Longitudinal relationship between problematic internet use with loneliness during and after COVID-19 social restrictions

Phil Reed[1], Angharad Davies[1], Katie Evans[1], & Lisa A. Osborne[2,3]

[1]Swansea University; [2]The Open University, UK; [3]Swansea Bay University Health Board

Correspondence address: Phil Reed,
Department of Psychology,
Swansea University,
Singleton Park,
Swansea, SA2 8PP, UK.
e-mail: p.reed@swansea.ac.uk

Short title: Internet use and loneliness

Psychiatry Research.

Abstract

Two, three-month long longitudinal studies examined the temporal relationships between problematic internet use (PIU), internet usage, and loneliness ratings, during and after lockdown restrictions. Experiment 1 examined 32, 18-51 year old participants, over a three-month period of lockdown restrictions. Experiment 2 studied 41, 18-51 year old participants, over a three-month period following the lifting of lockdown restrictions. Participants completed the internet addiction test, UCLA loneliness scale, and answered questioned about their online usage, at two time points. All cross-sectional analyses revealed a positive relationship between PIU and loneliness. However, there was no association between online use and loneliness. Longitudinal relationships between PIU and loneliness differed during and after lockdown restrictions. During a period of lockdown, there were both positive associations between earlier PIU and subsequent loneliness, and between earlier loneliness and subsequent PIU. However, following the easing of lockdown restrictions, only the temporal relationship between earlier internet addiction and later loneliness was significant.

Keywords: internet usage; problematic internet use; loneliness; social media; longitudinal.

Problematic Internet Use (PIU) refers when people have a compulsive need to spend much of their time on digital activities to the point where other areas of life suffer (Reed et al., 2015; Young, 2009). An individual displaying PIU will need to spend greater amounts of time online, and they will also experience withdrawal effects when not connect digitally (Romano et al., 2013). It should be noted that, although much research effort has be devoted to PIU, it is not yet fully clear whether PIU is a disorder in its own right, or whether it is related to other problems (Ryding & Kaye, 2018). For example, excessive use of the internet may not be related to a need for digital activity per se, but may be related to specific obsessions, such as pornography (Camilleri et al., 2021), gambling (King et al., 2020), or gaming (Steven et al., 2021); indeed, the DSM-5 lists Internet Gaming Disorder as a diagnosable condition, but not PIU in general. There are also higher rates of other psychiatric symptoms, such as obsessive-compulsive disorder, depression, and anxiety, for individuals with high scores on a psychometric assessment of PIU (Ghaderi et al. 2018; Mustafa, 2011). Nevertheless, research has suggested PIU is separable from other digital-disorder (Pontes & Griffiths, 2014), and much data has examined relationships between psychometrically-defined PIU and a range of problems in functioning, making this construct a viable one for investigation. In most studies of PIU, the construct is typically defined psychometrically, by the negative impact that internet-related activities have on a range of real-world functioning domains for the individual (Young, 1999). These domains include inability to control internet usage leading to to impaired psychological, work, school, and social life (see Odacı & Çelik, 2013, for a discussion).

An area of concern is the effect of high levels of PIU on social functioning and the experience of loneliness (Alheneidi et al., 2021; Moretta & Buodo, 2020). Conceptually there are several reasons why PIU and loneliness may be related (Moretta & Buodo, 2020). Firstly, use of digital communication technologies may displace deep face-to-face

relationships, replacing them with only superficial digital communication that lacks intimacy (Turkle, 2011). People with PIU spend more and more time online, and have less time for social connections with family and friends, become more lonely as a result. It may also be that people who are lonely attempt to increase their connectedness through digital means to meet their emotional needs (Moretta & Buodo, 2020), which may not be met Turkle, 2011), producing a cycle of increased loneliness. Alternatively, Valkenburg (2007) suggests online communication will enhance connectedness and reduces loneliness. Nowland et al. (2018) suggest that the connection between PIU and loneliness noted may vary depending on whether emotional loneliness or social connectedness is studied. Given these conceptual views suggesting a relationship between PIU and loneliness, and as online communication has been a major form of social interaction, especially during periods of social restrictions associated with the COVID-19 pandemic, it was thought important to determine whether forced digital communication influenced the relationship between PIU and loneliness (see Alheneidi et al., 2021).

The existent literature has numerous discrepancies, and there is an array of reported relationships between PIU, internet use, and loneliness (see Moretta & Buodo, 2020, for a review). Some researchers have claimed a strong association (even a causal relationship) between PIU and loneliness (Costa et al., 2019; Kraut et al., 1998; Moody, 2004); some have suggested that lonely people seek out the comfort of digital communication (Hamburger & Ben-Artzi, 2003; Kim et al., 2009); and others have suggested a bidirectional relationship between internet use and loneliness (Moretta & Buodo, 2020; Zhang et al., 2018).

Kraut et al. (1998; see also Costa et al., 2019; Zhang et al., 2018) conducted a longitudinal study over two years, where participants used the internet as a means of communication. In this study, greater amounts of internet use were associated with subsequent declines in communication with family members, and the size of participants'

social circle, and also were associated with later increased reports of loneliness and depression. In contrast, Shaw and Gant (2004) reported internet use decreased subsequent loneliness and depression. Other researchers have claimed people who are lonely in the first instance use the internet to feel connected (Hamburger & Ben-Artzi, 2003; Zhang et al., 2019). Kim et al. (2009) found that individuals who were lonely, or who did not have good social skills, were more likely to develop a compulsive internet use, which subsequently resulted in negative outcomes, such as harm to their work- or social-life. Ceyhan and Ceyhan (2008) analysed loneliness, depression, and computer self-efficiency as predictors for problematic internet use in 559 Turkish students. They found that loneliness was the most important predictive variable of problematic internet use.

