



# Longitudinal association of adolescents' perceptions of parental mediations and compulsive Internet use<sup>☆</sup>

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## ABSTRACT

Today's adolescents do not know a life without the Internet, which is here to stay. Much of adolescents' Internet consumption takes place at home. Accordingly, it is imperative that parents are centrally positioned to aid adolescents to maximize the opportunities it presents while also minimizing the associated risks. This 2-year, four-wave longitudinal study involved 1983 middle school adolescents (Mage = 13.01, SD = 0.70; Grade seven at Time 1; 46.9% female) to examine the relationship between adolescents' perceived parental mediation styles, including encouragement, worry, monitoring, and permission, and compulsive Internet use (CIU). Autoregressive cross lag panel analyses showed that the mediation styles functioned differently and interacted with CIU at different time periods. Parental encouragement was the only mediation that reduced adolescents' CIU, and it only worked during a school year, but not across school years. CIU was a constant trigger of parental worry in all time periods. CIU predicted parental monitoring across school years but not within a school year. It also prompted parental permission during a school year. Parents exhibited more than one parental mediation style at any given time period. Steps to elevate parental encouragement should be put in place so as to reduce adolescents' CIU.

## 1. Introduction

This study sought to understand the longitudinal relationship of the different parental mediations and compulsive Internet use (CIU). In today's digital age, the entrenchment of information and communication technology (ICT) is the norm rather than the exception. ICT has become an integral part of many people's lives. Today's children, referred to as digital natives (Prensky, 2001), have increasingly engrained ICT into their day-to-day activities. Indeed, many may not experience a life without the Internet. Yet, they may still be ill equipped to survive in a digital environment, and hence be susceptible to its harm and not be able to make the most of it. Since ICT is here to stay, it is vital for parents to both empower their children to fully benefit from it and also protect them from its potential harm (Symons et al., 2020). Consequently, they will be able to safely survive in a digital environment and grow to be

responsible and resilient adults (Livingstone & Byrne, 2018). Potential harm includes Internet addiction, Internet dependence, Internet gaming disorder, pathological Internet use, and CIU. Different researchers use some of these terms to mean the same thing (Germani et al., 2023). There is no consensus on the best definition of Internet-related problems, but it is agreed that problematic Internet use is distressing and time-consuming and interferes with functioning in important areas of life (Van den Eijnden et al., 2008). The present study examined CIU among adolescents, focusing on these traits rather than the addictive and pathological behaviors that require professional diagnosis and treatment. CIU is defined as a pattern of behaviors characterized by an uncontrollable strong urge to use the Internet, often to the detriment of one's responsibilities and daily life. It encompasses impaired control over Internet use, psychological and emotional dependence on the Internet, negative impacts on social relationships, reduced sleep, and

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overlook of schoolwork and daily obligations (Dhir et al., 2015; Meerkerk et al., 2009).

Parents are facing the challenge of ensuring a balance to maximize the benefits of the Internet while minimizing its potential risks to their children (Dingus Keulen et al., 2020; Livingstone & Byrne, 2018). Use of the Internet has increased among adults and children; the age of Internet access has gradually decreased, and the number of children who feel uncomfortable when they are not online, a symptom of CIU, has risen (Aslan & Yilmaz, 2021). A high percentage of children (90%) in developed countries access the Internet at home (Mullan & Hofferth, 2022). Steinfeld (2021) reported that 93% of older children ( $M_{age} = 14.95$ ,  $SD = 1.33$ ) and 75% of a younger sample ( $M_{age} = 9.96$ ,  $SD = 0.78$ ) surfed websites by themselves. Since the uptake of ICT has witnessed exponential growth, it is probable that the estimates will also keep increasing over time, which may lead to Internet overuse (Dhir et al., 2015). In this regard, scholars have examined the strategies employed by parents to mitigate the negative effects as well as to enhance the positive effects of media on children (Kirkorian et al., 2008).

Parenting has a direct impact on a child's development because children spend a substantial amount of time at home (Chou et al., 2016). Adolescents with increased parental monitoring have been shown to have fewer problematic Internet behaviors (Bleakley et al., 2016). The risk of developing excessive Internet use is lower among adolescents who feel comfortable, taken seriously, understood (van den Eijnden et al., 2010), supported, offered explanations of prohibition, and allowed choices (Elsaesser et al., 2017; Padilla-Walker et al., 2018) by their parents when talking about their Internet use, but higher among those whose parents exhibit authoritarian and protective-demanding styles (Dogan et al., 2015). Conflicts and poor family support are strong predictors of Internet addiction among Korean adolescents (Park et al., 2008). Inconsistent parenting increases adolescents' CIU (Miltuze et al., 2021). The extant literature has demonstrated that the approach parents adopt impacts on or is closely related to adolescents' Internet behaviors.

### 1.1. General parenting and specific parental mediation

Baumrind (1971, 1991) proposed four general parenting styles, namely authoritative, authoritarian, neglectful, and indulgent. They could be dichotomized according to parental warmth (responsiveness) and control (demandingness). The former adapts and responds to children's needs, whereas the latter consistently demands moral maturity from children and demonstrates an inclination to discipline children when they fail to meet parental expectations (Dhir & Khalil, 2018; Liu et al., 2021). This article was centered on specific parenting in relation to Internet use, that is, Internet parenting, which predominates in media consumption research and is often referred to as parental mediation. In the present study, parental mediation was conceptualized in terms of parental encouragement (PE), worry (PW), monitoring (PM), and permission (PP) (Dhir & Khalil, 2018; Lau & Yuen, 2013; Valcke et al., 2010). PE entails all that parents discuss and share to help their children maximize the benefits of the Internet. PW appears when parents harbor a perception that their children may be harmed by Internet-related risks such as exposure to pornography, online violence, health and emotional problems, and so forth; parents generally become uneasy when their children use the Internet. On the other hand, PM stems from disapproval of youngsters' online activities and an intention to control them. Parents monitor their children's online activities, for instance, by asking them whom they chat with online. Lastly, PP occurs when parents let their children have their way concerning the use of the Internet; they place no restrictions on Internet use and allow their children to chat with friends, play online games or freely download music/movies.

Parental mediation is more complicated than general parenting due to the generational technology divide. Naturally, a more knowledgeable other will less likely consult the less knowledgeable one or give little notice to or disregard their advice altogether. On the same note, with

regard to digital technology, there exists a generational divide (Mitchell et al., 2005) between today's adolescents and their parents. For instance, Livingstone et al. (2017) showed that about 92% of children feel confident about Internet usage compared with 62% of their parents. Also, parents' perceived competence and self-efficacy related to their digital skills positively influence how they involve their children in discussing media and Internet related activities (Benedetto & Ingrassia, 2021). A scenario in which children become more competent in Internet use than their parents can precipitate reversed socialization (Grossbart et al., 2002) whereby the children have acquired better ICT skills than their parents. Due to this reversed socialization, children tend to make more decisions in terms of the hardware and software to be installed (Youn, 2008), hence having more say when it comes to Internet use. Thus, it is arguable that adolescents' Internet use is likely to trigger their parents' responses of being worried, giving encouragement, granting permission, or monitoring their Internet use. An understanding of the (bidirectional) relationship between CIU and parental mediation using longitudinal data would help to clarify the causality of the variables. The present study could raise awareness among parents, policy makers, and other stakeholders in terms of how adolescents perceive their parents regarding their Internet use. This, in turn, can inform the drafting of optimal interventions that can avert adolescents' CIU.

