A prospective study of the motivational and health dynamics of Internet Gaming Disorder

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The American Psychiatric Association has identified Internet Gaming Disorder (IGD) as a potential psychiatric condition and called for research to investigate its etiology, stability, and impacts on health and behavior. The present study recruited 5,777 American adults and applied self-determination theory to examine how motivational factors influence, and are influenced by, IGD and health across a six month period. Following a preregistered analysis plan, results confirmed our hypotheses that IGD criteria are moderately stable and that they and basic psychological need satisfaction have a reciprocal relationship over time. Results also showed need satisfaction promoted health and served as a protective factor against IGD. Contrary to what was hypothesized, results provided no evidence directly linking IGD to health over time. Exploratory analyses suggested that IGD may have indirect effects on health by way of its impact on basic needs. Implications are discussed in terms of existing gaming addiction and motivational frameworks.

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25 **Abstract**
26
27 The American Psychiatric Association has identified Internet Gaming Disorder (IGD) as a

28 potential psychiatric condition and called for research to investigate its etiology, stability, and

29 impacts on health and behavior. The present study recruited 5,777 American adults and applied

30 self-determination theory to examine how motivational factors influence, and are influenced by,

31 IGD and health across a six month period. Following a preregistered analysis plan, results

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33 psychological need satisfaction have a reciprocal relationship over time. Results also showed

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35 what was hypothesized, results provided no evidence directly linking IGD to health over time.

36 Exploratory analyses suggested that IGD may have indirect effects on health by way of its

37 impact on basic needs. Implications are discussed in terms of existing gaming addiction and

38 motivational frameworks.

40

42 **Introduction**

43   Internet-based video games are a ubiquitous form of recreation pursued by the majority

44 of adults and young people (Duggan, 2015a). With sales eclipsing box office receipts, games are

45 now an integral, even inescapable, part of modern leisure (MPAA, 2015; Newzoo, 2016).

46 Commensurate with their popularity, concerns that games dysregulate the behavior of some have

47 immerged (Kardefelt-Winther, 2014b). The widespread appeal of these virtual contexts has been

48 of particular interest to psychologists and psychiatrists (for a review see King, Haagsma,

49 Delfabbro, Gradisar, & Griffiths, 2013). In fact, the most recent revision of the Diagnostic and

50 Statistical Manual of Mental Disorders (DSM-5; American Psychiatric Association, 2013)

51 identifies Internet Gaming Disorder (IGD) as a possible psychiatric condition. Following this

52 determination, the American Psychiatric Association's (APA) Substance-Related Disorders

53 Work Group outlined a call for rigorous research into the potential disorder's validity, etiology,

54 and temporal stability (Hasin et al., 2013).

55   Because research responding to this call for a better understanding of IGD is at a

56 formative stage, there are active debates surrounding the construct's conceptual scope and

57 measurement approaches (Griffiths et al., 2016; Kardefelt-Winther, 2014b; Petry et al., 2014).

58 Some argue for a theoretical framing akin to a substance abuse disorder (e.g. Petry et al., 2014),

59 wherein gaming is, in itself, inherently addictive, whereas other scholars frame Internet-based

60 gaming as a self-regulatory challenge (e.g., Griffiths et al., 2016; Kardefelt-Winther, 2014). The

61 state of the art work in this area suggests links with social behaviors and life satisfaction, but

62 does not differentiate between online and offline games (e.g. Festl, Scharkow, & Quandt, 2013),

63 adequately distinguish between passionate and pathological engagement (for a review see,

64 Ferguson, Coulson, & Barnett, 2011). Though ongoing research has examined the prevalence of

65   individual criteria in line with APA guidance, it has not bridged the self-regulation and addiction

66   literatures (see Przybylski, 2016; Przybylski, Weinstein, & Murayama, 2016b). In addition,

67   though this body of work offers some evidence that IGD-type symptoms may link with social

68   and mental health (e.g., Festl et al., 2013), there is very little longitudinal evidence exploring

69   antecedents and consequences of IGD symptoms (for an exception see Scharkow, Festl, &

70   Quandt, 2014). The aim of the present research is to directly address this gap by linking self-

71   regulation and Internet Gaming Disorder research. Our goal is to directly examine how

72   problematic gaming emerges from a state of dysregulation, and how it predicts health.