However, it is difficult to draw firm conclusions from this literature. In some cases, the constructs of internet use and PIU are blurred, as internet use and PIU are not one and the same thing. In other cases, the research was conducted some time ago, with limitations on its generality to the rapidly changing digital landscape. In addition to dramatic changes in online communication systems over the years, there have been drastic alterations in social contact imposed due to pandemic restrictions (Alheneidi et al., 2021). Moreover, the emergence of COVID, and the associated social restrictions, may also have changed the relationships between these constructs. As a consequence, the current studies were designed explore the longitudinal association between internet use, PIU, and loneliness during and after COVID restrictions on real social contact.

To these ends, the current study compared longitudinal relationships between PIU, online usage, and loneliness, over a three-month period. This was done both during a period of social lockdown (Experiment 1), and after those restrictions were lifted (Experiment 2). In both studies, the longitudinal nature of the design allows evidence of temporal precedence (rather than causal impact) between the constructs. Each study examines: firstly, the nature

of the correlations between the three variables (internet use, PIU, and loneliness) at time 1; secondly, the degree to which there are temporal correlations between the variables at time 1 and time 2; and thirdly, examines whether the relationships between PIU/internet use at time 1 and loneliness at time 2, or loneliness at time 1 and PIU/internet use at time 2 are stronger. In this way, the current associations between these constructs can be established, and the impact of internet-based communication on loneliness during a period of social restriction can be assessed in comparison to periods of nonrestricted real social contact.

Experiment 1

Due to the apparent discrepancies between results reported in previous research (cf. Costa et al., 2019; Moody, 2004; Kim et al., 2009; Zhang et al., 2018; see Moretta & Buodo, 2020, for a review), and the advent of lockdowns due to the COVID-19 pandemic, the first experiment explored the relationship between internet usage, PIU, and loneliness, during a period of lockdown. A longitudinal approach was adopted to determine the temporal precedence of these relationships. On the bases of the previous findings, it was suggested that there would be a correlation between PIU and loneliness scores at both time points. The longitudinal relationship between internet use and PIU and loneliness was explored to determine whether PIU at Time 1 and loneliness at Time 2 were more, or less, strongly correlated than loneliness at Time 1 and PIU at Time 2. A three-month longitudinal study was conducted (April, 2020 to July, 2020), using self-reports of PIU and loneliness, along with screen shots of the past weeks' digital usage. Each of these measures was taken at time one, and then three months later.

Method

Participants

Participants were recruited through advertisements placed on a University campus, and through e-mails to students at a UK university. Forty participants originally responded to the advertisement. Of these, 34 (85%) agreed to participate. However, two participants (5%) failed to supply any data, leaving a total of 32 participants in the experiment (13 males, 18 females, 1 nonbinary). All of these participants completed the study. The mean age of the participants was 26.62 (SD $\pm$ 8.75; range = 19-51) years. Participants did not receive any payment or course credit for their participation in the study. Ethical permission was granted by the Department of Psychology Ethics Committee at the University, and all participants gave informed consent. G-Power calculations suggested that, for a large effect size seen in previous studies (r = .5), using a rejection criterion of $p < .05$, for 90% power, 31 participants would be needed to detect a significant correlation.

Materials

Internet Addiction Test (IAT; Young, 2009) is a widely-used and well-validated 20-item self-report measure of life disruption by the internet. Questions are rated on a 5-point scale (1 = "Does not apply" to 5 = "Always"). The score can range from 20 to 100; scores of 50-79 suggest mild to moderate interruptions to life due to internet usage, and scores above 80 suggest a significant problem. The internal reliability (Cronbach α) of the IAT for the current sample was .87 at time 1, and .91 at time 2.

UCLA Loneliness Scale (UCLA; Russell et al, 1978) is a widely-used and well-validated measure of self-reported feelings of loneliness. There are 20 questions concerning perceived relationships with others and their internal emotions. These statements are rated on a 4 point-scale (0 = "I never feel this way" to 3 = "I often feel this way"). Scores range from

0-60, with higher scores indicating more severe loneliness. The internal reliability (Cronbach α) of the IAT for the current sample was .85 at time 1, and .84 at time 2.

Procedure

Once participants had agreed to take part, they were sent the first set of questionnaires (IAT and UCLA) using an online link. The participants were asked to say how many hours a day they spent online, on average, over the last week. These questionnaires were sent out during April 2020 (two to five weeks after a lockdown was announced). After three months (and still during the lockdown period), the participants were again sent the questionnaires, and asked how long they spent online over the past week.

Results and Discussion

Table 1 about here

Table 1 shows the sample mean scores for PIU, online use (hours/week), and loneliness (UCLA), at Time 1 and Time 2. These data suggest that the mean sample scores for internet addiction were below the threshold for PIU. It also displays the Pearson correlations between each of these scores at time 1 and that score at time 2. The scores for each measure at time 1 were positively correlated with that score at time 2.

