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Compulsive internet use and the development of self-esteem and hope: A four-year longitudinal study

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Abstract

Objective: Compulsive internet use (CIU) has been linked to decrements in mental health and well-being. However, relatively little is known about how CIU relates to evaluations of the self, and in particular, whether CIU is antecedent to or is a consequence of negative evaluations of one's social worth (self-esteem) and general efficacy (hope). To examine this, we explored the longitudinal relations between CIU and the development of self-esteem and hope among adolescents over a four-year period.

Method: Two thousand eight hundred and nine adolescents completed measures yearly from Grade 8 (M_{Age} = 13.7) to Grade 11. Autoregressive cross-lagged structural equation models were used to test whether CIU influenced or was influenced by self-esteem and hope.

Results: We found consistent support for a CIU-as-antecedent model. CIU preceded reductions in trait hope, and small reductions in self-esteem. In contrast, we did not find evidence for a CIU-as-consequence model: low self-esteem and hope did not predict increases in CIU over time.

Conclusions: Our findings suggest that CIU has negative consequences for young people's feelings of goal-efficacy, and that interventions that address the compulsive use of the internet are likely to strengthen hope and self-esteem among young people.

KEYWORDS
compulsive internet use, hope, longitudinal, self-esteem, structural equation model

1 | INTRODUCTION

As the internet reaches unprecedented uptake rates across the world, policy-makers and researchers continue to grapple with its effects on mental health and social functioning, and in particular, its impacts among young people. The International Telecommunication Union (2017) estimates that globally, 70% of people aged 15–24 are online. A recent survey found that in the United States, 92% of teenagers (aged 13–17) report going online daily, while 24% report being online "almost constantly" (Lenhart et al., 2015). There is evidence that internet use can enhance young people's well-being, for example when used to maintain existing friendships (Bessière, Kiesler, Kraut, & Boneva, 2008; Valkenburg & Peter, 2007). However, there is also evidence that excessive internet use has harmful effects among young people (Carli et al., 2013; Ciarrochi et al., 2016; Kim, La Rose, & Peng, 2009). In particular, high levels of online communication have been shown to precede the development of compulsive internet use (CIU; also referred to as "problematic internet use" and "internet dependence"; van den Eijnden, Meerkerk, Vermulst, Spijkerman, & Engels, 2008; Van Der Aa et al., 2009).

CIU is broadly understood as an inability to regulate one's use of the internet, with associated feelings of guilt about

one's lack of control, rumination about being online when not, and withdrawal and disengagement from daily activities (Caplan, 2003; Spada, 2014). CIU can be *specific* when it relates to only one type of internet activity, such as online gaming or social media use, or *generalized* when it implies a general overuse of and dependency on the internet (Caplan, 2003). Generalized CIU, the focus of the present investigation, is thought to be strongly associated with interpersonal exchanges on the internet and using the internet to seek social contact and reinforcement, in place of face-to-face contact with others (Davis, 2001). Generalized CIU has been linked to a range of negative outcomes, including mental ill-health (Carli et al., 2013; Ciarrochi et al., 2016), stress (Muusses, Finkenauer, Kerkhof, & Joy, 2014), and decrements in general well-being (Muusses et al., 2014; van den Eijnden et al., 2008).

However, relatively little is known about whether and how generalized CIU relates to changes in the evaluations of the self over time. Adolescence is a time when self-evaluations are changing rapidly, and these in-turn have an important influence on young people's levels of social engagement, academic performance, and overall well-being (Ciarrochi, Heaven, & Davies, 2007; Marshall, Parker, Ciarrochi, & Heaven, 2013; Orth, Robins, & Widaman, 2012; Trzesniewski et al., 2006). Therefore, understanding the extent to which generalized CIU might predict or be predicted by young people's self-evaluations is critical in advancing our understanding of the antecedents and consequences of unhealthy internet use. Further, a number of recent studies and reviews of generalized CIU have called for more longitudinal research to better tease apart predictors and consequences of CIU (Carli et al., 2013; Durkee et al., 2012; Ko, Yen, Yen, Chen, & Chen, 2012; Spada, 2014). The present study fills this gap, exploring the longitudinal relations between generalized CIU and two widely researched evaluations of the self—self-esteem and dispositional hope—among an adolescent sample (Grades 8–11).

2 | CAUSES AND CONSEQUENCES OF CIU

CIU has been described by criteria such as: (a) experiencing unpleasant emotions when internet use is impossible, (b) continuing internet use despite the intention or desire to stop or cut down the use, (c) using the internet to ameliorate negative emotions, (d) internet use dominating one's thoughts and behaviors, and (e) internet use resulting in inter or intrapersonal conflict (Meerkerk, Van Den Eijnden, Vermulst, & Garretsen, 2009). There is indeed debate as to whether CIU represents an impulse control disorder or a behavioral addiction (Ko et al., 2012). Nonetheless, conceptually, CIU appears to share similarities with other addictive disorders, such as the experience of withdrawal, tolerance, and negative social repercussions (Pies, 2009), and appears to share the same neurobiological mechanisms as substance addictions (Holden, 2001).

Several theoretical accounts have been provided for how CIU might link to negative self-evaluations. In one account, negative self-evaluations—often linked to social isolation and feelings of loneliness—are said to lead to a preference for online interaction with others (perceived as less threatening than face-to-face interactions), in turn leading to dependence on the internet and CIU (Caplan, 2003; Kim & Davis, 2009). This suggests that negative self-evaluations may lead to CIU, which we will term the "CIU-as-consequence" model. Alternatively, it has been proposed that the compulsive use of the internet will undermine individuals' self-evaluations over time, which will be termed the "CIU-as-antecedent" model. Specifically, excessive internet use has been theorized as leading to heightened social comparison and contingent self-regard, in turn leading to negative self-evaluations (Caplan, 2003; Pantic et al., 2012). There is also a possibility that the antecedent and consequence models are both correct, suggesting a reciprocal relationship wherein negative self-evaluations lead to CIU, which in turn further undermine feelings of self-worth and competence.