### 1.2. Conceptualizing the relationship between CIU and parental mediation using the bio-ecological systems theory

The contentious age-old debate about children's interaction with media is intensified as new forms of technology emerge. Thus, to best explain the dynamic nature of a child's Internet media-related development, the present study drew on the bio-ecological systems theory (Bronfenbrenner & Morris, 2006). The theory posits that an individual's development is determined by the environment consisting of five nested concentric layers of subsystems in the order of microsystem, mesosystem, exosystem, macrosystem, and chronosystem (Bronfenbrenner & Morris, 2006; Patel, 2011). The first three layers are crucial in children's Internet use (O'Neill, 2015). The microsystem, the immediate environment, is most influential because the relatively long interactions take place and have the greatest impact on a child's development. In the present study, the microsystem level focuses on parental mediation (PE, PW, PM, and PP). As parents are in many ways the gatekeepers in a family structure (Lau & Yuen, 2016; Livingstone & Byrne, 2018), our argument is that parental mediation strongly influences children's Internet use. For example, PE or PW may affect adolescents' Internet use in different ways, making confident or anxious Internet users.

The next level, the mesosystem, is made up of the interactions between a child's different microsystems, such as school, peer groups, home and/or church, and their influence on Internet use. Individuals learn not only from their parents but also by observing and modelling the behavior of peers and other models (Bandura & Walters, 1977). It is therefore possible for children to become more tech-savvy than their parents due to media disintermediation (Cai, 2023), where the Internet allows children to bypass their parents in accessing information. This in turn can fuel the generation gap (Mitchell et al., 2005) and sets the precedent for reverse socialization (Grossbart et al., 2002).

Traditional mass media belongs to the exosystem. However, due to the evolution and disruptive interconnectedness of the Internet, greater responsibility and demands have been placed on parents to manage the flow of exosystem media content at the microsystem level (O'Neill, 2015). Moreover, children sometimes have longer and closer contact with their personal devices than their parents. Such an ecological approach provides a framework for understanding the complex interplay between parental mediation and CIU in the present study.

### 1.3. Previous research on parental mediations and CIU and the research hypotheses

The following paragraphs reviewed previous research on the four parental mediations and CIU. Research hypotheses were proposed based on the literature review. First of all, PE is a positive attitude towards technology which results in discussing the benefits of technologies and the Internet with children (Dhir et al., 2019). Such conversations make adolescents feel understood, warm, and taken seriously, and thus reduce their CIU (van den Eijnden et al., 2010). Children are likely to develop Internet dependency in response to parent-child conflict, parental hostility, and parents' insufficient emotional warmth (Kwon et al., 2011). Likewise, Lau and Yuen (2013) noted that PE reduces Internet stickiness (time spent on a webpage or site). Parents who present warm and authoritative strategies generally reduce problematic Internet use or CIU among children (e.g., Miltuze et al., 2021; Smetana, 2017; Özasan et al., 2022). It is conceivable that when parents perceive that their encouragement reduces adolescents' Internet compulsivity, they would be motivated to continue the communication. On the other hand, adolescents' CIU predicts a decrease in parental communication (van den Eijnden et al., 2010). Therefore, we hypothesize that PE regarding adolescents' Internet use has a negative reciprocal relationship with CIU over time (H1).

A worrisome person is plagued by fear and conjures up bad happenings (Staksrud & Ólafsson, 2020). Dhir et al. (2019) defined PW as a lower form of parental warmth whereby parents imagine negative outcomes of adolescents' use of the Internet. The imaginations may lead to parental forbidding of adolescents' Internet use. When adolescents perceive parents' constant worry about their Internet use, they respond by isolating and hiding themselves so that their parents do not see them using the Internet. Such actions may lead adolescents to develop more negative emotions such as anxiety, addiction, or compulsivity (Lo et al., 2020) which may lead to greater parental restrictions to Internet access (Miltuze et al., 2021). For adolescents to ward off the effect of negative emotions, they may seek comfort by plunging themselves into more Internet use (Zhang et al., 2015). This may, in turn, raise PW. Furthermore, according to the coercion theory, a child's deviant behaviors may be reinforced as they interact with peers and family (Patterson, 2016). In relation to Internet use, through negative reinforcement, parents acquiesce to a child's CIU so as to find relief from their whining and throwing of tantrums whenever they address the CIU (Thomas, 2011). To the detriment of the child, such actions are likely to recur as children manipulate the parents to prevent them from terminating their CIU. Thus, we hypothesize that PW about adolescents' Internet use is positively and reciprocally related with CIU over time (H2). In other words, an adolescent's development of CIU causes parents to become worried, and vice versa.

PM consists of practices and behaviors that parents engage in to keep themselves informed about their children's activities, peers, and whereabouts (Bleakley et al., 2016) with the aim of preventing the children from exhibiting problem behavior (Smetana, 2017). It is a higher form of parental control (Dhir et al., 2019; Lau & Yuen, 2013). Common PM strategies applied by parents include solicitation, observing and listening, control through rules, receiving information from a spouse, other children, and non-family members, being actively involved in the child's activities (Keijsers & Laird, 2014), and using software for tracking and restricting online content and activities (Chen & Shi, 2019). In the present study, PM was conceptualized as a relational exercise whereby parents rely on information adolescents willingly disclose to them (Kerr et al., 2010), that is, focusing on solicitation, which is made known to the adolescents. Thus, the parent-child relationship plays a crucial role.

With a good relationship, more parental solicitation predicts more disclosure from adolescents, and in turn, more adolescent disclosure encourages more parental solicitation (Keijsers & Laird, 2014). Keijsers and Laird further argued that when adolescents become open to their

parents about their Internet use, the parents interpret it as a sign of approval of their monitoring, thereby increasing PM. The good quality relationship between parents and adolescents deters the development of CIU among adolescents (van den Eijnden et al., 2010). On the same note, PM is associated with less problematic Internet behavior (Bleakley et al., 2016). When parents notice adolescents' CIU, they are likely to take advantage of the goodwill or the legitimacy that the adolescents have bestowed on PM to engage in more solicitation leading to more disclosure, hence helping adolescents reduce their CIU.