Figure 1 about here

The top panel of Figure 1 shows the Pearson correlations between the three variables at Time 1, along with the scatterplots and 95% confidence limits. Inspection of these data

reveals that only the relationship between PIU (IAT) and loneliness (UCLA) was significant (r = .589). The bottom panel of Figure 1 shows these relationships for Time 2, and these data also reveal that only the relationship between PIU (IAT) and loneliness (UCLA) was significant (r = .519).

Figure 2 about here

The top panel of Figure 2 shows the regression coefficients for the relationship between internet addiction (IAT) and loneliness (UCLA) at time 1 and time 2. Inspection of these data shows that all of the relationships represented were significant (all ps < .001). There was no difference (t < 1, p > .70) between the strength of the regression coefficients for internet addiction at time 1 predicting loneliness at time 2 (.537), and loneliness at time 1 predicting internet addiction at time 2 (.591).

The bottom panel of Figure 2 shows the regression coefficients for the relationship between internet use (hrs/wk) and loneliness (UCLA) at time 1 and time 2. Inspection of these data shows that only the autoregressive relationships were significant (both ps < .001). There was no difference (t < 1, p > .90) between the strength of the regression coefficients for internet use at time 1 predicting loneliness at time 2 (-.011), and loneliness at time 1 predicting internet use at time 2 (-.009).

These results suggest that there was a strong correlation between PIU and loneliness at both time points. These relationships corroborate the results from other studies which have shown similar positive relationships between these variables (Hamburger et al 2003; Kraut et al., 1998). There was little relationship between either of these variables and time spent on the internet. There were strong positive correlations over time between PIU (but not internet use) and loneliness. However, there were no differential relationships between earlier PIU

and later loneliness, and vice versa, over time. This suggests that, during a period of social restrictions occasioned by a lockdown, there was a bidirectional relationship between the two variables. In contrast, these data suggest that time using the internet per se is not a determinant of loneliness, or vice versa. Rather, it is the perceived negative impact of the internet on everyday functioning that is related to current and future experiences of loneliness; and the experience of loneliness is related to current perceptions of the negative impact of internet use (PIU), and also to PIU at a later time.

Experiment 2

The second experiment replicated the above study, but did so in a period following the lifting of lockdown restrictions (January, 2022 – April, 2022). This study was conducted to see whether, under normal conditions, the relationships between the variables were any different from during a period of lockdown.

Method

Participants

Participants were recruited as described in Experiment 1. Fifty-one participants originally responded to the advertisement. Of these 45 (88%) agreed to participate. However, four participants (9%) failed to supply any data, leaving a total of 41 participants in the experiment (12 males, 28 females, 1 nonbinary). All of these participants completed the study. The mean age of the participants was 23.88 (± 6.99; range = 18-51) years. Ethical permission was granted by the Department of Psychology Ethics Committee at the University, and all participants gave informed consent.

Materials and Procedure

The same questionnaires were employed as were described in Experiment 1: Internet Addiction Test (IAT; Young, 2009); and the UCLA Loneliness Scale (UCLA; Russell et al., 1978). The procedure was as described in Experiment 1.

Results and Discussion

Table 2 about here

Table 2 shows the sample mean scores for PIU, online use (hours/week), and loneliness (UCLA), at Time 1 and Time 2, along with the Pearson correlation between the scores are time 1 and time 2. Inspection of these data shows a mean score below the threshold for PIU. These scores for each of the measures at Time 1 were positively correlated that that measure taken at time 2.

Figure 3 about here

The top panel of Figure 2 shows the Pearson correlation between the three variables at Time 1, along with the scatterplots and 95% confidence limits. Inspection of these data reveals that only the relationship between PIU (IAT) and loneliness (UCLA) was significant ($r = .535$, $p < .001$). The bottom panel of Figure 2 shows these relationships for Time 2, and these data also reveal that only the relationship between PIU (IAT) and loneliness (UCLA) was significant at this time point ($r = .604$, $p < .001$).

Figure 4 about here

The top panel of Figure 4 shows the regression coefficients for the relationship between internet addiction (IAT) and loneliness (UCLA) at time 1 and time 2. Inspection of these data shows that all of the relationships represented were significant (all *p*s < .001), with the exception of that between loneliness at time 1 and internet addiction at time 2 (.243). There was a significant difference ($t(78) = 2.85$, $p = .005$) between the strength of the regression coefficients for internet addiction at time 1 predicting loneliness at time 2 (.748), and loneliness at time 1 predicting internet addiction at time 2 (.243).

The bottom panel of Figure 4 shows the regression coefficients for the relationship between internet use (hrs/wk) and loneliness (UCLA) at time 1 and time 2. Inspection of these data shows that only the autoregressive relationships were significant (both *p*s < .001). There was no difference ($t < 1$, $p > .90$) between the strength of the regression coefficients for internet use at time 1 predicting loneliness at time 2 (.174), and loneliness at time 1 predicting internet use at time 2 (.168).

The cross-sectional data collected during a period of no lockdown restrictions were similar to those reported in Experiment 1 from a period of lockdown. There was a strong correlation between PIU scores and loneliness at both time points, and there was little relationship between either of these variables and time spent on the internet. The data differed from the lockdown data, however, in that while there was a strong positive correlation over time between PIU at Time 1 and loneliness at Time 2, there was little reverse relationship. These findings suggest that, under conditions of normal, non-restricted social access, the perceived negative impacts of the internet on everyday functioning are related to future experiences of loneliness, but the experience of loneliness is not related to future PIU.