73   **Gaming and Health**

74   To this end we build on a growing literature that suggests there is a basis to expect excessive or

75   problematic gaming may be related to lower health, though findings in this area are mixed. There is

76   some evidence that video gaming can promote healthy behaviors (Baranowski, Buday, Thompson, &

77   Baranowski, 2008; Granic, Lobel, & Engels, 2014; Hofferth & Moon, 2012), and large longitudinal

78   studies suggest that it has no detrimental effects, even at high levels of play, in the population over time

79   (Parkes, Sweeting, Wight, & Henderson, 2013). Yet a broad group of gaming behaviors which are

80   termed problematic gaming seem to be indicative of behavioral dysregulation (Faulkner, Irving, Adlaf,

81   & Turner, 2015; Ferguson et al., 2011; Festl et al., 2013) and mirror work outside of gaming suggesting

82   that problematic Internet use, more broadly, is reflective of dysregulation (Widyanto & McMurran,

83   2004). Studies that suggest dysregulation underlies such problematic gaming include work linking it to

84   trait-level neuroticism (Peters & Malesky, 2008), and to other dysregulated behaviors such as cigarette

85   smoking and fighting in adolescents (Desai, Krishnan-Sarin, Cavallo, & Potenza, 2010). Perhaps

86   because it is dysregulating, problematic gaming may undermine physical, social, and mental health; for

87   example, linking with lower levels of life satisfaction, more anxiety, and more depression in nationwide

88   surveys (Mentzoni et al., 2011). Evidence here is mixed as well (Gentile et al., 2011), and a meta-

89   analysis of this literature suggests that correlations with mental health are small ($r = .15$), absent for

90   social health, and effect sizes discrepant across studies for all health outcomes (Ferguson et al., 2011).

91   Indeed, the only large-scale longitudinal study which systematically tests problematic gaming, a German

92   sample of young adults ages 19-39 years, reports inconsistent and weak relations between dysregulated

93   gaming and perceiving oneself as successful, though no lagged effects with life satisfaction were

94   observed (Scharkow et al., 2014).

95   **Psychological Need satisfaction**

96   Given IGD is a form of problematic gaming that may have its roots in dysregulation, we

97   employ self-determination theory (SDT; Deci & Ryan, 2000) in an attempt to better understand

98   its etiology and consequences. SDT provides a well-tested empirical framework for

99   understanding how dysregulation occurs and its potential implications for health and functioning.

100   SDT posits that three basic psychological needs foster healthy self-regulation and promote

101   mental and physical health; those for autonomy – or a sense of choice and self-expression,

102   competence – or efficacy to act on the world in desired ways, and relatedness – or feelings of

103   closeness and intimacy with others. Findings consistently show that having psychological needs

104   satisfied is associated with more mental, physical, and psychosocial health (Deci & Ryan, 2000).

105   For example, those who are need satisfied report fewer symptoms of depression and disordered

106   eating (Bartholomew, Ntoumanis, Ryan, Bosch, & Thogersen-Ntoumani, 2011; Chen et al.,

107   2015; Luyten & Blatt, 2013; Nguyen-Rodriguez, Unger, & Spruijt-Metz, 2009; Soenens, Park,

108   Vansteenkiste, & Mouratidis, 2012; Verstuyf, Patrick, Vansteenkiste, & Teixeira, 2012), fewer

109   negative and more positive emotions indicative of mental health (Ryan & Deci, 2001), better

110   physical health including fewer physical symptoms such as headaches and gastrointestinal

111   problems (Reinboth, Duda, & Ntoumanis, 2004; Sheldon, Ryan, & Reis, 1996; Thompson &

112   Prottas, 2006), and better psychosocial functioning (H. S. Hodgins, Koestner, & Duncan, 1996;

113   Moller & Deci, 2010; Patrick, Knee, Canevello, & Lonsbary, 2007; Weinstein, Hodgins, &

114   Ostvik-White, 2011). Psychological support, in the form of basic psychological needs, provide

115   an avenue for understanding Internet gaming and player health. By applying SDT to IGD we can

116   test the role these psychological factors play in fostering dysregulation, and better understand

117   how dysregulation is related to mental, psychosocial, and physical health.