However, the story may be different when CIU is high and the parent-child relationship is poor. The solicitation may be perceived by adolescents as an invasion of their privacy, prompting their repulsion and not opening up to parents (Liu, 2020). Geržická et al. (2023) suggest that PM may have undesirable consequences if not accompanied by open discussion. For instance, it may cause adolescents to become more alert and secretive about their Internet use, hence increasing their risk of developing CIU. Moreover, parental restrictiveness (Lukavská et al., 2022) and forbidding (Miltuze et al., 2021) Internet use may instigate psychological reactance from adolescents because of their desire for autonomy (Liu, 2020). Such actions may only exacerbate adolescents' CIU (Lukavská et al., 2022; Miltuze et al., 2021) more so among older adolescents (Chen & Shi, 2019). High PM and resistance from adolescents may break down parent-child communication and sever their relationship, causing adolescents to lean even more on the Internet for emotional satisfaction and so to have worsening CIU (Özaslan et al., 2022). Therefore, we hypothesize that high CIU predicts high PM, whereas high PM could be uncertain for CIU, depending on the parent-child relationship over time (H3).

Finally, PP is a lower form of parental control (Dhir & Khalil, 2018) and low demandingness (Valcke et al., 2010). For a parent to grant permission implies that there is a level of accountability expected from the person who has been granted the permission; as a result, there may be rule setting (about time and content), consistent disciplining (if rules are broken), monitoring online behavior of a child (to ensure compliance), and expecting high moral maturity (Dhir & Khalil, 2018). The unintended consequence of PP is that adolescents may perceive their parents' actions to be lethargic, cold, intrusive, and non-responsive to their plight. This may induce in adolescents the desire to break free from parental supervision and irresponsiveness. That is, they might escape from parents to seek virtual companionship to ward off the negative effects of internal pressure (e.g., shame should the terms of permission for using Internet be violated) and external pressure (e.g., removal of privileges of permission to use the Internet) (Smetana, 2017; Özasan et al., 2022), and hence Internet stickiness (Lau & Yuen, 2013) and CIU (Zhang et al., 2015). PP requires little effort and digital literacy skills on the part of the parents (Livingstone et al., 2017) and appears to be the most preferred mediation by both parents, especially fathers (Lau & Yuen, 2016). It is a strong predictor to explain adolescents' leisure-related Internet usage. Covertly, adolescents may perceive parental permissiveness as endorsement of their Internet usage (Chen & Shi, 2019). The more adolescents get permission to engage in online activities, the more they are emboldened and become hardwired to use the Internet. This may, in turn, make parents give up the possibility of altering adolescents' Internet use (van den Eijnden et al., 2010). Thus, upon considering the enumerated factors, it is conceivable that PP and CIU have a positive reciprocal relationship over time (H4). That is, the more adolescents perceive that they are permitted to participate in an online environment, the more addiction to the Internet they develop, and vice versa.

## 2. Methods

The hypotheses were tested using longitudinal data which were collected at four time points from the same group of participants over 2 years. We analyzed how adolescents' CIU and various parental mediation strategies (i.e., PE, PM, PW, and PP) predicted one another between

subsequent periods from Time 1 (T1) to Time 4 (T4).

## 2.1. Participants and procedures

Seven schools were recruited as representative samples in order to capture different school characteristics in this longitudinal study. The considerations for selecting the schools were according to public/private, small/large, type, as well as districts of low/high socio-economic status. Of the seven schools, one was private, three were large, five were Grade 7–9 middle schools, two were Grade 7–12 comprehensive schools, and four were from below the average socio-economic status districts. None of them was an international school. Although ethnicity was not surveyed, the predominant participants were local, that is, of Chinese ethnic origin. Subjects voluntarily participated and the confidentiality of their responses was ensured. T1 and T2 were the first and second semesters of Grade 7, respectively. There were 2316 participants enrolled at Time 1, but only data from 1983 participants collected for all study variables across all four waves were used in the final analyses, resulting in an attrition rate of 14.38% from T1 to T4. Some participants did not complete the study because of absenteeism or being occupied by other activities at the time of data collection. Missing data were analyzed. At T1, participants' ages ranged between 12 and 15 years (46.9% female,  $M_{age} = 13.01$  years,  $SD = 0.70$ ). The printed questionnaires were distributed during lunch break, in class, or after school, depending on participants' preferences.

## 2.2. Instruments

The construct validity and internal consistency of all the instruments were examined by confirmatory factor analysis (CFA) using the maximum likelihood estimator and Cronbach's alpha, respectively. Model fit indices were regarded as good when the Tucker-Lewis Index (TLI) and comparative fit index (CFI) > 0.95, and the standardized root mean square residual (SRMR) and root mean square error of approximation (RMSEA) < 0.06.

### 2.2.1. Compulsive Internet use scale (CIUS)

The CIUS is a valid and psychometrically sound instrument which evaluates the severity of CIU with adolescents (Meerkerk et al., 2009). The scale, showing a one-factor solution, was validated for use in the Chinese context by Dhir et al. (2015). The 14 items of the Chinese CIUS ask about participants' problems related to their Internet use (e.g., How often are you short of sleep because of the Internet?) and about their online behavior (e.g., How often do you find it difficult to stop using the Internet when you are online?). In relation to the data of this study, the scale showed an internal consistency of Cronbach's alpha = .91. It uses a 5-point Likert scale (1 = *Strongly disagree* and 5 = *Strongly agree*), where a higher score suggests a higher CIU. Time 1 data were used to conduct CFA. There were six pairs of items whose variances correlated. The data confirmed the proposed factor structure evidenced by good model fit, that is, TLI = 0.95, CFI = 0.96, SRMR = 0.04, and RMSEA = 0.06.

### 2.2.2. Parental mediation

Parental mediation was measured by the Parenting Style Scale (Lau & Yuen, 2013). It was accompanied by a 5-point Likert scale (1 = *Strongly disagree* to 5 = *Strongly agree*). Lau and Yuen developed the scale based on Valcke et al.'s (2010) parental control and warmth dimensions. Based on Time 1 data, the CFA confirmed four subfactors: PE, PW, PM, and PP (i.e., TLI = 0.95, CFI = 0.97, SRMR = 0.04, RMSEA = 0.05). The four subscales were distinct and independent of each other. (1) The PE subscale has five items (e.g., My parents encourage me to use computers frequently). Variances of the first two and the last two items were paired. The subscale shows high warmth of parents towards adolescents' Internet usage (Dhir & Khalil, 2018). The subscale yielded an internal consistency of Cronbach's alpha ( $\alpha$ ) = 0.87 (2) PW comprises four items (e.g., My parents worry about the online risks that may have a negative

impact on me (e.g., online violence, pornography information)). This subscale can also be branded as low warmth of parents towards adolescents' use of the Internet. The internal consistency of the subscale was good ( $\alpha$  = 0.82). (3) PM is parents' high control (Dhir & Khalil, 2018) concerning adolescents' Internet usage. The subscale is composed of two items (e.g., My parents always ask me who I chat with on the Internet). It showed internal consistency with  $\alpha$  = 0.83. (4) PP indicates parents' low control of what adolescents do when using the Internet. It includes three items (e.g., My parents allow me to chat with net friends),  $\alpha$  = .65. In sum, the validity and reliability of the constructs of the Parenting Style Scale were confirmed.