Despite these theoretical accounts, relatively little research has examined the extent to which CIU may reciprocally relate to adolescents' self-evaluations. Some studies have examined the cross-sectional associations between self-esteem and CIU (Kim & Davis, 2009; Niemz, Griffiths, & Banyard, 2005; Yao, He, Ko, & Pang, 2014), including among adolescents (Aydin & Sari, 2011; Fioravanti et al., 2012; Van Der Aa et al., 2009). However, more research is needed to better understand the longitudinal relations among these variables, so as to more precisely test the above theoretical predictions and to better understand the antecedents and consequences of CIU. The present study does this, by exploring the longitudinal links between CIU and both self-esteem and hope.

2.1 | CIU as an antecedent to self-esteem

Self-esteem, defined as an evaluation of one's general worth as a person (Robins, Hendin, & Trzesniewski, 2001), is an important predictor of social and emotional well- being. For example, self-esteem has been found to predict greater happiness (Cheng & Furnham, 2004), positive affect (Orth et al., 2012), and social support (Marshall et al., 2013) and less depression and anxiety (Sowislo & Orth, 2013). Conversely, having low global self-esteem as an adolescent has been linked with antisocial behavior and delinquency (Donnellan, Trzesniewski, Robins, Moffitt, & Caspi, 2005), as well as poor physical health and antisocial behavior in adulthood (Trzesniewski et al., 2006). A person's self-esteem is a relatively stable trait across the life span; however, it does change

as a result of changes in the social environment, and is most malleable among young people and the elderly (Orth, Maes, & Schmitt, 2015; Trzesniewski, Donnellan, & Robins, 2003).

A number of factors have been shown to influence the development of self-esteem among adolescents. There is evidence that the quality of relationships with family, close friends, and peers all influence self-esteem development (Heaven & Ciarrochi, 2008; Orth et al., 2012), as does the quality of a person's physical health (Reitzes & Mutran, 2006), and demographic factors such as gender and ethnicity (Orth, Trzesniewski, & Robins, 2010). Further, stressful life events have been found to predict subsequent decreases in self-esteem over time (Joiner, Katz, & Lew, 1999).

However, almost no research has explored whether unhealthy use of the internet might influence self-esteem development. Low self-esteem has been shown to be negatively correlated with the compulsive use of the internet in general (Aydin & Sari, 2011; Griffiths, 2008; Kim & Koh, 2018) and the excessive use of social networking sites in particular (Ellison, Steinfield & Lampe, 2007; Steinfield, Ellison & Lampe, 2008). Further, CIU has been associated with loneliness and depression in several studies, both of which are negatively correlated with self-esteem (Kim et al., 2009; Meerkerk et al., 2009; Muusses et al., 2014; van den Eijnden et al., 2008). These findings suggest that CIU is linked to low self-esteem, but do not provide insight into directions of effects.

How might CIU undermine adolescents' self-esteem (i.e., the "CIU-as-antecedent" model)? Pantic et al. (2012) proposed that much internet use, especially social networking platforms, involves social comparison, which may heighten feelings of contingent self-worth. In particular, social feedback on the internet is not face to face, potentially undermining the quality of feedback received and increasing the incidence of taking ambiguous social feedback negatively (Pantic et al., 2012). This, in turn, means that individuals are more vulnerable to threats to their self-esteem, thereby undermining the overall levels of self-esteem over time (Pantic et al., 2012). Related to this explanation, another proposition is that CIU leads to less face-to-face interaction with others, which, ironically, leads to greater social isolation and feelings of loneliness (as opposed to greater social connection), and this in turn leads to reductions in self-esteem over time (Craig, 1995).

We are only aware of one study to have explored the longitudinal relations between CIU and self-esteem, and thereby test the antecedent model (Muusses et al., 2014). Muusses et al. (2014) measured both constructs five times over a four-year period, among a sample of adults. Muusses et al. (2014) did not find evidence that CIU precedes the loss of self-esteem over time. These findings may be because self-esteem is relatively stable in adulthood, meaning that CIU does not influence its development post-adolescence (Orth et al., 2012). It may be that among adolescents, CIU is more closely linked to self-esteem over time, particularly because among young people, self-esteem is developing and is closely tied to social comparisons which are linked to CIU (Kim & Davis, 2009; Yao et al., 2014). Clearly, these possibilities need to be tested, and lead to our first hypothesis.

> *Hypothesis 1:* CIU will be antecedent to lower self-esteem over time.

2.2 | CIU as a consequence of low self-esteem

Alternatively, it may be that having low self-esteem precedes the development of CIU over time. One theoretical explanation for this prediction is that when individuals with low self-esteem encounter an aversive experience, they perceive the internet as less threatening than face-to-face interactions, and as a means of reestablishing social connection (Caplan, 2003). This means that people with low self-esteem are more likely to develop a dependence on the internet and therefore have greater likelihood of compulsive use of the internet (Caplan, 2003). There is indeed cross-sectional (e.g., Caplan, 2003) as well as preliminary longitudinal support for this proposition (e.g., Gámez-Guadix, Calvete, Orue, & Las Hayas, 2015).

A related theory is that low self-esteem leads to fewer personal resources, and this in turn undermines self-control which manifests in the compulsive use of the internet (Kim & Davis, 2009; LaRose, Lin, & Eastin, 2003). Low self-esteem has been shown to deplete resources needed for self-regulation and goal pursuit (Finkenauer, Engels, & Baumeister, 2005; Tangney, Baumeister, & Boone, 2004), and self-regulatory deficits have been identified as a core feature of CIU as well as many other compulsive behaviors (Gámez-Guadix et al., 2015; LaRose et al., 2003). This theorizing leads to our second prediction.

> *Hypothesis 2:* Low self-esteem will precede CIU over time.

2.3 | CIU as an antecedent to low hope

Hope describes one's general sense of agency and efficacy in identifying pathways for achieving one's goals (Snyder et al., 1991). Hope comprises two discrete components. The first is a sense of personal agency and volition in working successfully toward one's goals (Snyder et al., 1991, p. 570). The second is the ability to identify viable pathways for and overcome obstacles to achieving

one's goals. Hope is closely related to the concept of self-efficacy, in that it relates to one's general effectiveness and competence (Ciarrochi, Parker, Kashdan, Heaven, & Barkus, 2015; Wells, 2006). However, hope specifically relates to efficacy regarding *goal* pursuit, which distinguishes it from the (broader) concept of self-efficacy (Snyder et al., 1991). Further, hope is related to self-esteem in that it is a global evaluation of the self (Ciarrochi et al., 2015). However, the constructs are distinct in that self-esteem is an assessment of one's *relative* self-worth and value as a person, while hope centers around one's capacity to have agency and efficacy in working toward goals (Ciarrochi et al., 2015). Hope and self-esteem have been shown to be moderately correlated but distinguishable (Ciarrochi et al., 2007).