118   **Having Psychological Needs Met Reduces Dysregulation.** A central question of IGD

119   concerns its antecedents, the conditions under which it might emerge. Based in SDT, we

120   hypothesized that the absence of psychological need satisfaction is a risk factor for such

121   dysregulated Internet gaming. This expectation is informed by previous research suggesting that

122   environments low in need satisfaction have a dysregulating effect during development

123   (Brenning, Soenens, Braet, & Bosmans, 2012; Roth & Assor, 2012; Roth, Assor, Niemiec, Ryan,

124   & Deci, 2009; Roth et al., 2009), contribute to burnout and disengagement (Bartholomew et al.,

125   2011; Van den Broeck, Vansteenkiste, De Witte, & Lens, 2008), stoke reactive aggression

126   (Przybylski, Deci, Rigby, & Ryan, 2014; Weinstein, 2009), and foster behavioral addictions

127   (Williams, Hedberg, Cox, & Deci, 2000).

128   More immediate to the current work, SDT research has been applied to dysregulated

129   technology use in cross-sectional research. The absence of need satisfaction has been linked to

130   excessive use of Facebook and other Internet use (Sheldon, Abad, & Hinsch, 2011; Williams et

131   al., 2000), whereas its presence has been linked to Internet use that contributes to well-being

132   (Sheldon et al., 2011). Individuals who experience need satisfaction also report lower obsessive

133   passion for videogame play (Przybylski, Weinstein, Ryan, & Rigby, 2009), as well as play

134   indicative of more pressure and less enjoyment of the task (Lafrenière, Verner-Filion, &

135   Vallerand, 2012). In sum, this body of work suggests that need satisfaction reduce the likelihood

136   of behavioral regulation, and as such individuals who experience the satisfaction for these three

137   psychological needs in their day-to-day lives are less likely to engage Internet gaming in a

138   disordered and problematic manner.

139   **Dysregulation Reduces Psychological Needs.** A second central question concerning

140   IGD has to do with its psychological consequences, the downstream effects that dysregulated

141   gaming might have on need satisfaction and health. Based on a smaller body of work concerning

142   needs and dysregulation, we might expect that IGD would deprive people of need satisfaction

143   over time. In line with this prediction, we would expect a reciprocating relationship between

144   psychological need satisfaction and IGD. Dysregulated players may experience their gaming as

145   disruptive to the fulfillments they might otherwise experience in their daily lives. For example,

146   pathological patterns of engagement might interfere with opportunities to experience a sense of

147   competence by achieving desired goals in the real world, or even in the gaming world if the

148   player feels the play to be more of a compulsion than a gratification. It is also possible that IGD

149   could displace or interfere with other activities such as family meals, social events, and academic

150   or workplace meetups as suggested by relations between problematic gaming and social capital

151   (Scharkow et al., 2014). Although this expectation has not been tested in relation to Internet

152   gaming *per se*, there is some support for this idea in that individuals who have obsessive passion

153   indicative of dysregulation in the workplace experience less support for the three needs of

154   autonomy, competence, and relatedness (Forest, Mageau, Sarrazin, & Morin, 2011). Indeed, it

155   may be that those with IGD show poor health because IGD undermines their psychological

156   needs. The literature reviewed above suggests a robust link between psychological need

157   satisfaction and mental, physical, and psychosocial health. Insofar as IGD undermines needs, it

158   might indirectly impact on these criteria. In line with this idea, workplace need satisfaction in the

159   research discussed above have mediated the link between obsessive passion and mental health

160   (Forest et al., 2011; Przybylski et al., 2009).

161   **Gaming and Everyday Activities**

162   Research has also suggested that problematic gaming may impact players' health and

163   functioning because it reduces the likelihood of engaging social and physical activities (Charlton,

164   2002; Charlton & Danforth, 2007). Indeed, the displacement hypothesis (Neuman, 1988;

165   Valkenburg & Peter, 2009) has been applied to understanding screen time more broadly, and

166   suggests that using screens may reduce well-being because it reduces quality time with friends.

167   Evidence from a number of studies suggests the time devoted to Internet-based games could

168   supplant such activities, leading to lower levels of exercise (Sisson, Broyles, Baker, &

169   Katzmarzyk, 2010) and resulting in increased body mass (Anderson, Economos, & Must, 2008).

170   At least one study indicates Internet gamers choose less real-world social activity (B. D. Ng &

171   Wiemer-Hastings, 2005), and additional studies link Internet use to increased levels of social

172   isolation (Kraut et al., 1998). The potential cost to real-life interactions is concerning, because

173   high quality of social interactions are essential for health (e.g., Cohen, 2004; Cohen &

174   Hoberman, 1983; Seeman, 1996). Data on the effects of gaming time are not uniform, however,

175   as work indicates that some kinds of play may promote physical activity (Lanningham-Foster et

176   al., 2006) and provide important avenues for in-person socialization (Duggan, 2015b; Lenhart,

177   2015). Although these observed effects, for good or ill, on everyday activities are modest

178   (Boone, Gordon-Larsen, Adair, & Popkin, 2007), they suggest diminished social and physical

179   activity may serve as a bridge that links IGD to poorer health outcomes for players over time,

180   and may provide a better account of why IGD might result in more costs to health than do

181   subjective experiences of basic psychological needs.