## 2.3. Data analysis

The attrition rate was 18.21% ( $n = 224$ ) for boys and 10.03% ( $n = 109$ ) for girls. The chi-squared test revealed a significant difference ( $\chi^2(1, 2316) = 31.31, p < .001$ ) between genders and attrition rates. A two-way ANOVA examined the influence of survey completion status (incomplete/complete) and gender (male/female) on PP and CIU using the T1 data. The result showed no significant difference between in-/complete and between genders concerning PE, PW, and PM. However, differences were found between those who completed the survey and those who did not in PP,  $F(1, 2312) = 5.44, p = .02$ , and in CIU,  $F(1, 2312) = 4.17, p = .04$ . Thus, there was an attrition bias for PP and CIU. Participants who did not complete the survey had higher PP and CIU at T1 than those who completed the survey.

Full information maximum likelihood was used to impute partially missing data. Descriptive and inferential statistics were obtained by averaging the composite scores of the items for each scale. First, for all the study variables, correlation analyses and descriptive statistics were conducted to grasp an overall understanding of CIU, PE, PW, PM, and PP levels and their association. Afterwards, upon controlling for gender as a covariate in all waves, an autoregressive cross-lagged panel model was conducted using Mplus to test the longitudinal relationship among the variables.

## 3. Results

### 3.1. Correlations of adolescents' parental mediations and CIU

All the scales used in this present study applied 5-point Likert scales. The means, standard deviations, and correlations of the variables of the four waves are shown in Table 1. All mean scores of parental mediations at all times were above 3.00 except for PE, which was the lowest among the mediations. The means for PM ranged between 3.17 at the onset of the study and 3.10 at the end of the survey. PM scores had the highest variability with standard deviations of more than 1.00 at all times, suggesting that the participants' PM perception varied over a wider range compared to other parental mediation styles. Moreover, the means of all dimensions of parental mediation at all times was between 2.53 ( $SD = 0.83$ ) in PE and 3.38 ( $SD = 0.86$ ) in PW, which may illustrate that adolescents in this present study perceived their parents' mediation to be moderate. On the other hand, the means of CIU were between 2.76 ( $SD = 0.78$ ) at the onset of the study and 2.96 ( $SD = 0.70$ ) at the end of the survey; in general, there was a steady increase of CIU from T1 to T4.

Concerning the correlation, except for PE, the other parental mediations (PW, PM, and PP) positively correlated with CIU. Correlations between CIU and PE were the lowest ( $r \approx -0.05$ ) and oftentimes were not significant, which partially supported H1. The rest of the correlations were small and positive, supporting H2, H3, and H4. The results imply that, largely, parental mediations about adolescents' Internet use have little deterrence to reduce CIU.

### 3.2. The relationship between parental mediations and CIU

Based on the significant correlation results between CIU and parental

**Table 1**  
Means (SD) and Pearson correlation of parental mediation and compulsive internet use from time 1 to time 4.

| Variable   | 1      | 2      | 3      | 4      | 5     | 6      | 7      | 8      | 9      | 10    | 11    | 12    | 13    | 14    | 15    | 16    | 17    | 18    | 19    | 20   |
|------------|--------|--------|--------|--------|-------|--------|--------|--------|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|------|
| 1. PE_T1   | 1      |        |        |        |       |        |        |        |        |       |       |       |       |       |       |       |       |       |       |      |
| 2. PE_T2   | .51**  | 1      |        |        |       |        |        |        |        |       |       |       |       |       |       |       |       |       |       |      |
| 3. PE_T3   | .48**  | .55**  | 1      |        |       |        |        |        |        |       |       |       |       |       |       |       |       |       |       |      |
| 4. PE_T4   | .40**  | .49**  | .55**  | 1      |       |        |        |        |        |       |       |       |       |       |       |       |       |       |       |      |
| 5. PW_T1   | -.08** | -.10** | -.09** | -.11** | 1     |        |        |        |        |       |       |       |       |       |       |       |       |       |       |      |
| 6. PW_T2   | -.12** | -.15** | -.13** | -.09** | .37** | 1      |        |        |        |       |       |       |       |       |       |       |       |       |       |      |
| 7. PW_T3   | -.13** | -.12** | -.13** | -.05*  | .45** | .51**  | 1      |        |        |       |       |       |       |       |       |       |       |       |       |      |
| 8. PW_T4   | -.12** | -.08** | -.10** | -.01   | .44** | .25**  | .23**  | 1      |        |       |       |       |       |       |       |       |       |       |       |      |
| 9. PM_T1   | -.02   | .01    | -.01   | .03    | .19** | .45**  | .29**  | .29**  | .40**  | 1     |       |       |       |       |       |       |       |       |       |      |
| 10. PM_T2  | -.03   | -.03   | -.02   | .06**  | .20** | .28**  | .48**  | .32**  | .39**  | .50** | 1     |       |       |       |       |       |       |       |       |      |
| 11. PM_T3  | -.04   | -.01   | -.02   | .17**  | .24** | .24**  | .29**  | .50**  | .33**  | .44** | .54** | 1     |       |       |       |       |       |       |       |      |
| 12. PM_T4  | .21**  | .18**  | .16**  | .13**  | .06*  | -.08** | -.10** | -.07** | .09**  | -.04  | -.04  | -.05* | 1     |       |       |       |       |       |       |      |
| 13. PP_T1  | .16**  | .30**  | .19**  | .16**  | -.02  | .01    | -.09** | -.05*  | -.04   | .05*  | -.05* | -.04  | .45** | 1     |       |       |       |       |       |      |
| 14. PP_T2  | .12**  | .21**  | .27**  | .19**  | -.03  | -.09** | -.04   | -.04   | -.07** | .01   | -.03  | .41** | .35** | .51** | 1     |       |       |       |       |      |
| 15. PP_T3  | .10**  | .16**  | .16**  | .29**  | -.04  | -.04   | -.05   | .052*  | -.04*  | .02   | -.04  | .07** | .17** | .12** | .12** | 1     |       |       |       |      |
| 16. PP_T4  | -.01   | -.01   | -.02   | .01    | .29** | .20**  | .19**  | .19**  | .23**  | .10** | .11** | .11** | .17** | .12** | .12** | .12** | 1     |       |       |      |
| 17. CIU_T1 | -.05*  | -.04   | -.03   | .01    | .19** | .31**  | .23**  | .24**  | .15**  | .22** | .19** | .17** | .11** | .15** | .11** | .11** | .59** | 1     |       |      |
| 18. CIU_T2 | -.04   | -.05*  | .01    | -.02   | .15** | .23**  | .32**  | .25**  | .12**  | .14** | .22** | .16** | .10** | .10** | .14** | .13** | .53** | .65** | 1     |      |
| 19. CIU_T3 | -.06*  | -.06** | -.05*  | .02    | .10** | .18**  | .23**  | .36**  | .06**  | .10** | .13** | .23** | .07** | .09** | .07** | .17** | .45** | .53** | .64** | 1    |
| 20. CIU_T4 | 2.49   | 2.53   | 2.26   | 2.74   | 3.41  | 3.38   | 3.33   | 3.29   | 3.17   | 3.16  | 3.14  | 3.10  | 3.36  | 3.31  | 3.35  | 3.37  | 2.76  | 2.84  | 2.90  | 2.96 |
| M          | .89    | .83    | .81    | .78    | .97   | .86    | .86    | .85    | 1.21   | 1.10  | 1.07  | 1.02  | .92   | .86   | .82   | .77   | .78   | .75   | .73   | .70  |
| SD         |        |        |        |        |       |        |        |        |        |       |       |       |       |       |       |       |       |       |       |      |