Individuals with high dispositional hope have been found to experience more positive emotions (Ciarrochi et al., 2007, 2015), have greater life satisfaction (Valle, Huebner & Suldo, 2006), be more resilient to life setbacks (Horton & Wallander, 2001; Valle et al., 2006), and positively influence their friends' well-being (Parker, Ciarrochi et al., 2015). Dispositional hope has also been associated with healthy forms of coping with daily stressors (Roesch, Duangado, Vaughn, Aldridge, & Villodas, 2010).

Several factors have been shown to predict the development of hope among young people. A recent meta-analysis of the antecedents and consequences of hope identified factors including social support, optimism, and life satisfaction as predictors of greater hope among adolescents (Yarcheski & Mahon, 2016). Predictors of low hope among adolescents included exposure to violence, stress, and depression (Yarcheski & Mahon,, 2016). However, to our knowledge, no research has examined the possibility that CIU might precede decrements in hope over time, or vice versa.

We expect that CIU will be an antecedent to less hope over time. Young people develop hope through the experience of success and mastery (Bandura, 1993; Bandura, Barbaranelli, Caprara, & Pastorelli, 2001; Snyder, 2005). They set goals, encounter barriers, learn from their mistakes, develop distress tolerance around their goal striving, and discover pathways around goal barriers (Hayes & Ciarrochi, 2015; Snyder, 2005). We expect that compulsive internet activity will be problematic for young people's levels of general hope because extensive online activity limits a young person's mastery opportunities in other domains such as face-to-face communication, physical activity, and other offline pursuits such as academic study (Billieux & Van Der Linden, 2012; LaRose et al., 2003). While CIU may lead to mastery experiences in some online activities, for example online gaming, we expect that excessive engagement in such activities will have an *overall* detrimental effect on general hope in young people, due to the absence of mastery experiences in other life domains.

Consistent with this idea, and conversely, studies have shown that *higher* levels of hope are associated with less addictive behavior (Bradshaw, Shumway, Wang, & Harris, 2014; Mathis, Ferrari, Groh, & Jason, 2009), including among adolescents (Carvajal, Clair, Nash, & Evans, 1998). In addition, research on compulsive behavior such as smoking (Bowen & Marlatt, 2009; Gifford et al., 2004), gambling (Lakey, Campbell, Brown, & Goodie, 2007), and drug use (Lee, An, Levin, & Twohig, 2015) has found that these addictions inhibit the capacity to identify goal-congruent pathways, and narrow the range and flexibility of behaviors a person engages in to achieve their goals (Zettle, Hayes, Barnes-Holmes, & Biglan, 2016). This theorizing suggests that CIU may undermine individuals' hope over time, and leads to our third hypothesis.

> *Hypothesis 3:* CIU will be antecedent to less dispositional hope over time.

2.4 | CIU as a consequence of low hope

Having high levels of hope may also protect young people from being drawn into the compulsive use of the internet. Hopeful people might be less prone to CIU because they identify more ways in which pressures to engage in compulsive behavior can be resisted (i.e., protective outcome expectancies, the "pathways" component) *and* have stronger beliefs as to their capacity to withstand such pressures (i.e., protective expectancies of personal agency, the "agency" component; Carvajal et al., 1998). Hopeful youth may also be engaged in more offline activities such as sport and academics and may therefore be less motivated to engage in compulsive internet activity that displaces these other activities.

Further, in the context of CIU research, low levels of hope may precede the development of CIU via the avoidance of face-to-face contact with others (e.g., Kim & Davis, 2009; LaRose et al., 2003). Extending related theorizing on self-esteem and CIU (Kim & Davis, 2009; LaRose et al., 2003), it may be that when individuals face difficulties in identifying self-relevant goals and lose a sense of personal efficacy in pursuing these, they turn to the internet in order to escape these difficulties. Under this explanation, a preference for online interaction—as a way of boosting self-concept—is the mechanism by which low levels of hope may lead to CIU. Based on this theorizing, our fourth hypothesis was as follows:

> *Hypothesis 4:* Low hope will precede CIU over time.

A final possibility is that both the "CIU-as-cause" and "CIU-as-consequence" models will be supported, implying

a "downward spiral" of CIU preceding less self-efficacy and hope, in turn predicting yet more CIU. This can be termed a reciprocal influence model. Such an outcome would mean that all four of our hypotheses are supported.

3 | METHODS

3.1 | Participants and procedure

This study was a part of the Australian Character Study, a multiyear program of research among high school students in Australia that collected a range of information relating to adolescent behaviors, relationships, beliefs, aspirations, and self-evaluations. Participants in the current study attended 17 Catholic high schools in two Australian states. Catholic schools in Australia account for 20.52% of secondary schools (Australian Bureau of Statistics, 2012). The schools participating in this study were concentrated in the cities of Wollongong (New South Wales) and Cairns (Queensland), but included schools in regional and rural areas, thereby ensuring the socioeconomic and cultural diversity of the participants. The Australian Government's socioeconomic index for schools sets the Australian average at 1,000 (http://bit.ly/1mJK7KC). The schools in the present study had a socioeconomic ranking almost identical to the Australian average (1,025; $SD = 43$), meaning this sample was broadly representative of the socioeconomic status of schools across Australia.

Participants completed measures for this study in the third of a four-term year in each of the four years of the study, from Grades 8 to 11. Participants' mean age was 13.7 years ($SD = 0.45$) in Grade 8. The total sample consisted of 2,809 participants (1,395 or 49.7% male, 1,399 or 49.8% female, 15 unknown). Ethics approval was granted by the University of Woollongong and informed consent was obtained from the study participants.