General Discussion

The aim of this research was to examine the longitudinal relationships between PIU, internet usage, and loneliness, and to explore whether these relationships altered during and after social restrictions impose during a COVID-19 lockdown. The data corroborated the suggestion that PIU was associated with loneliness: PIU scores positively correlated with loneliness. However, there was no association between amount of online use and loneliness. A novel finding was that the longitudinal relationships between PIU and loneliness differed during and after lockdown restrictions. During a period of lockdown, there were positive associations between earlier PIU and subsequent loneliness, and between earlier loneliness and subsequent PIU. In contrast, following the easing of lockdown restrictions, only the temporal relationship between earlier PIU and later loneliness was significant.

These findings regarding the relationship between PIU and loneliness corroborate some previous work conducted on this topic. Research reported by Kraut et al. (1998), and by Moody (2004), both noted excessive internet usage was associated with increased loneliness. That such findings were replicated in the current study, despite many changes to the online environment, suggests that this relationship is a strong one (see Costa et al., 2019; Moretta & Buodo, 2020). The current findings stand in opposition to other previous work reported by Kim et al. (2009), and Ceyhan and Ceyhan (2008), who both noted that loneliness levels were a stronger predictor for internet use than vice versa.

The current finding of no association between online use (hours/wk) and loneliness is also in line with that reported by Gross et al. (2004), who found that internet use had no association with well-being. However, other researchers, such as Pantic et al. (2012), have noted that hours spent on the internet per day is predictive of loneliness and depression. The

likelihood is that the weak association between usage and addiction suggests that the function of the usage is a more important variable to consider than time spent in usage.

Although cross-sectional correlations do not show cause and effect, time lagged studies offer some insight into the nature of this relationship (albeit not necessarily strong causal evidence). The current results suggest that PIU and loneliness are related across time, but that the nature of this relationship may alter depending on the constraints that are placed on the society in which the online usage occurs. During lockdown, there were clear and strong bidirectional relationships between PIU and loneliness. It may be that those who were lonely developed an addiction to online usage, perhaps as an escape from those negative feelings (see Bonetti et al., 2010). In addition, those with PIU problems felt more isolated over time. However, when social contact restrictions were lifted, the clear relationship was that PIU drove loneliness (Kraut et al., 1998; Moody, 2004).

The reasons why the lifting of lockdown produced a change in the temporal relationship between PIU and loneliness is unclear. It may be that greater opportunities for social contact allowed feelings of loneliness to be alleviate without using online escape strategies. There were few differences between the scores associated with the measured variables during and after lockdown. Although time spent online decreased from a mean 30 to 22 hours a week after lockdown was eased, $t(71) = 3.84$, $p < .001$, $d = .91$; there was no difference in PIU scores (31 during versus 27 after), $t(71) = 1.22$, $p = .224$, $d = .29$, nor in terms of loneliness (10 during and after lockdown), $t < 1$, $d = .043$. As the only variable that changed was time spent online, and this was not related to either of the other variables, some other factors are more likely responsible for the during versus after differences noted here.

There are a number of factors that future research could usefully explore in this regard. For example, Caplan (2007) found that social anxiety was predictive of online usage in addition to loneliness, and it would be interesting to explore social anxiety alongside

loneliness. Additional types of loneliness, such as social and emotional loneliness, could explored separately (Moody, 2004), as could different forms of online usage. It needs to be acknowledged that participants may not necessarily be accurate in reporting the extent of their internet use, and other methods of assessing this variable than self-report may be useful. Moreover, the IAT scale does allow for the use of a number of cut-off points: > 40 for no PIU, 40-69 for moderate PIU, and >70 for severe PIU. These could also have been explored for their impacts on loneliness, although a larger sample would be needed for such analyses.

To summarise, PIU was associated with loneliness, but there was no association between online use and loneliness. During lockdown there were bidirectional positive associations between PIU and loneliness. However, following the easing of lockdown restrictions, only earlier PIU predicted later loneliness. These findings add to the literature showing the potential problems of PIU for social and emotional functioning.

References

Alheneidi, H., AlSumait, L., AlSumait, D., & Smith, A.P. (2021). Loneliness and problematic internet use during COVID-19 lock-down. *Behavioral Sciences*, *11*(1), 5.

Bonetti, L., Campbell, M.L. & Gilmore, L. (2010). The relationship of loneliness and social anxiety with children's and adolescents' online communication. *Cyberpsychology, Behavior, and Social Networking*, 13(3), 279-285.

Camilleri, C., Perry, J.T., & Sammut, S. (2021). Compulsive internet pornography use and mental health: A cross-sectional study in a sample of university students in the United States. *Frontiers in Psychology*, *11*, 613244.

Caplan, S.E. (2005). A social skill account of problematic internet use. *Journal of Communication*, 55(4), 721-736.

Caplan, S.E. (2007). Relations among loneliness, social anxiety, and problematic internet use. *CyberPsychology & Behavior*, 10(2), 234-242.

Ceyhan, A.A. & Ceyhan, E. (2008). Loneliness, depression, and computer self-efficiency as predictors of problematic internet use. *CyberPsychology & Behavior*, 11(6), 699-701.