Note. PE = parental encouragement; PW = parental worry; PM = parental monitoring; PP = parental permission; CIU = compulsive Internet use; T1 = Time 1; T2 = Time 2; T3 = Time 3; T4 = Time 4. \*\* $p < .01$ . \* $p < .05$ .

mediation styles, we went ahead and investigated longitudinal relationships between the study variables. Table 2 presents the results of the coefficients of the autoregressive and cross-lagged paths of the relationships between the study variables. They were combined and visualized in Fig. 1 in the order of PE, PW, PM, and PP. The fit indices of the models are explained under the corresponding subheadings. Gender, as a covariate, was controlled at all time points in all the models. It was a significant covariate for CIU in all the models in the first semesters of Grades 7 and 8 (T1 & T3). The means for males were higher than for females at T1 ( $M_{boys} = 2.80$ ,  $SD = 0.79$ ;  $M_{girls} = 2.71$ ,  $SD = 0.76$ ) but the inverse was the case at T3 ( $M_{boys} = 2.88$ ,  $SD = 0.74$ ;  $M_{girls} = 2.92$ ,  $SD = 0.71$ ). This is reported here because CIU was the variable shared in all models. Gender effects for PE, PW, PM, and PP are described separately in each section.

### 3.2.1. Relationship between parental encouragement (PE) and CIU

The results of the cross-lag autoregressive analyses for PE are presented as the first numeric code among the four in Fig. 1. The indices for the PE model had a good fit, that is, RMSEA = .02, CFI = 0.99, TLI = 0.99, and SRMR = 0.01. Autoregressive coefficients between two subsequent time points of both PE and CIU were moderate and receded over time. The estimates from T1, T2, T3 to T4 were 0.51, 0.42, and 0.37 for PE and .59, .52, and 0.49 for CIU. The estimates from T1 to T3, T2 to T4, and T1 to T4 for both variables remained significant but with lower values. Gender was controlled at all time points, but no significant covariate was found for PE.

The cross-lag coefficients were of low effect sizes, which is common when autoregression is involved in a model. The results showed that PE in the first semester of Grade 7 negatively predicted CIU in the second semester. Likewise, the same significant path was repeated in Grade 8. Both variables had an insignificant relationship with each other between T2 and T3, which crossed school years and involved a 2-month summer break. The participants had likely scaled down academic activities during the summer. The result suggests that parents' encouragement to adolescents within the academic calendar year impeded their CIU. However, PE does not function when academic activities are lessened during long summer holidays or when they had to adjust to a new school year.

### 3.2.2. The relationship between parental worry (PW) and CIU

Given that PW and CIU were significantly correlated with each other, we proceeded to scrutinize their longitudinal ties. The coefficients of the paths are listed next to those of the PE model in Fig. 1. The model fit was good with RMSEA = .02, CFI = 0.99, TLI = 0.99, and SRMR = 0.01. The cross-lag paths reveal that CIU positively and significantly predicted PW at all times, that is, from T1 to T2, T2 to T3, and T3 to T4,  $p < .001$ . CIU is a constant predictor of PW. The results imply that parents are perpetually uneasy about adolescents' Internet use. However, the relation was not reciprocal because no significant prediction from PW to CIU was observed. Gender was not a significant covariate for PW at any time point.

### 3.2.3. The relationship between parental monitoring (PM) and CIU

The cross-lagged model had a good fit whereby RMSEA = .02, CFI = 1.00, TLI = 0.99, and SRMR = 0.01. Estimates of coefficients are presented in the third place in Fig. 1. The only significant path was from CIU at T2 (i.e., second semester of Grade 7) to PM at T3 (i.e., first semester of Grade 8), in between which was the summer vacation. This finding signifies that elevated online activities during the summer vacation might trigger parents' vigilance to monitor Internet use. Alternatively, the adolescents might sense heightened monitoring from parents when they had longer family time during the summer. Gender was a significant covariate for PM at T1 ( $M_{boys} = 3.10$ ,  $SD = 1.23$ ;  $M_{girls} = 3.25$ ,  $SD = 1.18$ ) and T2 ( $M_{boys} = 3.09$ ,  $SD = 1.12$ ;  $M_{girls} = 3.23$ ,  $SD = 1.07$ ). The perception for PM was higher for girls than for boys at both T1 and T2.