3.2 | Measures

3.2.1 | Compulsive internet use

This was measured using the compulsive internet use scale (Meerkerk et al., 2009). This scale was developed based on central features of addictive behavior as described in the DSM-IV and elsewhere, including withdrawal symptoms, loss of control, preoccupation, conflict with other activities, and lying to hide addictive behavior (Meerkerk et al., 2009). The scale contains 14 items rated on a 5-point scale, ranging from 0 (*never*) to 4 (*very often*). Due to space constraints, we used the 10 items that loaded most strongly onto this single-factor scale, dropping items 11–14 (see Meerkerk et al., 2009). Sample items include "Do you find it difficult to stop using the Internet when you are online?" and "Do you feel restless, frustrated, or irritated when you cannot use the Internet?" The scale has a clear single-factor structure, and has shown factorial stability across time and different samples. Cronbach's alphas for this measure in among the present sample were acceptable (Grade 8, $\alpha = 0.88$; Grade 9, $\alpha = 0.89$; Grade 10, $\alpha = 0.89$; Grade 11, $\alpha = 0.89$).

3.2.2 | Self-esteem

Trait self-esteem was measured using the 10-item Rosenberg Self-Esteem scale (RSE; Rosenberg, 1979). Participants were asked to indicate their agreement with statements such as, "Generally I feel satisfied with myself" and "I think that I am a failure" using a binary response scale ("yes" or "no"). The response scale used as this version of the RSE measure has been validated in previous research and has been found to have as-good-as or stronger internal consistency than the 4-point version of the measure (Heaven, Ciarrochi, & Hurrell, 2010; Marshall et al., 2013). Cronbach's alphas for this scale across the four study years were Grade 8, $\alpha = 0.85$; Grade 9, $\alpha = 0.86$; Grade 10, $\alpha = 0.88$; and Grade 11, $\alpha = 0.88$.

3.2.3 | Dispositional hope

This was measured using the six-item Children's Hope Scale (Lopez, Ciarlelli, Coffman, Stone, & Wyatt, 2000; Snyder et al., 2002). This scale measures the two facets of dispositional hope: agency and pathways. Sample agency items are "I think I am doing pretty well" and "I think the things I have done in the past will help me in the future." Sample pathway items are: "When I have a problem, I can come up with lots of ways to solve it" and "I can think of ways to get the things in life that are most important to me." Participants rated themselves on each item using a 6-point Likert scale ranging from "none of the time" (1) to "all of the time" (6). This measure has demonstrated acceptable psychometric properties (Snyder et al., 1991) and is known to be correlated to measures of adolescent adjustment (Valle et al., 2006). Cronbach's alphas for this scale across the four study years were Grade 8, $\alpha = 0.87$; Grade 9, $\alpha = 0.89$; Grade 10, $\alpha = 0.90$; and Grade 11, $\alpha = 0.91$.

3.3 | Statistical analyses

3.3.1 | Autoregressive cross-lagged models

To test our hypotheses, we used autoregressive cross-lagged (ACL) models. An ACL approach enables one to identify the likely temporal ordering of changes in phenomena across time, and the extent to which these changes are unidirectional or bidirectional (Parker, Marsh, Morin, Seaton, & Zanden, 2015). In the present study, this approach enabled us to test whether: (a) CIU predicts reductions in

self-esteem and hope (i.e., an antecedent model); or (b) low self-esteem and hope precede the development of CIU (i.e., a consequence model); or (c) the development of CIU and low self-esteem and hope is mutually reinforcing (i.e., a reciprocal influence model).

To test these alternative possibilities across the four years of the study, we ran a series of structural equation models (SEMs) in the R program (R Core Team, 2019) using the *lavaan* package (Rosseel, 2012). Analyses were conducted using latent variables for all study variables, following similar approaches elsewhere (e.g., Ciarrochi et al., 2015; Marshall et al., 2013; Donald, Ciarrochi, Parker, Sahdra, Marshall, & Guo, 2018). An advantage of a latent SEM approach is that it estimates a measurement model (rather than assuming one, as in manifest models) and so controls for measurement error (Parker, Marsh et al., 2015).

3.3.2 | Modeling approach

In the present study, we examined the longitudinal relations between CIU and self-esteem, and CIU and hope, in two separate sets of models. Because self-esteem and hope are related constructs, and therefore likely to be correlated, modeling them together with CIU in a single model means that shared variance in CIU explained by both self-esteem and hope is co-varied. Thus, for completeness, we report the effects in separate models and in one comprehensive model.

For each relationship tested, we ran a series of five progressively more constrained models. As a first step, a configural measurement model was estimated, in which all model parameters were allowed to vary across time. If the hypothesis of configural invariance is not rejected, stronger forms of measurement invariance may be tested and potentially used (Bollen, 1989). Second, we estimated a measurement model in which we tested for measurement invariance across time. To achieve this, the loadings of each factor onto its respective items were constrained to be equal across the four waves of the study. Support for this model indicates that the construct being measured has the same meaning at each time point and is an assumption of covariance-based models such as the ACL models estimated here (Ciarrochi et al., 2016).

Following tests of measurement invariance, we tested a series of three SEMs, in which regression coefficients between latent variables were estimated. The first of the structural models was a "fully-forward" model in which estimates for all paths (both autoregressive and cross-lagged) were estimated, including lags across multiple time points. Next, all lags greater than one were removed, and single-lag estimates were calculated, per Figure 1a. Finally, we constrained estimates across single-year lags to be equal, thereby testing for developmental equilibrium (see Figure 1b).

The data for this study had a nested structure with the 2,809 students nested within 17 schools. As our hypotheses related to individual differences, we controlled for differences in effects due to school membership. To do this, we used a "no pooling" approach, in which each of the 17 schools was included in all models as a set of dummy variables (Gelman & Hill, 2007). This approach is more conservative than a classic multilevel modeling approach ("partial pooling"), as it does not force random effects to be normally distributed, thereby allowing for greater heterogeneity in school-level effects (Gelman & Hill, 2007). Further, to address the well-documented problem of method bias due to the use of negatively worded items in self-report measures, we included a method factor by correlating the errors between these items (DiStefano & Motl, 2006).

3.3.3 | Missing data

Given that this was a longitudinal study with high school students, participant attrition was a potential problem. Of the 2,809 participants, 966 had data from all four waves (50.2% female), 837 had data from three waves (49.2% female), 532 had data from two waves (49.5% female), and 470 (52.0% female) had data from only one wave of the study. Participant attrition can result in data that are not missing completely at random, leading to biased parameter estimates when methods such as pairwise or listwise deletion of missing data are used (Baraldi & Enders, 2010).

