females $r = .28$, $p < .001$ Association between Internet addiction and loneliness in males $r = .35$, $p < .001$ Association between Internet addiction and loneliness in females $\beta = .17$, $p < .01$ net of indices of face-to-face social support Association between Internet addiction and loneliness in males

Table 1 (continued)

Authors	Sample characteristics	Study design	Measure of PIU	Measure of loneliness	Relationship between PIU and loneliness
					$\beta = .25$, $p < .001$ net of indices of face-to-face social support
Ren et al. [43•]	416 left-behind middle school students; 50.7 males	Cross-sectional	The Internet Addiction Disorder Diagnostic Scale for Middle School Students (IADDS, 13 items). Two-level scoring is used, with "yes" scored 1 point and "no" scored 0 points. Cronbach's α was .71	The ULS-8 Loneliness Scale (eight items; an adaptation from the UCLA-20 scale). The items are rated on a four-point Likert scale (never, rarely, sometimes, always). Cronbach's α was .80	Association between Internet addiction and loneliness $r = .32$, $p < .01$ Association between Internet addiction and loneliness $\beta = .13$, $p = .035$ net of social anxiety
Li et al. [44]	1021 individuals 73 individuals with ADHD; age range 19–33 years; 53.4% males 73 controls matched by gender and age	Cross-sectional	The Revised Chen Internet Addiction Scale (CIAS-R; 26 items). The items are rated on a four-point Likert scale. The items assess five dimensions of Internet-related problems: tolerance, compulsive use, withdrawal, the negative impact on social activities, interpersonal relationships and physical conditions, and time management	The UCLA Loneliness Scale (version 3; 20 items). The items are rated on a four-point Likert scale (never, rarely, sometimes, always)	Association between Internet addiction and loneliness in individuals with ADHD $r = .54$, $p < .01$ Association between Internet addiction and loneliness in controls $r = .52$, $p < .01$ Association between Internet addiction symptoms and loneliness in individuals with ADHD $\beta = .33$, $p = .006$ net of gender, Internet use-related characteristics, impulsiveness, novelty seeking, and behavioral inhibition Association between Internet addiction symptoms and loneliness in controls $\beta = .06$, $p = .6$ net of gender, Internet use-related characteristics, impulsiveness, novelty seeking, and behavioral inhibition
Savolainen et al. [45••]	1212 individuals from American; 49.8% males 1192 individuals from South Korean; 49.6% males; 1200 individuals from Finland; 50% males Age range 15–25 years	Cross-sectional	The Compulsive Internet Use Scale (CIUS; 14 items). The items are rated on a five-point Likert scale (from 0 = never to 4 = very often). Cronbach's α was .95 in the United States, .95 in South Korea, and .93 in Finland	The three-item Loneliness Scale (adapted from the standard Loneliness Scale, three items). The items are rated on a three-point Likert scale (1 = hardly ever, 2 = some of the time, and 3 = often)	Association between compulsive internet use and perceived loneliness $\beta = .41$, $p < .001$ in United States; $\beta = .30$, $p < .001$ in South Korea; $\beta = .28$, $p < .001$ in Finland net of gender, age, and living situation (i.e., living alone) Association between compulsive internet use and perceived loneliness $\beta = .30$, $p < .001$ in United States; $\beta = .21$, $p < .001$ in South Korea; $\beta = .23$, $p < .001$ in Finland net of gender, age, living situation (i.e., living alone), belonging to friends, belonging to an online community,

Table 1 (continued)