182   **The Present Research**

183   The goal of the present research was to rigorously investigate the etiology and personal

184   outcomes of Internet Gaming Disorder and to expand what is empirically known about the health

185   effects of this potential psychiatric disorder. To this end we conducted a prospective longitudinal

186   study with a large and representative adult cohort informed by DSM-5 guidance (Hasin et al.,

187   2013; Kardefelt-Winther, 2014b) and motivational theory (Deci & Ryan, 2000; Ryan & Deci,

188   2000), using an approach grounded in open science methodology (Morey et al., 2016).

189   In this study we evaluated confirmatory hypotheses (i.e., a priori and pre-registered) and

190   conducted exploratory analyses (e.g., data and theory driven, but not pre-registered) concerned

191   with the antecedents and consequences of Internet Gaming Disorder (Cumming, 2012;

192   Wagenmakers, Wetzels, Borsboom, Maas, & Kievit, 2012). By making this distinction,

193   summarized in Table 1, we were able to draw robust conclusions about IGD by rejecting or

194   upholding our a priori hypotheses, and to explore theoretically important questions after the data

195   were known (Ioannidis, 2012). Our first set of confirmatory predictions concerned the temporal

196   stability of IGD, need satisfaction, and health. We hypothesized that the observation of each

197   factor at the start of the study would be linked to the same factor at the end of the study

198   (Hypotheses 1-3); Testing these direct effects also served as a control for the cross-lagged paths.

199   Building on motivational work indicating that the absence of need satisfaction leads to

200   dysregulated behaviour, our second set of confirmatory hypotheses concerned the interrelations

201   between psychological needs, health, and IGD. We anticipated that need support would predict

202   fewer IGD symptoms six months later (Hypothesis 4), and we expected reciprocal effects with

203   need satisfaction such that IGD symptoms at the start of the study would also undermine need

204   satisfaction six months later (Hypothesis 5). Informed by the motivational literature linking

205   psychological needs to mental, social, and physical health we anticipated that need satisfaction at

206   the start of the study would link to health six months later (Hypothesis 6). Moreover, based on

207   the extant literature on dysregulated gaming we expected that IGD symptoms at the start of the

208   study would predict poorer health six months later (Hypothesis 7).

209   To supplement the confirmatory model and data, we also conducted several exploratory

210   analyses based on motivational theory. Providing that we could find support for the hypothesized

211   cross-lagged model, and that it can hold over a longer time period (i.e. equilibrium assumption),

212   the model also tests if psychological need satisfaction would serve as a mediator between IGD

213   and health outcome (Little, Preacher, Selig, & Card, 2007). We examined this possible

214   mechanism by directly reporting the mediation effect computed in the confirmatory model

215   (Figure 1), but did not pre-register this hypothesis (Exploratory Analysis 1). Furthermore,

216   consistent with SDT, we investigated the extent to which the individual basic psychological

217   needs for competence (Exploratory Analysis 2), relatedness (Exploratory Analysis 3), and

218   autonomy (Exploratory Analysis 4) need satisfaction serve as mediators for the linkage between

219   IGD and health. It may be that only one need, for example, lower experiences of competence,

220   carries effects identified with IGD symptoms. Finally, we examined the possibility that IGD

221   symptoms, as a form of problematic gaming, may displace real-life social and physical activity

222   (Lanningham-Foster et al., 2006; Neuman, 1988; Sisson, Broyles, Baker, & Katzmarzyk, 2010),

223   and by doing so undermine health (Cohen, 2004; House, Landis, & Umberson, 1988). We tested

224   this possibility in two alternative models that add these factors to the confirmatory model (see

225   Figure 2). On this basis we expected that these two activities might link directly to health

226 (Exploratory Analyses 5 & 6) and mediate the relations between IGD and health (Exploratory