To probe the effect of participant attrition, we compared those participants who completed all four waves of data ("completers") with those who completed less than four waves ("non-completers"), on the study variables of CIU,

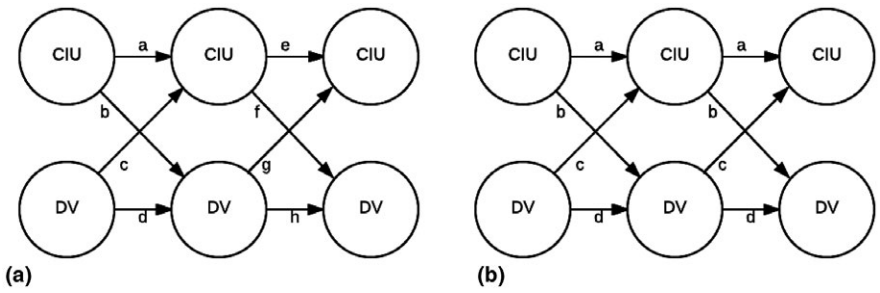

FIGURE 1 A conceptual diagram of a single-lag structural model (a) and a structural model in which autoregressive and cross-lagged paths are constrained to be equal across time (b). *Note.* CIU = compulsive internet use; DV = dependent variable, representing self-esteem and hope

self-esteem, and hope, and on gender. Mean scores on CIU were lower (at the $p < 0.05$ level) among completers than non-completers in Grade 8 (respectively, 1.32 vs. 1.42) and Grade 9 (1.42; 1.51) but were not significantly different in Grades 10 and 11. For self-esteem, mean scores were higher among completers than non-completers in Grade 8 (0.72 vs. 0.68), Grade 9 (0.83; 0.77), and Grade 10 (0.82 vs. 0.78); but were not different in Grade 11. Mean scores on hope were higher among completers than non-completers in Grade 8 (4.17 vs. 4.05), Grade 9 (4.23; 4.06), Grade 10 (4.24 vs. 4.08), and Grade 11 (4.13 vs. 4.03). Finally, we tested whether there were differences in the number of females between completers and non-completers but did not find evidence for this (50.5% for completers vs. 50.2% for non-completers; $p = 0.891$). Although there were statistically significant differences between completers and non-completers on CIU, self-esteem, and hope in some years, these differences were typically small: the Cohen's *d* effect sizes for these differences were all less than 0.20. This was not surprising given that the unit of selection was "school" and thus random factors like absenteeism on the day of testing or participants changing schools accounted for much of the attrition. Nevertheless, to deal with these missing data, we used full information maximum likelihood estimation (FIML) methods in all models—as opposed to ad hoc methods such as listwise deletion. A key advantage of the FIML approach to missing data is that it uses all the available information for parameter estimation—both complete and incomplete cases—and identifies parameter values that have the highest probability of producing the sample data (Baraldi & Enders, 2010).

3.3.4 | Fit statistics

Models were considered to fit the data well if parameter estimates were consistent with the theory proposed, the solution was well defined, and the fit indices were acceptable (McDonald & Marsh, 1990). In addition to the chi-squared statistic, we used three other fit indices: the Tucker–Lewis index (TLI) and comparative fix index (CFI), and the root mean square error of approximation (RMSEA). Generally accepted minimum thresholds for the former two indices are 0.90, while 0.08 is generally considered an acceptable maximum threshold for RMSEA (Chen, 2007; Cheung & Rensvold, 2002). In comparing the fit of successively more restrictive models, we used the criteria by Cheung and Rensvold (2002) who suggest that invariance exists between nested models if changes in CFI is <0.01 (we used the same criteria for the TLI), and the criteria described by Chen (2007), who suggests invariance between nested models exists if changes in RMSEA is ≤0.015.

4 | RESULTS

4.1 | Preliminary analyses

Latent means and standard deviations for CIU, self-esteem, and hope are shown in Table 1, and were relatively consistent across the four waves of the study.

As shown in Table 2, correlations between variables were generally as-expected, with the largest correlations being for the most proximal time points, and smaller correlations for more distal time points. Also, test–retest correlations within variables were medium-to-high, ranging from 0.54 to 0.68 for CIU; from 0.54 to 0.76 for self-esteem; and from 0.54 to 0.64 for hope. Correlations both within and between variables over time were, on average, larger among females than males, with typical differences in correlation between the genders being around 0.10 in magnitude.

4.2 | Main analyses

We next examined our main research question—the longitudinal relations between CIU and self-esteem, and CIU and hope—using the methods outlined above where we tested a series of five separate, increasingly restrictive models for

TABLE 1 Latent means and standard deviations for study variables across the four study years

	Grade 8		Grade 9		Grade 10		Grade 11	
	Mean	***SD***	**Mean**	***SD***	**Mean**	***SD***	**Mean**	***SD***
CIU	2.16	1.01	2.18***	0.99	2.26	1.00	2.34**	1.00
Self-esteem	0.85	0.22	0.80***	0.28	0.79	0.28	0.76*	0.31
Hope	4.15	0.65	4.28***	0.75	4.31	0.80	4.25*	0.81

Notes. CIU = compulsive internet use. *SD* = standard deviation. There were significant differences (at the $p < 0.05$ level) in mean scores on CIU between Grades 8 and 9 and between Grades 10 and 11; in self-esteem between Grades 8 and 9 and between Grades 10 and 11; and in hope between Grades 8 and 9 and between Grades 10 and 11. These are indicated by asterisks showing differences between the current and previous period for each study variable, where *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$. Significant differences in means between Grades 9 and 10 were not found for any of the three study variables.