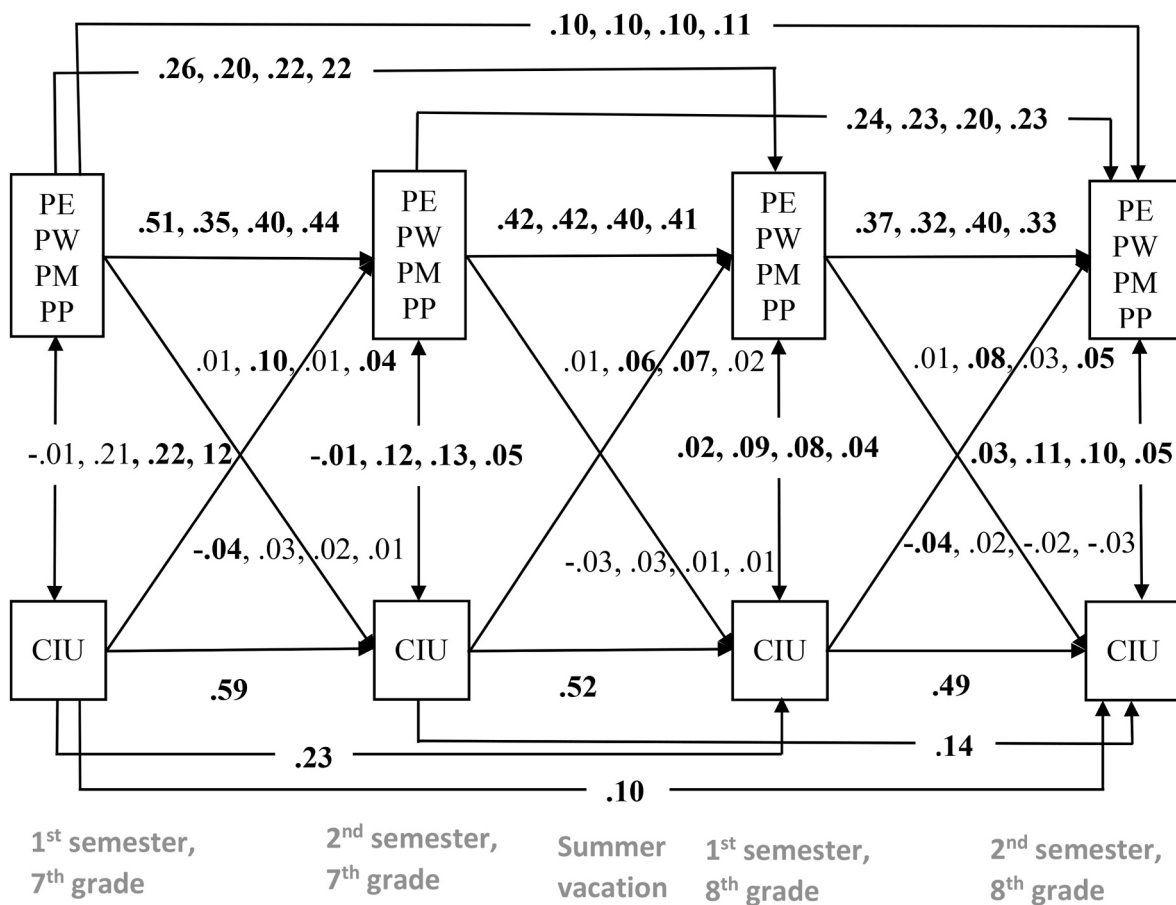
**Table 2**

Coefficients of autoregressive and cross-lagged paths of parental mediation and compulsive internet use.

| Time     | PE to PE             | PW to PW             | PM to PM             | PP to PP             | CIU to CIU           | PE to CIU             | CIU to PE | PW to CIU | CIU to PW            | PM to CIU     | CIU to PM            | PP to CIU     | CIU to PP            |
|----------|----------------------|----------------------|----------------------|----------------------|----------------------|-----------------------|-----------|-----------|----------------------|---------------|----------------------|---------------|----------------------|
| T1 to T2 | .51(.02)<br><i>a</i> | .35(.02)<br><i>a</i> | .40(.02)<br><i>a</i> | .44(.02)<br><i>a</i> | .59(.02)<br><i>a</i> | -.04(.02)<br><i>a</i> | .01(.02)  | .03(.02)  | .10(.02)<br><i>a</i> | .02(.02)      | .01(.02)             | .01(.02)      | .04(.02)<br><i>a</i> |
| T2 to T3 | .42(.02)<br><i>a</i> | .42(.02)<br><i>a</i> | .40(.02)<br><i>a</i> | .41(.01)<br><i>a</i> | .52(.02)<br><i>a</i> | -.03(.02)             | .01(.02)  | .03(.02)  | .06(.02)<br><i>a</i> | .01(.02)      | .07(.02)<br><i>a</i> | .01(.01)      | .02(.02)             |
| T3 to T4 | .37(.02)<br><i>a</i> | .32(.02)<br><i>a</i> | .40(.02)<br><i>a</i> | .33(.02)<br><i>a</i> | .50(.02)<br><i>a</i> | -.04(.02)<br><i>a</i> | .01(.02)  | .02(.02)  | .08(.02)<br><i>a</i> | -.02<br>(.02) | .03(.02)             | -.03<br>(.01) | .05(.02)<br><i>a</i> |
| T1 to T3 | .26(.02)<br><i>a</i> | .20(.02)<br><i>a</i> | .22(.02)<br><i>a</i> | .22(.02)<br><i>a</i> | .22(.02)<br><i>a</i> | —                     | —         | —         | —                    | —             | —                    | —             | —                    |
| T2 to T4 | .24(.02)<br><i>a</i> | .23(.02)<br><i>a</i> | .20(.02)<br><i>a</i> | .23(.02)<br><i>a</i> | .15(.02)<br><i>a</i> | —                     | —         | —         | —                    | —             | —                    | —             | —                    |
| T1 to T4 | .10(.02)<br><i>a</i> | .10(.02)<br><i>a</i> | .10(.02)<br><i>a</i> | .11(.02)<br><i>a</i> | .10(.02)<br><i>a</i> | —                     | —         | —         | —                    | —             | —                    | —             | —                    |

Note. PE = parental encouragement; PW = parental worry; PM = parental monitoring; PP = parental permission; CIU = compulsive Internet use; T1 = Time 1; T2 = Time 2; T3 = Time 3; T4 = Time 4.

<sup>a</sup>  $p < .001$ . \*\* $p < .01$ . \* $p < .05$ .

**Fig. 1.** Relationship between Parental Mediation and Compulsive Internet Use

Note. PE = parental encouragement; PW = parental worry; PM = parental monitoring; PP = parental permission; CIU = compulsive Internet use. The coefficients refer to the models with PE (first), PW (second), PM (third), and PP (fourth), respectively. Coefficients in bold are significant with  $p < .05$ . Time zone at the bottom.

### 3.2.4. The relationship between parental permission (PP) and CIU

The coefficients of the PP model are the last numbers affixed to Fig. 1. The model fit was almost perfect, that is, RMSEA = .01, CFI = 1.00, TLI = 1.00, and SRMR = .01. CIU in the first semester of Grades 7 and 8 positively predicted PP in the second semester of Grades 7 and 8, respectively. PP did not predict CIU at all. The result depicts that parents' permission played no apparent role in reducing CIU; instead, CIU increased PP within a school year. However, CIU and PP showed no relationship across school years (and summer break). Gender was a

significant covariate for PP in the second semester of Grade 8 with boys having a higher perception of PP than girls ( $M_{boys} = 3.42$ ,  $SD = 0.81$ ;  $M_{girls} = 3.32$ ,  $SD = 0.74$ ).

## 4. Discussion

Although parental mediation studies delving into Internet use abound, most of them are cross-sectional and unidirectional, mainly focusing on risk reduction and restriction of adolescents from perceived

harm related to media and Internet use (Lau & Yuen, 2016). Based on adolescents' perceptions, the present study endeavors to bridge this gap in the literature by analyzing the longitudinal relationship of parental mediation and CIU. The results revealed statistically significant cross-lag paths between the variables. These paths appeared in diverse patterns and suggested directional, rather than reciprocal, relationships. All the significant cross-lag paths of the four models are condensed, simplified, and represented in a single model shown in Fig. 2. PE negatively predicted CIU within the seventh grade. The result was repeated in the eighth grade, but not between the grades, which included a 2-month summer break. Next, CIU positively predicted PW between all time periods. On the other hand, CIU predicted PM only once during the transition from seventh grade to eighth grade. Finally, CIU predicted PP within a school year (i.e., between the first and second semesters) but not across school years. It was generally observed that the only instance a parental mediation predicted CIU was when PE negatively predicted CIU. The inverse was the case with the remaining parental mediation dimensions. Thus, all hypotheses need to be revised because (1) there were no reciprocal relationships between parental mediation and CIU, (2) the mediations worked in different patterns, PE and PP during a school year, PM across school years, and PW all the time, and (3) the relationships between PM and CIU were positive (H3), rather than negative.