227 Analyses 7 & 8).

Materials & Methods

229 **Participants**

230   Data were collected at two time points with participants recruited through YouGov's 1.8

231 million person Internet-based American panel. Following an approach used in previous

232 behavioral health research (e.g., Cranwell, Opazo-Breton, & Britton, 2016; Reeves, Halsey,

233 McMeel, & Huber, 2013) panelists were selected at random from the panel using quotas

234 informed by 2010 U.S. Census data and pre-captured information about panelists' age, gender,

235 ethnicity, and geographic region. Fieldwork was conducted between October 2015 and March

236 2016. From this, a nationally representative sample of 5,777 adults aged 18 years and older from

237 the United States completed the initial assessment as part of an ongoing project studying Internet

238 Gaming Disorder (see: (Przybylski et al., 2016a) and a total of 4,594 completed the follow-up

239 measures six months later. Consistent with our earlier IGD research (Przybylski et al., 2016a),

240 we focused on participants who recently played Internet games at the time of assessments, a total

241 of 2,316 individual (885 males and 1431 females) played Internet games at both time points.

242 This subsample ranged in age from 19 to 91 years ($M = 49.21$, $SD = 1.32$), of which 1,689

243 (72.9%) identified as White, 246 (10.6%) as Black, 184 (7.9%) as Hispanic, 69 (3.0%) as Asian,

244 21 (0.9%) as Native American, 3 (0.2%) as Middle Eastern, and 101 (4.4%) as mixed race or

245 another identification. In terms of educational attainment, 75 (3.2%) had not completed

246 secondary school, 659 (28.5%) completed secondary school, 598 (25.8%) completed some

247 college, 257 (11.1%) completed a two-year degree, 504 (21.8%) completed a four-year degree,

248 and 223 (9.6%) completed a post graduate degree. Estimates of total annual household income

249   were provided by 2,316 participants, these ranged from less than $10,000 (6.3%) more than

250    $500,000 a year (0.2%) with most (77%) reporting between $10,000 and $150,000. The

251   distributions of participants were broadly similar to those of videogame players, who tend to be

252   equally divided among men and women and whose average age, including players under the age

253   of 18 years, is 35 years (Pew Research Centre, 2015), yet females were somewhat

254   overrepresented at 60.8% in the final sample.

255   **Ethical Review**

256   Ethical review for data collection and analysis was conducted by the research ethics

257   committee at the University of Oxford (C1A15006). All participants polled for the present

258   research were above 18 years of age and members of the YouGov American panel. Panel

259   participants completed a double opt-in process that involved both agreeing to the YouGov Terms

260   and Conditions (YouGov, 2017a) meaning they were willing to be contacted as part of

261   participating a member of the Internet-based YouGov Omnibus panel generally, and they agreed

262   to participate in the present study. In line with the YouGov Privacy Policy (YouGov, 2017b), the

263   investigators did not have access to any uniquely identifying participant information. Participants

264   could contact investigators using by way of email contact at YouGov. No inquiries linked to the

265   present studies were received.

266   **Measures**

267   **Internet gaming disorder.** Participants completed a nine-item criteria checklist drafted

268   in consultation with clinical and research psychologists studying video games and behavioral

269   addictions and applied in two previous investigations of IGD (Przybylski, 2016; Przybylski et al.,

270   2016a), and included items such as "I felt moody or anxious when unable to play", "I felt that I

271   should play less but couldn't", and "risked friends or opportunities due to games". More than half

272   of participants reported no criteria at the first time point (70.0%) or at follow-up (73.2%). The

273   proportion of participants decreased as the number of criteria endorsed increased for both the

274   first and follow-up period. Overall, participants endorsed a small number of criteria ($M = 0.56$,

275    $SD = 1.13$ at T1; $M = 0.47$, $SD = 0.97$ at T2). APA recommendations for clinical levels of IGD

276   include endorsing five or more of the nine criteria (Hasin et al., 2013; Petry et al., 2014) paired

277   with endorsement of personal distress due to Internet gaming use (American Psychiatric

278   Association, 2013). The proportion of participants who endorsed five or more criteria was 1.49%

279   (95% CI = [1.11%, 2.00%]) at the first time point and 0.99% (95% CI = [0.65%, 1.51 %]) at

280   follow-up, and only a very small proportion of participants endorsed the statement that they

281   "suffered significant distress due to gaming" in the past six months, the criteria for addiction as

282   identified in earlier research (Przybylski et al., 2016a): 0.38% (95% CI = [0.21%, 0.68 %]) at the

283   first time point and 0.30% (95% CI = [0.13 %, 0.65%]) at the end of the study. Interestingly,

284   only three participants reported more than four IGD criteria at both observed time points and

285   none of the participants who met a diagnostic threshold including distress at the start did so at the

286   end of the study.