TABLE 2 Bivariate correlations between study variables, with correlations for males above and for females below the diagonal

	CIU 8	CIU 9	CIU 10	CIU 11	SE 8	SE 9	SE 10	SE 11	Hope 8	Hope 9	Hope 10	Hope 11
CIU 8	–	**0.54*****	**0.43*****	**0.38*****	−0.26***	−0.21***	−0.15***	−0.21***	−0.14***	−0.14***	−0.14***	−0.18***
CIU 9	**0.64*****	–	**0.56*****	**0.50*****	−0.18***	−0.31***	−0.17***	−0.22***	−0.09*	−0.14***	−0.10**	−0.11**
CIU 10	**0.52*****	**0.64*****	–	**0.59*****	−0.19***	−0.20***	−0.25***	−0.23***	−0.12**	−0.11**	−0.14***	−0.21***
CIU 11	**0.40*****	**0.53*****	**0.68*****	–	−0.16***	−0.24***	−0.14***	−0.30***	−0.14***	−0.14***	−0.17***	−0.25***
SE 8	−0.33***	−0.30***	−0.17***	−0.18***	–	**0.57*****	**0.41*****	**0.44*****	0.39***	0.32***	0.30***	0.31***
SE 9	−0.33***	−0.36***	−0.24***	−0.24***	**0.68*****	–	**0.54*****	**0.54*****	0.31***	0.47***	0.31***	0.32***
SE 10	−0.22***	−0.24***	−0.28***	−0.20***	**0.54*****	**0.64*****	–	**0.61*****	0.25***	0.31***	0.45***	0.38***
SE 11	−0.19***	−0.23***	−0.26***	−0.28***	**0.51*****	**0.62*****	**0.76*****	–	0.25***	0.31***	0.31***	0.49***
Hope 8	−0.19***	−0.20***	−0.10**	−0.15***	0.49***	0.39***	0.33***	0.28***	–	**0.57*****	**0.53*****	**0.45*****
Hope 9	−0.22***	−0.23***	−0.18***	−0.20***	0.45***	0.58***	0.41***	0.42***	**0.60*****	–	**0.54*****	**0.52*****
Hope 10	−0.19***	−0.22***	−0.22***	−0.18***	0.35***	0.42***	0.59***	0.48***	**0.47*****	**0.64*****	–	**0.61*****
Hope 11	−0.19***	−0.21***	−0.25***	−0.23***	0.34***	0.41***	0.49***	0.59***	**0.45*****	**0.60*****	**0.69*****	–

Notes. CIU = compulsive internet use. SE = self-esteem. Within-variable correlations are in bold. Between-variable correlations are not in bold.
$^{*}p < 0.05$. $^{**}p < 0.01$. $^{***}p < 0.001$.

each relationship examined. Each of these five successively more restrictive models was compared, and if the deterioration in fit was within the accepted thresholds, the more restrictive model was preferred (Bollen, 1989).

4.2.1 | Model fit

As Table 3 shows, all models showed acceptable fit to the data. CFI and TLI indices were above the generally accepted threshold of 0.90; and RMSEA was below the threshold of 0.08 for all models. Further, in all cases, the deterioration in fit between successively more restrictive models was within the 0.01 recommended for CFI and TLI, and the 0.015 recommended for the RMSEA statistic.

Notably, the stability of the factor structure across time was supported (i.e., CFA 2, the time-invariant CFA). Second, for both relationships tested, the structural model (SEM 1) in which only single-lags are estimated had acceptable fit to the data, meaning it was appropriate to test only single-lagged effects across time. Finally, the fit of the developmental equilibrium models (SEM 3) did not deteriorate beyond the thresholds outlined above, making these the preferred models.

4.2.2 | Path coefficients for developmental equilibrium models

Given that the developmental equilibrium models displayed acceptable fit and were therefore preferred over the less restrictive models, we only report results from these models below. Figure 2 displays the cross-lagged relations between CIU predicting changes in self-esteem and hope ("CIU-as-antecedent"), and both self-esteem and hope predicting changes in CIU ("CIU-as-consequence"), from each of the models we ran. Figure 2 shows 90% and 95% confidence intervals (CIs) around each estimate. Assuming a normally distributed population and known population variance, a 95% CI indicates an 83% likelihood that the effect size estimate of a replication study would lie within the interval, while a 90% CI indicates a 76% likelihood that the effect size estimate of a replication study would lie within the CI (Cumming & Maillardet, 2006; Cumming, 2013).

As Figure 2 shows, CIU consistently predicted significant decreases in hope ($\beta = -0.08$, $p < 0.001$, CI 95% [−0.09, −0.06]) and self-esteem ($\beta = -0.03$, $p < 0.01$, CI 95% [−0.04, −0.02]), thereby providing support for Hypotheses 1 and 3. Notably, we did not find support for the CIU-as-consequence model (Hypotheses 2 and 4), with both effects being nondifferent from zero. The complete results of each of these developmental equilibrium models, with both cross-lagged and autoregressive paths, are presented in Supplemental Material Table S1.

TABLE 3 Fit statistics for CFA and SEM models

	CIU and self-esteem					CIU and hope				
Model	χ^2	*df*	**RMSEA**	**CFI**	**TLI**	χ^2	*df*	**RMSEA**	**CFI**	**TLI**
CFA 1	8,948.592	3,480	0.024	0.934	0.928	8,224.34	2,332	0.030	0.925	0.918
CFA 2	9,120.875	3,540	0.024	0.933	0.927	81,457.385	2,380	0.030	0.924	0.918
SEM 1	9,754.211	3,704	0.024	0.928	0.922	8,874.303	2,512	0.030	0.920	0.914
SEM 2	9,856.023	3,716	0.024	0.927	0.921	9,043.18	2,524	0.030	0.918	0.912
SEM 3	9,863.174	3,724	0.024	0.927	0.921	9,047.006	2,532	0.030	0.918	0.912

Notes. CFA 1 was a configural CFA model. CFA 2 was a CFA with factor loadings constrained to be equal across time points. SEM 1 was a structural model in which all paths (both cross-lagged and autoregressive) were estimated. SEM 2 was a model in which only single-year cross-lagged and autoregressive paths were estimated. SEM 3 was the developmental equilibrium model.