#### 4.1. Parental encouragement negatively predicted compulsive Internet use within a school year

H1 postulated that CIU would be negatively and reciprocally related to PE over time. From our results, adolescents' perceptions of PE regarding Internet use negatively predicted CIU and not the other way around. It occurred from semesters one to two in Grade 7, the same pattern was repeated in Grade 8, but the pattern did not occur when students were transitioning from one grade to the next. Hence, H1 was true about the negative association, but wrong about the reciprocal relationship. Our finding is echoed by van den Eijnden et al. (2010), Geržičáková et al. (2023) and Chen and Shi (2019), who concur that quality communication between parents and adolescents about Internet use is a potential inhibitor to developing CIU and media-related risk among adolescents. This confirms that adolescents not only value parental warmth, but also value being engaged in collaborative communication (Dingus Keuhlen et al., 2020), and being understood, taken seriously, and made to feel comfortable (van den Eijnden et al., 2010). However, PE only reduced CIU within the school year. An explanation could be that PE functions at a period when academic pressure and Internet use for academic purposes are relatively high. Moreover, the heavy schoolwork might prompt parents to closely supervise adolescents' Internet use.

#### 4.2. Compulsive Internet use always positively predicted parental worry

The model between PW and CIU showed that the former did not predict the latter between any time periods (Fig. 2); instead, it was CIU that predicted PW between all the time points. In other words, adolescents' CIU seemed to be a constant cause of worry to parents. H2, which hypothesized that PW would be positively and reciprocally related to CIU over time, was correct about the positive relationship, but mistaken about the bi-directional influence. Staksrud and Olafsson (2020) observed that parents whose children accessed the Internet more frequently using mobile phones confessed to being greatly worried. Upon the adolescents developing CIU, parents may employ strategies to restrain it. However, parents' attempts may likely fail, especially if the personality or compulsivity has grown strong. As a result, after a while, parents become frustrated and hence resign themselves to the possibility of not being able to stop the compulsive tendencies. Parents then become even more worried because of their children's Internet use, a phenomenon best captured from the perspective of coercion theory. The theory claims that aggressive and aversive behaviors are likely to be cemented in children when there are cycles of ineffectual parental responses to a child's deviant behavior/s, and eventually, parents lose control over their children (Thomas, 2011).

Previous studies suggested that PW may indirectly increase CIU through parental restriction (Chen & Shi, 2019; Sciacca et al., 2022). That is, PW is a predictor of parental restriction about online activities (Sciacca, et al., 2022), which increases the likelihood of addiction to the Internet and media (Chen & Shi, 2019). The present study did not examine possible mediators and thus could not confirm the indirect effect. Furthermore, due to the technological-generational divide (Mitchell et al., 2005), parents may be lacking in technical expertise to supervise their adolescents who are at the peak of an autonomy-demanding developmental stage. The evidence of this study sheds light on the fact that PW does not directly reduce adolescents' CIU; instead, it is adolescents' CIU that torments parents to become worried about adolescents' use of the Internet. Heeding coercion theory, parents should be careful to supervise adolescents' Internet use to avoid ineffective parental control.

#### 4.3. Compulsive Internet use positively predicted parental monitoring only during the transition period from one grade to another

We hypothesized that CIU would predict PM, but that there would be an uncertain effect of PM on CIU (H3). It was partially supported by the data. CIU positively predicted PM from the second semester of Grade 7 to the first semester of Grade 8, but the relation was not reciprocal. CIU led to PM, especially during the summer when family time increases. However, PM insignificantly predicted any subsequent CIU. This finding

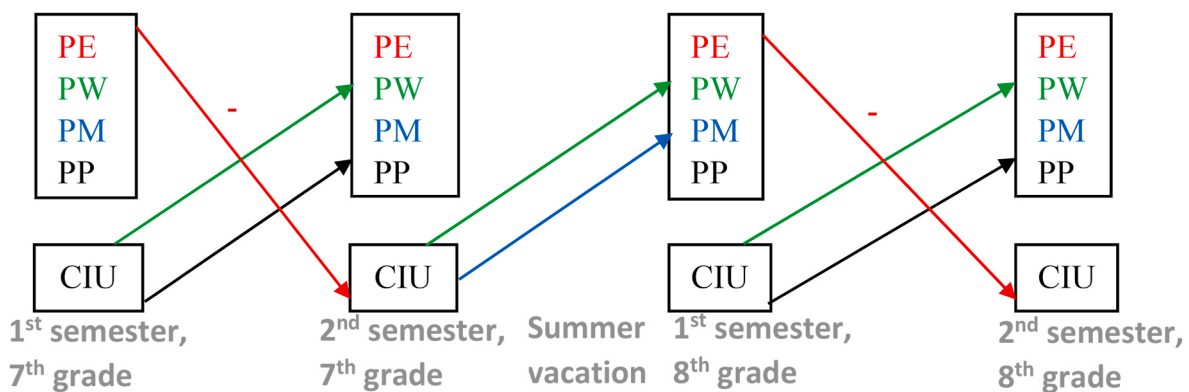


Fig. 2. Significant Paths of the Cross-lag Relationship between Parental Mediations and Compulsive Internet Use

Note. PE = parental encouragement; PW = parental worry; PM = parental monitoring; PP = parental permission; CIU = compulsive Internet use; (–) = negative path. Time zone at the bottom.

is echoed by Lau and Yuen (2016) who observed that no parenting styles could reduce Internet stickiness. Similarly, the meta-analysis by Lukavská et al. (2022) also concluded an unclear association between problematic Internet use and media-specific parenting (e.g., PM). The association may be moderated or mediated by several factors. PM, different from the other styles, depends much on the parent-child relationship. Therefore, it could be mediated by the legitimacy belief concerning parental engagement/supervision (Keijsers & Laird, 2014). Perceiving PM as psychological control and invasion of privacy (Keijsers & Laird, 2014; Liu, 2020) could raise parent-child conflict leading to decreased communication (van den Eijnden et al., 2010). Moreover, van den Eijnden et al. (2010) claimed that PM attenuates CIU only if parental reaction to adolescents' disclosure does not restrict time spent online. Future studies may measure the effect of mediators or moderators, such as legitimacy belief or parental reaction. Also, there could be a significant reciprocal relation between CIU and PM in case either of them is high. Given that adolescents in the present study perceived moderate PM ( $M \approx 3.15$ ), they might not be burdened by PM to modify their CIU.

#### 4.4. Compulsive Internet use positively predicted parental permission within a school year

H4 states that adolescents' perceptions of PP and CIU positively and reciprocally correlate over time. Our findings suggest that CIU could only positively predict PP between time intervals within the same grade periods when academic demands are high. On the other hand, PP never predicted CIU. Thus, H4 was marginally confirmed. Similar to the condition of parental worry, the adolescents dominated their technology use, perhaps because of their higher expertise (Leung & Lee, 2012). This might compel parents to continue granting permission for Internet use. According to Özaskan et al. (2022) and van den Eijnden et al. (2010), CIU causes deterioration in child-parent communication and induces adolescent-parent conflict. Therefore, parents may acquiesce to adolescents' Internet use. It is also reasonable that the adolescents who develop CIU cajole their parents, through persuasiveness or pestering, to grant more permission.