287   **Internet gaming.** Participants were asked to reflect on the past six months of their lives

288   and rate how frequently they engaged in online gaming: "Played video/computer games online

289   (e.g. Candy Crush, Minecraft, or Farmville)," using a 5-point response scale that ranged from 1

290   "*Never*" to 5 "*Every day or almost every day*". Of those who said they engaged with Internet

291   games, a total of 44.3% (95% CI = [42.6%, 46.1 %]) said they played every day , 25.3% (95% CI

292   = [23.8%, 26.8 %]) played once or twice a week, 11.4% (95% CI = [10.4%, 12.6 %]) once or

293   twice a month, and 18.9% (95% CI = [17.6%, 20.4 %]) less often at the start of the study. At the

294   end of the study 46.5% (95% CI = [44.4%, 48.5 %]) said they played everyday, 24.5% (95% CI

295   = [22.8%, 26.3 %]) played once or twice a week, 11.1% (95% CI = [9.9%, 12.5 %]) once or

296   twice a month, and 18.0% (95% CI = [16.4%, 19.6 %]) reported playing less often.

297   **Health.** A three-item scale was used to tap into participant health (Ahmad, Jhajj, Stewart,

298   Burghardt, & Bierman, 2014). Participants were asked to reflect on the past six months of their

299   lives and rate their social, mental, and physical health using a 5-point response scale that ranged

300   from 1 "*Poor*" to 5 "*Excellent*". Individual scores were averaged for Time 1 (α = .78, *M* = 3.26,

301   *SD* = 0.94) and Time 2 (α = .78, *M* = 3.26, *SD* = 0.93).

302   **Psychological need satisfaction.** A three-item motivation scale was used to tap into

303   participant psychological need satisfaction, taken from the widely used Basic Psychological

304   Needs Scale (BPNS; La Guardia, Ryan, Couchman, & Deci, 2000). Participants were asked to

305   reflect on the past six months and rate their experience of satisfaction for the needs for

306   autonomy, competence, and relatedness using a 5-point response scale that ranged from 1 "*Not*

307   *at all true*" to 5 "*Very true*". Individual scores were averaged for Time 1 (α = .81, *M* = 3.89, *SD*

308   = 0.96) and Time 2 (α = .82, *M* = 3.90, *SD* = 0.98).

309   **Physical and social activity.** Two single-item scales were used to measure everyday

310   behavior (Laganà, Bratly, & Boutakidis, 2011; Milton, Bull, & Bauman, 2011). Participants were

311   asked to reflect on the past six months of their lives and rate how frequently they engaged in

312   social activity: "Spent quality time with friends or family (e.g., playing games, picnics, or

313   reading)" and physical activity: "Engaged in physical exercise indoors or outdoors (e.g., gym,

314   aerobics, or sports)", using a 5-point response scale that ranged from 1 "*Never*" to 5 "*Every day*

315   *or almost every day*".

316   **Convergent validation.** To evaluate the extent to which these abbreviated assessments

317   mapped onto well-established assessments of health and motivational processes, an independent

318   sample of 507 American adults (228 male, 273 female, 6 transgender, gender non-conforming, or

319   other) were recruited using the Amazon Mechanical Turk platform. Ethical review was

320   conducted by the research ethics committee at the University of Oxford and participants were

321   compensated $1.20 to complete this brief survey which assessed our primary study measures as

322   well as need satisfaction using the Basic Need Satisfaction and Frustration Scale (Chen et al.,

323   2015), mental health using the Warwick-Edinburgh mental well-being scale (Clarke et al., 2011),

324   social and physical health using the MOS-36 (Sherbourne & Stewart, 1991; Ware & Sherbourne,

325   1992), and health-related anxiety using the HAI-18 (Salkovskis, Rimes, Warwick, & Clark,

326   2002). Linear models regressing longer measure scores onto our primary study measures

327   indicated our brief measures of basic psychological need satisfaction (β = .78), mental health (β

328   = .68), social health (β = .50), and physical health (β = .74) were highly correlated with the

329   longer well-validated assessments. More importantly, results from a model regressing physical

330   health scores (Ware & Sherbourne, 1992) simultaneously onto our brief physical health measure

331   (β = .60) and a measure of health anxiety (β = -.31; Salkovskis, Rimes, Warwick, & Clark, 2002)

332   indicated our brief assessment successfully tapped variance linked with perceptions of health.