Costa, R.M., Patrão, I., & Machado, M. (2019). Problematic internet use and feelings of loneliness. *International Journal of Psychiatry in Clinical Practice*, *23*(2), 160-162.

Erdoğan, Y. (2008). Exploring the relationships among internet usage, internet attitudes and loneliness of Turkish adolescents. *Cyberpsychology: Journal of Psychological Research on Cyberspace*, 2(2), article 4.

Ghaderi Rammazi, M., Askarizadeh, G., Ahmadi, G., & Divsalar, K. (2018). The role of psychiatric symptoms, social support and meaning in life in predicting internet addiction among university students: A causal model. *Practice in Clinical Psychology*, *6*(2), 101-110.

Gross, E.F. (2004). Adolescent internet use: What we expect, what teens report. *Journal of*

Applied Developmental Psychology, 25(6), 633-649.

Hamburger, Y.A. & Ben-Artzi, E. (2000). The relationship between extraversion and neuroticism and the different uses of the internet. *Computers in Human Behavior*, 16(4), 441-449.

Hamburger, Y.A. & Ben-Artzi E. (2003). Loneliness and internet use. *Computers in Human Behavior*, 19(1), 71-80.

Kim, J., LaRose, R. & Peng, W. (2009). Loneliness as the cause and the effect of problematic internet use: The relationship between internet use and psychological well-being. *Cyberpsychology and Behavior*, 12(4), 451-455.

King, D.L., Russell, A., & Hing, N. (2020). Adolescent land-based and internet gambling: Australian and international prevalence rates and measurement issues. *Current Addiction Reports*, *7*, 137-148.

Kraut, P., Patterson., M., Lundmark, V., Kiesler, S., Mukopadhyay., T. & Scherlis,W. (1998). Internet paradox: A social technology that reduces social involvement and psychological well-being? *American Psychologist*, 53, 65-77.

Moody, E.J. (2004). Internet use and its relationship to loneliness. *CyberPsychology & Behavior*, 4(3), 393-401.

Moretta, T., & Buodo, G. (2020). Problematic internet use and loneliness: How complex is the relationship? A short literature review. *Current Addiction Reports*, *7*(2), 125-136.

Morrison, C.M. & Gore, H. (2010). The relationship between excessive internet use and depression: A questionnaire-based study of 1,319 young people and adults. *Psychopathology*, 43(2), 121-126.

Mustafa, K. (2011). Internet addiction and psychopathology. *Turkish Online Journal of Educational Technology*, 10(1), 143-148.

Nowland, R., Necka, E.A., & Cacioppo, J.T. (2018). Loneliness and social internet use:

pathways to reconnection in a digital world? *Perspectives on Psychological Science*, *13*, 70–87.

Odacı, H., & Çelik, C.B. (2013). Who are problematic internet users? An investigation of the correlations between problematic internet use and shyness, loneliness, narcissism, aggression and self-perception. *Computers in Human Behavior*, *29*, 2382-2387.

Pantic, I., Damjanovic, A., TodorovicJ., Topalovic, D., Bojovic-Jovic, D., Ristic, S. & Pantic, S. (2012). Association between online social networking and depression in high school students: Behavioural physiology viewpoint. *Psychiatria Danubina*, 24(1), 90-93.

Pontes, H.M., & Griffiths, M.D. (2014). Internet addiction disorder and internet gaming disorder are not the same. *Journal of Addiction Research & Therapy*, *5*(4).

Reed, P., Vile, R., Osborne L.A., Romano, M. & Truzoli, R. (2015). Problematic internet usage and immune function. *PLOS One* 10(10).

Romano, M., Osborne, L. A., Truzoli, R. & Reed, P. (2013). Differential psychological impact of internet exposure on internet addicts. *PLOS One*, 8(2),

Russell, D , Peplau, L.A.. & Ferguson, M.L. (1978). Developing a measure of loneliness. *Journal of Personality Assessment, 42,* 290-294.

Ryding, F.C., & Kaye, L.K. (2018). Internet Addiction: a conceptual minefield. *International Journal of Mental Health and Addiction*, *16*, 225–232.

Shaw, L.H. & Gant, L.M. (2004). In defence of the internet: The relationship between internet communication and depression, loneliness, self-esteem, and perceived social support. *CyberPsychology & Behavior*, 5(2), 157-171.

Stevens, M.W., Dorstyn, D., Delfabbro, P.H., & King, D.L. (2021). Global prevalence of gaming disorder: A systematic review and meta-analysis. *Australian & New Zealand Journal of Psychiatry*, *55*(6), 553-568.

Turkle S. (2011). Alone together: why we expect more from technology and less from each other. *Choice Rev Online, 48*.

Valkenburg, P.M. (2007). Online communication and adolescent well-being: testing the stimulation versus the displacement hypothesis. *Journal of Computing Communication, 12*, 1169–82.

Weinstein, A. & Lejoyeux, M. (2010). Internet addiction or excessive internet use. *The American Journal of Drug and Alcohol Abuse: Encompassing All Addictive Disorders*, 36(5), 277, 283.

Young, K.S. (2009). Internet Addiction Test (IAT).

Young, K.S. (2009). Internet addiction: The emergence of a new clinical disorder. *CyberPsychology & Behavior*, 1(3), 237-244.