Authors	Sample characteristics	Study design	Measure of PIU	Measure of loneliness	Relationship between PIU and loneliness
					and psychological distress
Hou et al. [46]	64 individuals; age range = 18–24 years 32 addicts; mean age 20.34 ± 1.47 years 32 non-addicts; mean age 20.45 ± 1.34 years	Cross-sectional	Internet Addiction Test for Chinese (YIAT-C; 20 items). The items are rated on a five-point Likert scale (from 1 = never to 5 = always). Cronbach's α was .94	The Chinese version of UCLA Loneliness Scale (20 items). The items are rated on a four-point Likert scale (from 1 = never to 4 = all the time). The Cronbach's α was .86	Internet addicts showed higher loneliness levels than controls ($t = -3.72$, $p < .001$, Cohen's $d = .94$)
Yao et al. [12]	361 individuals; mean age 21.63 ± 2.60 years; 51.7% males	Two-wave panel survey	The IAT (20 items). The items are rated on a five-point Likert scale (from 1 = rarely to 5 = always)	The UCLA Loneliness Scale (20 items). The items are rated on a seven-point Likert scale	Associations between Internet addiction and loneliness at T1 $r = .47$, $p < .01$; at T2 $r = .35$, $p < .01$ Internet addiction at T1 positively predicted loneliness at T2 $\beta = .18$, $p < .001$
Zhang et al. [10••]	169 individuals; 47.9% males; mean age at the beginning of the study = 18.31 ± 0.77 years	Longitudinal—the beginning of the school year (T1, measures: social support and Internet addiction), 6 months later (T2, measure: loneliness), and 1 year later (T3, measures: social support and Internet addiction)	The Chinese Internet addiction scale (CIAS-R; 19 items). The items are rated on a four-point Likert scale (from 1 = strongly disagree to 4 = strongly agree). The scale includes four dimensions: compulsive Internet use and withdrawal from Internet addiction (CIU & WIA), tolerance of Internet addiction (TIA), time management problem (TMP), and interpersonal and health problem (IHP). The Cronbach's α for the total CIAS-R scale at T1 was .90, and the values for the four subscales were .75 (CIU & WIA), .73 (TIA), .82 (TMP), and .66 (IHP). The Cronbach's α for the total CIAS-R scale at T3 was .94, and the values for the four subscales were .83 (CIU & WIA), 0.79 (TIA), .85 (TMP), and .74 (IHP).	The Chinese version of UCLA Loneliness Scale (20 items). The items are rated on a four-point Likert scale (from 1 = never to 4 = often). The Cronbach's α at T2 was 0.91.	Associations between loneliness at T2 and CIU & WIA $r = .32$, $p < .01$; TIA $r = .25$, $p < .01$; TMP $r = .31$, $p < .01$; IHP $r = .30$, $p < .01$ at T1 Associations between loneliness at T2 and CIU & WIA $r = .27$, $p < .01$; TIA $r = .25$, $p < .01$; TMP $r = .32$, $p < .01$; IHP $r = .29$, $p < .01$ at T1 Loneliness at T2 was positively predicted by CIU & WIA ($\beta = .20$, $p < .05$) and TMP ($\beta = .19$, $p < .05$) at T1 Loneliness at T2 positively predicted CIU & WIA ($\beta = .21$, $p < .01$), TIA ($\beta = .19$, $p < .05$), TMP ($\beta = .30$, $p < .001$), and IHP ($\beta = .36$, $p < .001$) at T3
Tian et al. [11••]	291 individuals; mean age at the end of the study = 19.07 ± 0.78; 49% males	Longitudinal—the beginning of the university year (T1, measures: shyness, loneliness, and Internet addiction), 6 months later (T2, measures: shyness, loneliness, and Internet addiction), and 12 months later (T3, measures: shyness, loneliness, and Internet addiction)	The Chinese version of the Internet Addiction Scale (20 items). The items are rated on a six-point Likert scale (from 1 = never to 6 = always). The Cronbach's αs were .82, .84, and .87 at T1, T2, and T3, respectively	The Chinese version of the Cheek and Russell Loneliness Scale (ten items). The items are rated on a four-point Likert scale (from 1 = never to 4 = often). The Cronbach's αs were .87, .84, and .86 at T1, T2, and T3, respectively	Associations between generalized pathological Internet use (GPIU) and loneliness at T1 $r = .34$, $p < .01$; at T2 $r = .24$, $p < .01$; and at T3 $r = .45$, $p < .01$ GPIU at T1 positively predicted loneliness at T2 $\beta = .21$, $p < .01$ GPIU at T2 positively predicted loneliness at T3 $\beta = .21$, $p < .01$

Table 1 (continued)

Authors	Sample characteristics	Study design	Measure of PIU	Measure of loneliness	Relationship between PIU and loneliness
					Loneliness at T2 positively predicted GPIU at T3 $\beta = .17$, $p < .01$

between loneliness and Facebook addiction. However, the authors argued that the lack of high scorers on the measure of Facebook addiction may account for the null findings. In other words, the results may be representative of Facebook users rather than Facebook addicts [33].