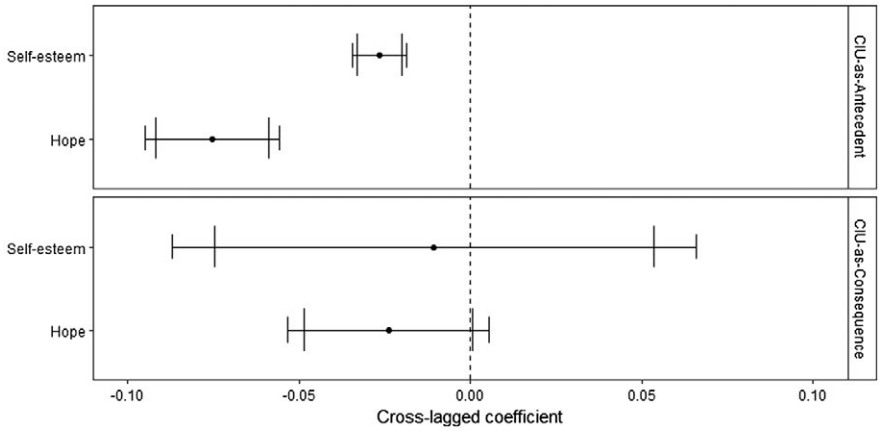

FIGURE 2 Standardized estimates (with 90% and 95% CIs) from developmental equilibrium structural equation models across the four years of the study, with CIU predicting ("CIU-as-Antecedent") and predicted by ("CIU-as-Consequence") self-esteem and hope

4.2.3 | Path coefficients from a combined model

For completeness, we ran a series of five models that combined CIU, self-esteem, and hope in a single model. The fit for these models was acceptable, and the developmental equilibrium model was preferred (see Supplemental Material Table S2, for fit statistics for these models). The cross-lagged estimates from the developmental equilibrium model were consistent with those reported in Figure 2, with CIU consistently preceding the development of less hope and self-esteem (Hypotheses 1 and 3), but not low hope and self-esteem preceding the development of CIU (Hypotheses 2 and 4). Cross-lagged estimates from CIU to hope were $\beta = -0.06$, $p < 0.001$, CI 95% [−0.08, −0.04], and from CIU to self-esteem were $\beta = -0.03$, $p < 0.05$, CI 95% [−0.04, −0.02]. Notably, the 95% confidence intervals around these estimates did not overlap, suggesting that, over multiple replications, the effect from CIU to hope is likely to be larger than the effect from CIU to self-esteem (Cumming & Maillardet, 2006). All autoregressive and cross-lagged estimates from these models are presented in Supplemental Material Table S3.

5 | DISCUSSION

Relatively little research has examined the longitudinal causes and consequences of the compulsive use of the internet. In particular, no research has examined the longitudinal relations between CIU and self-evaluations among adolescents—a cohort for whom self-concepts are highly formative. The aim of the present study was to test whether CIU is an antecedent or a consequence of both self-esteem and hope, and whether these effects are stable across adolescence. We found consistent support for CIU preceding less hope and to a lesser extent self-esteem (the "CIU-as-antecedent" model) but did not find evidence for CIU being a consequence of having low levels of hope and self-esteem (the "CIU-as-consequence" model).

5.1 | The CIU-as-antecedent model

We found general support for the CIU-as-antecedent model (Hypotheses 1 and 3), showing that CIU precedes modest declines in self-evaluations over time. Our findings extend recent longitudinal research showing that CIU predicts worse mental health (Ciarrochi et al., 2016) and predicts increases in loneliness, depression, and stress over time (Muusses

et al., 2014). Further, our results reinforce recent calls from longitudinal research to explore strategies for reducing the incidence of CIU, especially among children, given the emerging evidence for the downstream consequences of such behavior (Ciarrochi et al., 2016; Vondráčková & Gabrhelík, 2016).

Although the longitudinal effect sizes we obtained were relatively small in magnitude ($\beta = -0.08$ for hope and $\beta = -0.03$ for self-esteem), these effects were observed over a full-year lag, which is a considerable time period in the context of adolescent development. Further, the effects we observed are of a similar magnitude to effects observed in other longitudinal research on CIU. For example, Muusses et al. (2014) reported cross-lagged effects (across three one-year lags) of CIU to happiness ($\beta = -0.05$), depression ($\beta = 0.06$), and stress ($\beta = -0.05$) while van den Eijnden et al. (2008) reported a cross-lagged link between parenting practices and future compulsive internet usage of 0.02 to 0.10 (van den Eijnden et al., 2008).

Another notable feature of our "CIU-as-antecedent" findings is their stability over time (i.e., developmental equilibrium). This indicates that CIU may have cumulative effects on hope and self-esteem over multiple years, which amplify the otherwise modest year-on-year effects. For example, if a young person is consistently one standard deviation above average on CIU from Grades 8–11, they can expect to see their levels of hope drop by about one third of a standard deviation over this period. In addition, hope is a global variable that can affect many domains. A drop in hope may diminish a young person's well-being (Ciarrochi et al., 2015), influence them to affiliate with groups that are lower in hope (Parker, Ciarrochi et al., 2015), lead to diminished school grades in high school (Ciarrochi et al., 2007) and university [Feldman & Kubota, 2015]), and undermine job performance (Valero, Hirschi, & Strauss, 2016). Hope is considered one of the most important common processes for psychological change (Snyder, Ilardi, Michael, & Cheavens, 2000).

Notably, effects were larger from CIU to hope than from CIU to self-esteem. We speculate here on reasons for this, but future research is needed to test these explanations. Why might CIU have relatively little impact on self-esteem? Self-esteem relates to one's social worth, whereas hope relates to one's ability to achieve goals. The internet is inherently a social world, and research has consistently shown that interpersonal communication is the main application of the internet (Huang, 2010; Van Der Aa et al., 2009). Most generalized CIU has also been linked with interpersonal exchanges and seeking social contact online (Caplan, 2003; Davis, 2001). Given this, it may be that internet use provides both positive *and* negative social reinforcement, in turn explaining why CIU has modest net impacts on self-esteem. For example, research suggests that online communication with *existing* friends enhances adolescent well-being (Bessière et al., 2008; Valkenburg & Peter, 2007), whereas in other contexts, such as seeking out new friendships, it may inhibit well-being (Huang, 2010; Van Der Aa et al., 2009). Future research is needed to explore these potential differential effects, for example using latent profile analysis. Further, in the only longitudinal study we are aware of on CIU and self-esteem, Muusses et al. (2014) found that CIU neither predicted nor was predicted by self-esteem over a four-year period. Our findings that CIU has a small negative effect on self-esteem (in contrast to Muusses et al., 2014) may be because self-esteem is more malleable among adolescents that in adulthood.