#### 4.5. Reflection

This study revealed how parental mediation developed over time. In general, adolescents perceived higher parental worry in the beginning of the survey and higher parental permission at the end. Parents became less worried and allowed more Internet use. When study load was high during semesters, higher PE predicted lower CIU, and higher CIU resulted in higher permission. Parents seemed to have higher tolerance of children's Internet use. However, such predictions did not work when adolescents' focus was on something other than study. Across school years, PE did not function to reduce CIU, nor did CIU lead to PP.

This study also observed gender differences in PM and PP. Perception of PM was higher for girls than for boys over time. Previous studies revealed that girls tend to receive more parental monitoring than boys (Livingstone et al., 2014) and that girls feel more targeted than boys (Livingstone & Helsper, 2008). Livingstone et al. (2014) attributed this observation to gendered socialization, where rules, norms and expectations are acquired based on cultural context. Parents are more likely to monitor their daughters closely in order to emphasize their protection and safety. Conversely, stigma and stereotypes associate boys with technology use, resulting in lower parental surveillance (Livingstone et al., 2014). Moreover, gender was a significant covariate for PP in the second semester of grade 8, favoring boys over girls in perceiving permission to use the Internet. This may again be related to cultural norms and stereotypes that favor boys in terms of technology and computer literacy (Henwood et al., 2000), a situation that Helsper (2010) suggests may persist in the future. Thus, as boys get older (in the 8th grade in the present study), they may be given more leeway than girls in their Internet-related activities (Livingstone et al., 2014), making

them even more computer-savvy.

The hypotheses obtained from the parenting literature were not fully confirmed, reflecting some important issues in the field. First, adolescents can access the Internet through personalized devices, bypassing parental supervision. Traditional media falls in the exosystem, whereas the Internet may belong to the microsystem because adolescents sometimes have more intimate and longer contact with their mobile phones than with their parents. Thus, findings of parental mediation for Internet use are different from previous findings of media parenting. Second, the disparities between this study and the literature could be due to methodology. If we examine the correlations (Table 1), the results are similar to other cross-sectional studies. It is the longitudinal analysis that uncovers the difference. Third, the timing of the study may play a role since we found that the models interact with the school year and perhaps also with study load. More studies are needed to map the findings of various studies. Finally, the current study was conducted in an Asian culture, where parent-child relationships and adolescent socialization are distinct from those in western culture.

## 5. Conclusion

The current study sought to clarify longitudinal interaction between CIU and perceived parental mediation (PE, PW, PM, and PP) among adolescents. The first two sets of data were collected in the seventh grade and the last two were collected in the eighth grade. Within a school year, PE reduced CIU, whereas CIU triggered PW and PP. On the other hand, no parental mediation style predicted CIU between the transition from Grades 7 to 8; instead CIU predicted both PW and PM. As argued by Ren and Zhu (2022) and Valcke et al. (2010), CIU caused parents to inadvertently exhibit two typologies of parenting, that is, neglectful and authoritarian. Neglectful parenting is a combination of PP and PW, which involve low demandingness and low responsiveness, respectively. Furthermore, authoritarian parenting combines both PM and PW, which involve high demandingness and low responsiveness, respectively. The present study showed that none of the PP, PW, and PM were associated with less CIU. The other mediation, PE, lessens CIU, suggesting that a warm attitude toward positive Internet use is more effective than solicitation, rule setting, restriction, worry, and passive permission. Finally, CIU predicts parental mediation, rather than the opposite, in most circumstances. CIU dominates the relationship. Internet media should be moved from the exosystem to the microsystem in Bronfenbrenner's bio-ecological systems theory.

Overall, parents become reactive, rather than proactive with regard to adolescents' Internet use. This could be a sign that the adolescents are ahead of their parents in setting the pace when it comes to accessing and using the Internet, and that parents are merely playing catch up. In fact, parents themselves could be victims of CIU and are not only poor role models, but also have lost moral authority to effectively supervise their children's Internet use.

#### 5.1. Limitations

Although this was the first study to examine the longitudinal association of the four parental mediation styles (i.e., PE, PW, PM, and PP) with CIU together with a large sample size and a robust statistical data analysis, it still had its limitations. First, the coefficients for the cross-lag paths were small, which is common when autoregressive paths are involved (Collie et al., 2015). In this regard, we recommend that future studies could consider including additional variables in the study, and hence use alternative data analysis techniques such as moderation, mediation or latent profile analyses. This may broaden the understanding of nuances that underlie the interaction of parental mediation and CIU. Secondly, this present study only took into account adolescents' perceptions of parental mediation. Such an approach may give a lopsided understanding of the variables being examined, especially because past studies have shown that parents and adolescents have

varying perceptions of Internet use. It is, therefore, prudent for future studies to conduct studies that take parents' perceptions into account. Thirdly, this study surveyed adolescents' perceptions of parental mediation and did not distinguish between the parents, who could hold different mediation types. Future research may investigate parents' perspectives and how their background, consistency, and family types influence their mediation type. As heterogeneous as our sample was, not all the characteristics mentioned, that is, socio-economic status and type of school, as well as other characteristics such as adolescents in co-parenting situations, those living with both parents, or even those living with other caregivers, were analyzed. This study surveyed adolescents' perceptions of their parents' mediation. However, important factors such as their family income and compositions (living with or without parents, co-parenting) were not collected. These interesting research questions represent a potential area for future research. Finally, although the overall attrition rate for CIU, PP and gender were relatively low, it could still lead to some coverage errors being reflected in the results. It is possible, for example, that the different parental mediation strategies in the current study may have had a more pronounced effect on those with higher levels of CIU. This group could be investigated in future studies.

## 5.2. Implications of the study

There are a number of implications drawn from the present study. Because adolescents' CIU constantly triggers PW, this may imply that parents feel inadequate and helpless to handle adolescents' CIU. Consultation specifically linked to CIU may help parents to understand outcomes of CIU and how to communicate with adolescents regarding their Internet use. Moreover, PE predicts lower CIU. Since a high level of Internet skills among children weakens online participation and risks (Lee & Chae, 2012), it is imperative that both parents and adolescents are encouraged to increase their skills and discussion of their Internet use. Now that this present study has unveiled adolescents' parental perceptions of Internet use, experimental researchers can build on it to create interventions to reduce adolescents' CIU. In general, the current study broadened longitudinal understanding of the relationship of parental mediation and CIU. Since the Internet is here to stay, parents, teachers, policy makers and researchers should put more effort into exploring strategies that can help the current generation of adolescents to become responsible consumers of the Internet, hence maximizing its benefits and limiting its associated risks.

## Consent to participate

Verbal informed consent was obtained prior to each survey.

## CRedit authorship contribution statement

**Alphonse Akungu Okwach:** Literature review, Formal analysis, Writing – original draft. **Sufen Chen:** Conceptualization, Data collection, Methodology, Result interpretation, Funding acquisition, Supervision, Writing – review & editing. **Chiu-Hung Su:** Visualization, Writing –review.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Data availability

Data will be made available on request.

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