Interestingly, loneliness was found to be higher in individuals with than those without Internet addiction. Specifically, Ostovar et al. [34] found that Internet addiction was positively associated with loneliness by a medium effect size (home Internet users selected randomly from subscribers of Iranian Internet provider companies) and Internet addicts showed higher loneliness levels than nonaddicts. Hou et al. [46] also found that Internet addicts had higher loneliness score than controls.

All the aforementioned studies are cross-sectional and included different self-report measures to assess both problematic Internet use and loneliness (see Table 1). This makes comparison of the results difficult. Moreover, most of them have relied on correlation or regression approaches to data analysis, and the obtained results show that the strength of the relationship between loneliness and Internet use is indeed modest. A more critical analysis of the results is necessary, including the examination of the role of some confounding variables that may affect this relationship.

Problematic Internet Use, Loneliness, and Possible Confounding Variables

Loneliness has been found to be strongly related with increased depressive symptoms [51], shyness [52•], and anxiety [53], and decreased self-esteem [54], social skills, social network size, and social support [55] and to be affected by gender and age [56, 57]. Such pattern of associations makes it of primary importance to partial out the unique contribution of loneliness to problematic Internet use and may be one important determinant of several inconsistencies across studies.

Indeed, when the association between PIU and loneliness has been investigated without controlling for other variables in the analyses, most studies reported medium positive associations. However, as reported in Table 1, the effects seem to be much smaller after controlling for perceived social support and depression [35]; family functioning and self-esteem [37•]; interpersonal problems

[38•]; lack of a committed relationship, poorer family functioning, age, lack of time to spend with family due to time online, and lack of interference of time online on time spent socializing face-to-face with friends [42•]; psychological distress; belonging to a friendship group; and belonging to an online community [45••].

The Role of Sex and Age in the Relationship Between Loneliness and PIU

To the best of our knowledge, only few studies have recently investigated whether the association between loneliness and PIU differs across males and females. Specifically, it has been shown that the association between loneliness and generalized pathological Internet use was similar across males and females; however, the strength of this association was marginally stronger for males [11••]. Similar results have been found by Costa et al. [42•], investigating the relationship between loneliness and PIU in males and females separately (see Table 1). However, more studies on this topic are needed in order to further understand a possible role of sex in mediating the relationship between loneliness and PIU.

Studies that contrast the relationship between loneliness and PIU across different age groups are also limited. By examining the literature separately by age groups, higher loneliness has been associated to more severe PIU similarly across not only adolescents and young adults [32, 35, 36•, 37•, 38•, 40, 41•, 42•, 43•, 44, 45••] but also older adults [39•]. These findings seem to be in contrast with those on the relationship between loneliness and Internet use, where age moderates the relationship between loneliness and social Internet use [30•]. Although the most recent literature does not seem to highlight any age difference, further research should examine more closely the relationship between loneliness and PIU at different ages.

Loneliness and Problematic Internet Use: the Chicken-Egg Question

Although several studies so far have evidenced an often complex association between loneliness and PIU, the cause-effect relationship has remained elusive. Indeed, cross-sectional designs, which dominate this research field, do not allow for the exploration of longitudinal and possibly bidirectional relationships between the two variables of interest.

It could be hypothesized that lonely individuals may end up engaging excessively in online activities because of the increased potential for social interactions, and as a way to relieve negative affect associated with loneliness. In this perspective, loneliness would predate PIU and may be a cause of PIU. On the other hand, PIU may lead to withdrawal from offline social contact and thus may cause increased loneliness. If so, loneliness may be a consequence of PIU. Only few studies to our knowledge have directly addressed the cause-effect relationship between loneliness and PIU by using longitudinal designs (see Table 1). A cross-lagged panel survey of college students in Hong Kong [12] showed that Internet addiction measured at Time 1 significantly predicted loneliness at Time 2 (4 months later), thus suggesting that Internet addiction would cause increased feelings of loneliness over time.

Partially similar findings were obtained by Zhang et al. [10••] on post-secondary school students in China. In this longitudinal study, questionnaire measurements were taken at the beginning of the school year (T1), 6 months later (T2), and 1 year later (T3). Two dimensions of Internet addiction measured at T1, i.e., Compulsive Internet Use & Withdrawal from Internet addiction and Time Management Problems, were found to predict loneliness at T2. However, because loneliness at T2 positively predicted all four dimensions of Internet addiction (Compulsive Internet Use & Withdrawal from Internet addiction, Tolerance for Internet Addiction, Time Management Problems, and Interpersonal and Health Problems) at T3, the authors concluded that loneliness has a stronger and more extensive effect on Internet addiction than Internet addiction has on loneliness. A methodological limitation of this study, i.e., the fact that loneliness was measured only at T2, makes the interpretation of the results somewhat difficult. However, the pattern of findings suggests that there may be a vicious circle linking loneliness and Internet addiction.