Zhang, S., Tian, Y., Sui, Y., Zhang, D., Shi, J., Wang, P., ... & Si, Y. (2018). Relationships between social support, loneliness, and internet addiction in Chinese postsecondary students: A longitudinal cross-lagged analysis. *Frontiers in Psychology*, *9*, 1707.

Table 1: Experiment 1. Sample mean scores (standard deviation) for internet addiction (IAT), online use (hours/week), and loneliness (UCLA), at Time 1 and Time 2, along with the Pearson correlation between the scores at time 1 and time 2.

	Time 1	Time 2	r
IAT	31.28 (12.87)	32.44 (11.17)	.800***
Online use (Hours/week)	30.06 (10.64)	33.44 (16.44)	.804***
UCLA	10.09 (11.49)	9.03 (11.34)	.704***

*p<.05; **p<.01; ***p<.001

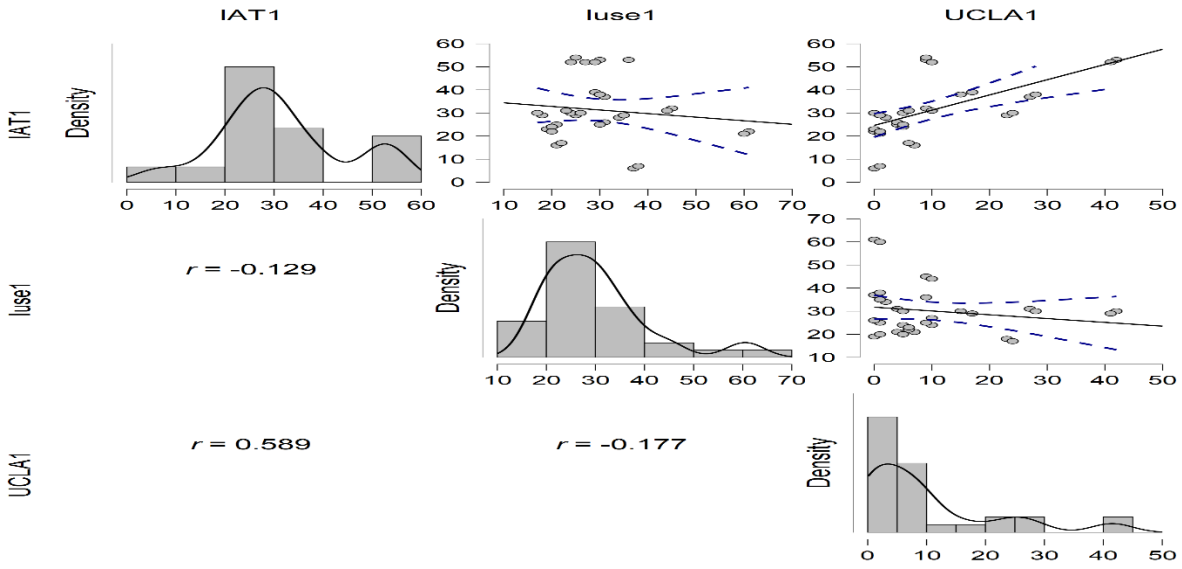
Table 2: Experiment 2. Sample mean scores (standard deviation) for internet addiction (IAT), online use (hours/week), and loneliness (UCLA), at Time 1 and Time 2, along with the Pearson correlation between the scores are time 1 and time 2.

	Time 1	Time 2	r
IAT	27.75 (11.69)	26.24 (11.17)	.800***
Online use (Hours/week)	22.46 (6.10)	22.82 (8.01)	.614***
UCLA	10.75 (10.15)	13.12 (9.26)	.660***

*p<.05; **p<.01; ***p<.001

Figure 1. Experiment 1. Top panel = Pearson correlation between PIU (IAT), online use (Iuse; hours/wk), and loneliness (UCLA) at Time 1, along with the scatterplots and 95% confidence limits. Bottom panel = Pearson correlation between PIU (IAT), online use (Iuse; hours/wk), and loneliness (UCLA) at Time 2, along with the scatterplots and 95% confidence limits.