333   **Results**

334   **Data and Analytic Strategy**

335   Study data, code, materials (Przybylski, Weinstein, & Murayama, 2017), and registered

336   analysis plan (Przybylski, Weinstein, & Murayama, 2016b), are available for download using the

337   Open Science Framework. Following this registered analysis plan, we modelled temporal

338   ordering using a Granger's causality approach, a cross-lagged model (Finkel, 1995; Menard,

339   2002; see also Marsh et al., 2016 for an application) where observations at follow-up were

340   jointly predicted by measurements at the start of the study (see Figure 1). Exploratory analyses

341   concerning mediation and models examining physical and social activity (see Figure 2) are also

342   conducted. Figure 3 presents the empirical findings in line with the preregistered analysis plan.

343   There was one noteworthy deviation from the registered analysis plan which concerned

344   examining IGD diagnoses in line with DSM-5 guidance (Hasin et al., 2013) and previous

345   research on IGD (Przybylski et al., 2016a). Contrary to expectations, none of the participants

346   who met the diagnostic threshold, that is, endorsed five or more items and experienced distress

347   as a result of their game use at the start of the study also did so at follow-up. This unexpected

348   result suggests formal diagnoses might not be stable over time. Our analyses therefore only

349   present the alternative, also preregistered, approach for operationalizing IGD; that is, summing

350   the number of endorsed criteria.

351   All the analyses were conducted with structural equation modelling using Lavaan

352   (Rosseel, 2012). In the current sample, participants who dropped out and those who stayed have

353   different average IGD scores, $M = 0.71$, $SD = 1.13$ and $M = 0.50$, $SD = 1.04$, respectively, t

354   $(3,144) = 4.43$, p < .01. To account for this attrition bias, we used full-information maximum-

355   likelihood method to estimate parameters. This method allow us to account for attribution bias in

356   estimating parameters by including the variables that are correlated with T2 attrition in the

357   analysis (e.g., T1 IGD). (e.g., T1 IGD) (Jeličić, Phelps, & Lerner, 2009). All the models we

358   analyzed were saturated (i.e. degree of freedom was zero). To account for this attrition bias, the

359   full information maximum likelihood estimator was implemented in the lavaan package.

360   Analyses were also conducted controlling for participant age and gender, and the results were

361   consistent with those reported below. Linear coefficients, beta values, reported below reflect

362   standardized units of change in the outcome variable as a function of one unit of change in the

363   predictor variable.

364 **Confirmatory Findings**

365   In line with our registered analysis plan, we examined hypotheses concerned with the

366   causes of Internet Gaming Disorder, psychological need satisfaction, and health using a cross-

367   lagged model.

368   **Internet Gaming Disorder**. We tested our expectation that IGD at follow-up would be

369   predicted by standing at the start of the study in two ways. Results from phi coefficient analyses

370   indicated that IGD appeared stable on a criterion level, coefficients ranged from a low of $r =$

371   0.18, for experiences of withdrawal when Internet games were not played, to $r = 0.31$, for using

372   Internet games as an escape from negative mood. Results from cross-lagged analyses (see Figure

373   1) confirmed the hypotheses that IGD at the start of the study ($\beta = .42$, $p < .001$; Hypothesis 1)

374   and basic need satisfaction ($\beta = -.08$, $p < .001$; Hypothesis 4) were causally related to IGD at

375   follow-up. The model also indicated health at the start of the study was not associated with later

376   standing on IGD ($\beta = -.01$, $p = .74$).

377   **Psychological need satisfaction**. Results from the planned cross-lagged analysis (Figure

378   1) supported the hypotheses that need satisfaction at the start of the study would be positively

379   predictive ($\beta = .56$, $p < .001$; Hypothesis 2), whereas IGD would negatively influence ($\beta = -.06$,

380    $p < .001$; Hypothesis 5) need satisfaction. Though the effects observed were small they were

381   consistent with our hypothesis suggesting that IGD could be disruptive to this form of

382   psychological functioning. Though it was not hypothesized, the model also indicated health at

383   the start of the study was associated with later standing on need satisfaction ($\beta = .17$, $p < .001$).