The findings of a third longitudinal study on Chinese university students, where GPIU, shyness, and loneliness were measured at three time points separated by 6-month intervals, again suggest the existence of bidirectional relationships between GPIU, shyness, and loneliness [11••]. Indeed, GPIU at T1 positively predicted increased loneliness at T2, GPIU at T2 positively predicted increased loneliness at T3, and loneliness at T2 positively predicted increased GPIU at T3. Furthermore, loneliness was found to play a bidirectional mediating role in the association between shyness and GPIU, i.e., shyness at T1 and GPIU at T3 were mediated through increased loneliness at T2, and GPIU at T1 and shyness at T3 were mediated through increased loneliness at T2.

Although the findings obtained by both Tian et al. [11••] and Zhang et al. [10••] suggest a bidirectional link between loneliness and PIU, one point is noteworthy. In all the three longitudinal studies mentioned above, PIU at T1 predicts loneliness at T2, and not the other way around. This may indicate that any potential vicious cycle linking PIU and loneliness indeed starts with excessive Internet use, which then increases loneliness as a consequence of withdrawal from face-to-face interactions. Further, increased loneliness would potentiate Internet use to compensate for poor offline social interactions, and thus trigger a "snowball effect." However, more longitudinal research is needed to verify the strength of this assumption.

Conclusion

Over the last decade, PIU has had an exponential growth worldwide, with the most problematic users among adolescents and young adults [58]. Despite the growing interest of researchers in PIU, its underlying mechanisms and negative consequences on a person's life remain under debate. Among the psychological factors that are believed to represent risk factors/negative consequences of PIU, loneliness has received considerable attention over the years. In the present work, we highlighted three critical questions regarding the relationship between loneliness and PIU: (i) Whether PIU and loneliness are positively related. Overall, the findings seem to suggest that whereas for Internet use, the relationship with loneliness may be positive or negative depending on one's motives of Internet use [30•]; in the case of PIU, the relationship with loneliness looks definitely positive but moderate. (ii) Whether there are confounding variables that may affect the relationship between PIU and loneliness. An examination of recent studies that investigated the relationship between loneliness and PIU by considering the effect of confounding variables seems to suggest that the strength of the relationship decreases when one or more variables related to loneliness and PIU are considered, e.g., perceived social support, depression, self-esteem, interpersonal problems, lack of a committed relationship, and psychological distress. Of note, the association of PIU with loneliness does not seem to differ across gender and age. (iii) Whether it is possible to establish the direction of the relationship between PIU and loneliness. Because only few studies have directly addressed this issue through longitudinal designs, it is not yet possible to surely claim the direction of this relationship. However, it seems that any potential vicious cycle linking PIU and loneliness starts with excessive Internet use, which then increases loneliness because of withdrawal from face-to-face interactions. In turn, increased loneliness would potentiate Internet use to compensate for poor offline social interactions, and thus trigger a "snowball effect." This assumption seems to be in accordance with the model proposed by Brand et al. [19], where in the early stages of PIU, one would mainly use the Internet to achieve gratification provided by Internet use itself. With the progression of the addiction process, it might be possible that using the internet cause the lack of offline social interactions and increase the subjective feeling to be lonely, that, in turn, would trigger compensating motives to keep using the Internet. As a result,

loneliness would be exacerbated and the vicious cycle between loneliness and excessive Internet use would be fueled.

An important limitation in the recent literature is the fact that all the studies included different self-report measures to assess PIU and loneliness. In order to improve construct validity and to allow study comparisons, an agreement about PIU criteria and loneliness assessment would be advisable. Moreover, the lack of diagnostic criteria for PIU makes it difficult to understand whether the study assessed PIU or excessive Internet use that does not require clinical attention.

Lastly, it may be a matter of interest for identifying possible treatment targets for PIU, exploring the psychobiological mechanisms underlying the relationship between PIU and loneliness over time, given the implication of the reward system in both loneliness and PIU [56, 59].

Compliance with Ethical Standards

Conflict of Interest Tania Moretta and Giulia Buodo declare that they have no conflicts of interest.

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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