Time 1



Time 2

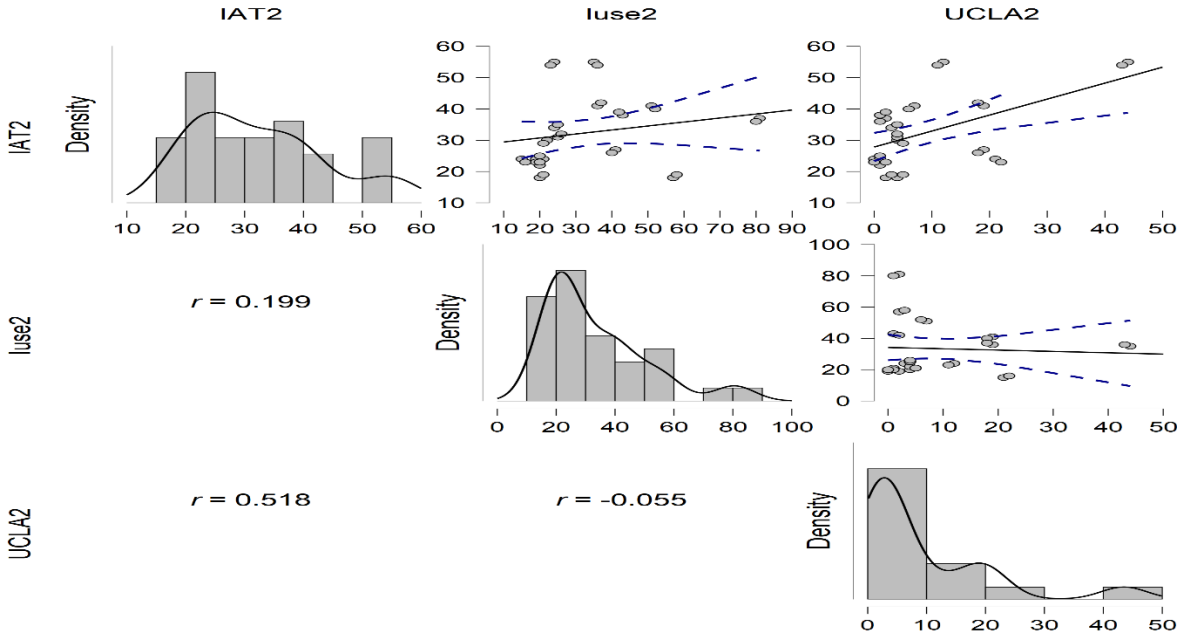
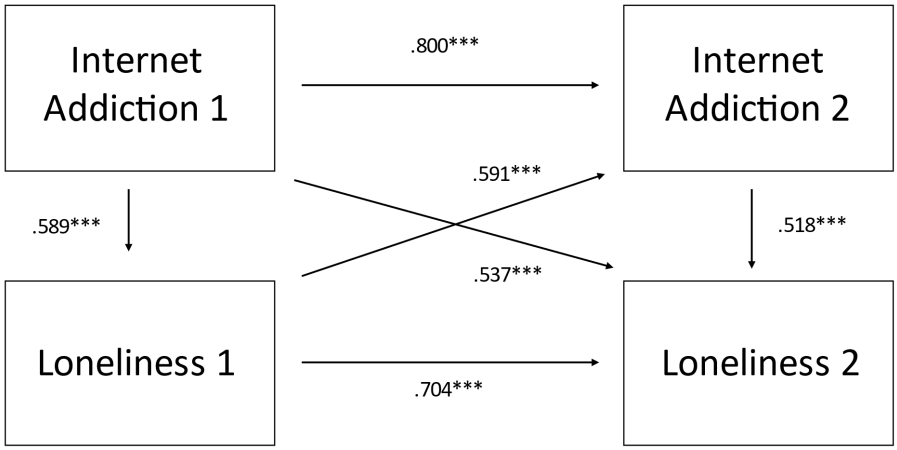


Figure 2: Experiment 1. Top panel = Cross-lagged relationships (regression coefficients) for internet addiction (IAT) and loneliness (UCLA) at time 1 and time 2. Bottom panel = Cross-lagged relationships (regression coefficients) for internet use (hr/wk) and loneliness (UCLA) at time 1 and time 2. *** $p < .001$.



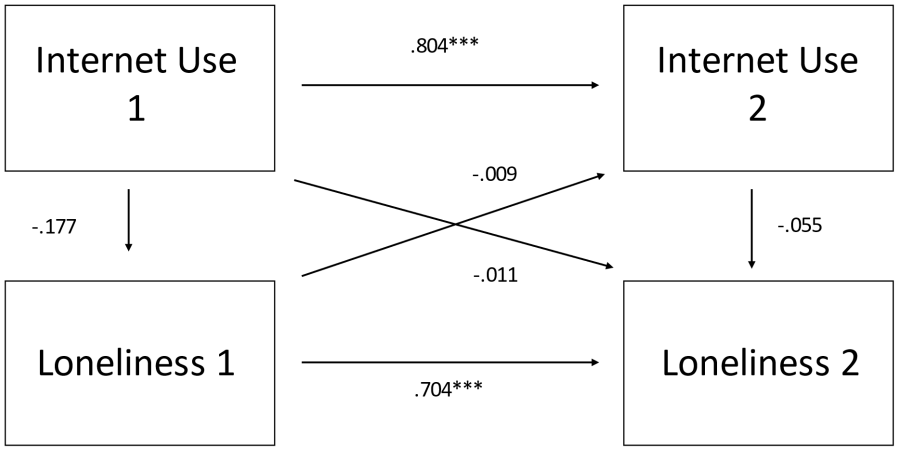
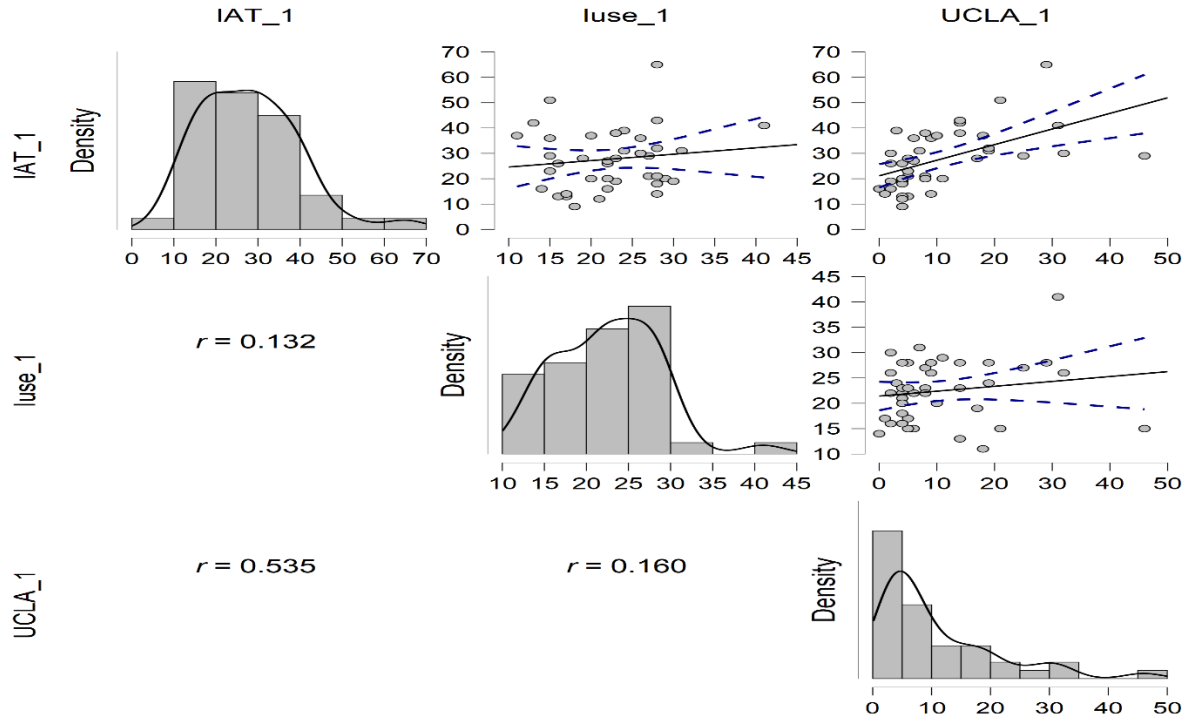