In contrast to self-esteem, which can be enhanced via social contact on the internet, we speculate that experiences of general hope are inhibited by having less mastery experience in the non-internet world. Young people who engage in CIU may have narrowed their range of behavior such that they engage in less offline activity, for example face-to-face social connection with others, and offline extracurricular activities such as sports, music, and other creative pursuits. As a consequence, they have fewer opportunities to practice goal persistence, learning from failure, and overcoming barriers to goals, meaning they experience less hope over time. We acknowledge, however, that these effects may vary for different profiles of young people, and further research is needed to explore this. For example, some young people's CIU may lead to *greater* hope—for example, via mastery experiences in online gaming or social exchanges—whereas for others, CIU may lead to large reductions in hope.

5.2 | The CIU-as-consequence model

We did not find evidence that low levels of self-esteem or hope predicted the development of CIU over time (Hypotheses 2 and 4). Researchers have theorized that negative self-evaluations lead to a preference for online (rather than face-to-face) interaction, in turn leading to CIU (Caplan, 2003; Kim & Davis, 2009; Muusses et al., 2014). Indeed, it has been proposed that poor mental health problems can form part of a "downward spiral," with more avoidant behavior leading to worse mental health, in turn leading to an increase in avoidant behavior (Ciarrochi & Bailey, 2008; Williams, Ciarrochi, & Heaven, 2012).

However, our results do not support these explanations. This may be because CIU is driven more by contextual factors such as access to the internet, time spent alone, social support, and the availability of non-internet alternatives, than by personality factors. Future research is needed to explore this possibility. Another possibility is that personality variables such as self-esteem and hope have indirect effects on CIU, via other mechanisms, such as a preference for online communication (Caplan, 2003). Future research could explore this by extending studies that have partially examined these models (e.g., Gamez-Gaudix, 2014), but using multi-wave longitudinal data sets to more rigorously

test these mechanisms. In addition, it might be that hope and self-esteem in years prior to Grade 8, for example in primary school years, are antecedents of CIU in Grades 8 to 11. Because our study was limited to these secondary school years, we cannot rule out this possibility. Further longitudinal research spanning both primary and secondary school years could investigate this possibility. Finally, the effects of CIU on self-esteem and hope may be a function of the amount of internet access the young person had in early childhood. For example, there may be a stronger link between CIU and hope or self-esteem among those who had ready internet access in early childhood compared with those who did not. This possibility could also be explored in subsequent longitudinal research.

5.3 | Strengths and limitations

This study is the first we are aware of to examine the longitudinal relations between CIU and both self-esteem and hope. Personality traits such as these are hypothesized to be modifiable over time, making them important variables in studying adolescent development (Orth et al., 2015; Snyder, 2005; Snyder et al., 1991; Trzesniewski et al., 2003). Furthermore, this study used state-of-the-art structural equation modeling approaches, testing a series of increasingly restrictive models to test the extent to which the longitudinal relations between CIU and self-evaluations were stable over time. These methods mean that we can draw relatively strong conclusions regarding the stability and significance of the effects we have identified. However, there are several limitations to this study that need to be acknowledged.

First, we cannot rule out the possibility that additional variables that were not measured in this study explain the relations between CIU and both self-esteem and hope over time. By using cross-lagged and autoregressive models, we were able to control for current-period levels of self-esteem and hope in assessing the extent to which current-period CIU predicts next-period self-esteem and hope. Conversely, when testing the effect of current-period self-esteem and hope on next-period CIU, we controlled for current-period CIU. This control should reduce the problem of common method variance (i.e., variance in the outcome being an artifact of the way the predictor was measured) because what is common in the scales is in theory removed from the cross-lagged estimates (DiStefano & Motl, 2006). Further, we controlled for school-level effects in all models. However, there may yet be unmeasured third variables that explain the effects in this study, such as demographics, other environmental factors such as family and peer support, and genetic factors. Future research could seek to assess and control for these other variables in a longitudinal design.

Second, this study focused on generalized CIU and did not explore the specific types of internet activities that may be predictive of negative self-appraisals over time. Previous research has shown that gaming, social media, and other forms of online communication tend to be the online activities most strongly associated with CIU in adolescents (Ciarrochi et al., 2016; Muusses et al., 2014). Do some forms of CIU have different effects than other forms? For example, perhaps addiction to online gambling would be a stronger predictor of less hope than addiction to social media. Future research should explore these questions.

Third, future research needs to focus on ways to most effectively reduce CIU and study the effects of these interventions on character development and related psychosocial outcomes. A recent meta-analysis of 108 studies of interventions designed to prevent internet addiction identified several priorities for such interventions (Vondráčková & Gabrhelík, 2016). First, CIU interventions should be targeted at preprimary, primary, and adolescent children, as this is where values and standards develop and are most able to be influenced. Second, and crucially, such interventions should target the close surroundings of adolescents, especially parents, family, the school environment, and extracurricular activities, and engage close others in the development of healthy internet use practices. Third, Vondráčková and Gabrhelík (2016) identified four common areas for focus in such interventions: (a) self-regulatory skills associated with internet use; (b) skills in coping with stress and emotions; (c) skills associated with interpersonal communication, including reduced interpersonal reactivity and greater interpersonal confidence; and (d) skills associated with one's daily regime and use of free time. The latter two foci seem especially relevant to self-esteem and hope, respectively. In their review, Vondráčková and Gabrhelík (2016) identified only eight studies of interventions specifically targeting the prevention of internet addiction (the remaining 100 studies targeted a range of other maladaptive behaviors), meaning that much more research is needed to understand the most efficacious interventions, their mechanisms, and their impact on life outcomes, including self-esteem and hope.

6 | CONCLUSIONS

We examined the longitudinal relations between CIU and both self-esteem and hope during adolescence. Our findings suggest that CIU precedes modest decrements in hope and self-esteem, and not the other way around. Moreover, our findings suggest that CIU has a relatively larger effect on perceptions of the self that relate to goal self-efficacy (i.e., hope) than more socially mediated self-evaluations (i.e., self-esteem). This may be because CIU narrows the range of a person's opportunities for experiencing mastery in their lives. Given the continued rapid increase in internet use among adolescents right across the world, and the impacts of poor adolescent self-regulation on important outcomes in

adulthood, our study underscores the need to identify family and educational interventions that foster healthy internet use among adolescents.

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CONFLICT OF INTERESTS

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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