Figure 3. Experiment 2. Top panel = Pearson correlation between PIU (IAT), online use (Iuse; hours/wk), and loneliness (UCLA) at Time 1, along with the scatterplots and 95% confidence limits. Bottom panel = Pearson correlation between PIU (IAT), online use (Iuse; hours/wk), and loneliness (UCLA) at Time 2, along with the scatterplots and 95% confidence limits.

Time 1



Time 2

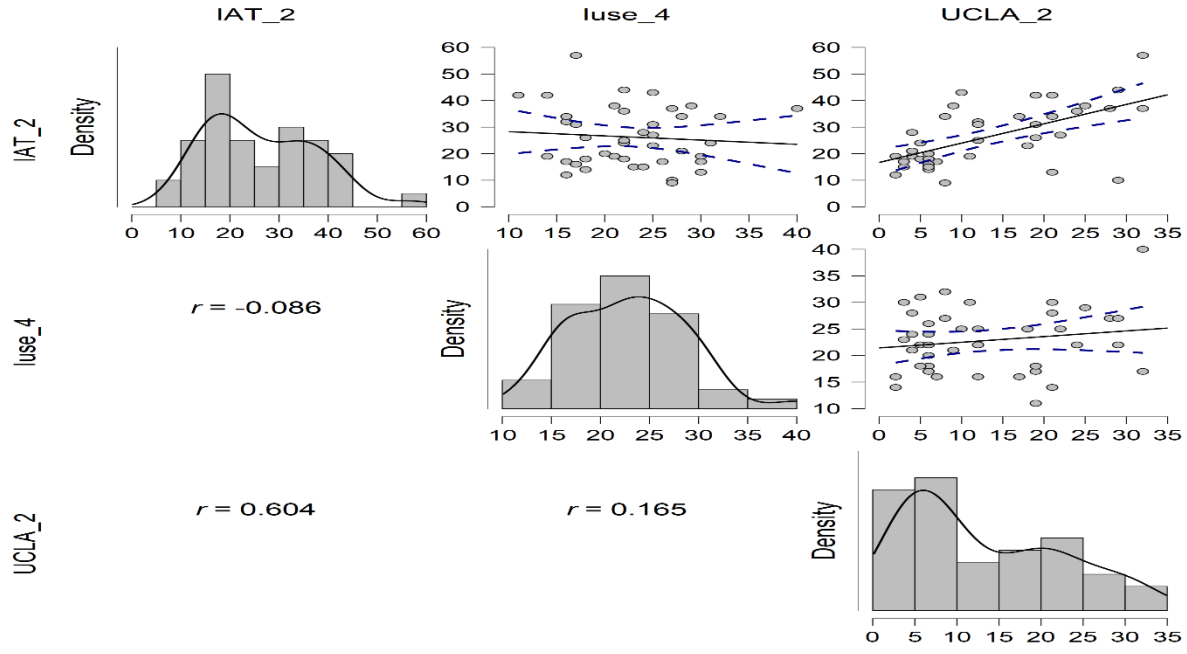


Figure 4: Experiment 2. Top panel = Cross-lagged relationships (regression coefficients) for internet addiction (IAT) and loneliness (UCLA) at time 1 and time 2. Bottom panel = Cross-lagged relationships (regression coefficients) for internet use (hr/wk) and loneliness (UCLA) at time 1 and time 2. *** $p < .001$.