384   **Health.** Findings from the causal model confirmed our hypothesis regarding the temporal

385   stability of health ($\beta = .72$, $p < .001$; Hypothesis 3) and the positive contribution of basic

386   psychological need satisfaction to subsequent health ($\beta = .07$, $p < .001$; Hypothesis 6). Contrary

387   to what was hypothesized (Hypothesis 7), IGD at the start of the study (β =.01, p = .66) did not

388   predict lower levels of health at follow-up. This unexpected result provided evidence that there is

389   no direct effect of dysregulated Internet gaming on adult health over time.

390   **Sensitivity analysis.** Using our IGD measure, participants reported few IGD criteria (M

391   = 0.47 at T2, out of 9 criteria). Although we employed a robust estimation method to account for

392   non-normality, responses to this scale may not be best described as a normal distribution. To

393   address the issue, we conducted negative binomial regression analysis predicting T2 IGD from

394   T1 IGD, T1 need satisfaction, and T1 health (all the independent variables were standardized) to

395   directly take into account the discrete count nature of the data with low occurrence rate (the part

396   of our model that is susceptible to this issue is depicted in Figure 1). The results were entirely

397   consistent with the SEM results (B_{T1IGD} = .65, p < .01; $B_{T1Health}$ = -0.06, p = .20; $B_{T1Needs}$ = -0.20,

398   p < .01), indicating findings were robust.

399   **Exploratory Analyses**

400   **Mediating influence of basic psychological needs.** The cross-lagged modelling

401   approach used to test the confirmatory hypotheses also provided evidence regarding the indirect

402   effects of IGD and health (Little, Preacher, Selig, & Card, 2007; see for an application, Bishop,

403   Martin, Poon, & Johnson, 2011). If a model provides evidence for the effects of IGD on basic

404   psychological needs, and for the effects of basic psychological needs on health, this supports an

405   equilibrium assumption (i.e., that the same relationship holds beyond the two time points we

406   assessed). As such, we can infer that IGD has indirect effects on health by its impact on basic

407   psychological needs. Results provided clear evidence that IGD was indirectly linked to health

408   through the support for basic psychological needs (see Table 2; Exploratory Analyses 1-4). All

409   three further cross-lagged mediation models evaluating competence, relatedness, and autonomy

410   separately exhibited significant mediation effects (Table 2). Taken together, these results suggest

411   each of the three needs has a mediating effect.

412   **Social and physical activity**. IGD may displace real-life social and physical activity, and

413   by doing undermine health directly (Sisson et al., 2010) or indirectly by relating to need

414   satisfaction (Mellor, Stokes, Firth, Hayashi, & Cummins, 2008; J. Y. Y. Ng et al., 2012; Wilson,

415   Rodgers, Blanchard, & Gessell, 2003). Given this, the mediating effects of psychological need

416   satisfaction might be apparent because need satisfaction correlates with social activity, and these

417   activities provide a better account for the harmful effects of IGD on health than do needs. To test

418   this alternative explanation, we evaluated two additional cross-lagged models that included either

419   social or physical activity (see Figure 2; Exploratory analyses 5 & 6). Results showed social (β =

420   0.42, $p < .01$) and physical ($\beta = .62, p < .01$) activity were consistent over time and supported our

421   expectations that physical activity at Time 1 would be associated with later health ($\beta = 0.07, p <$

422     $.001$), although social activity at Time 1 did not relate to health at Time 2 ($\beta = 0.02, p = .21$).

423   Contrary to our expectations (Exploratory analyses 7 & 8), those who exhibited more IGD

424   symptoms at Time 1 did not report different levels of social ($\beta = 0.01, p = .68$), or physical ($\beta =$

425     $0.02, p = .12$) activity at Time 2. Thus, we did not find support for indirect effects through these

426   activities. Moreover, links identified between IGD at Time 1 and needs at Time 2, and between

427   needs at Time 1 and health at Time 2 (the two links suggesting the presence of an indirect

428   effect), were significant controlling for activity levels (for the link between IGD and need

429   satisfaction, controlling for physical activity; $\beta = -0.06, p < .001$, controlling for social activity; β

430     $= -0.06, p < .001$; for the link between need satisfaction and health, controlling for physical

431   activity; $\beta = 0.09, p < .001$; controlling for social activity; $\beta = 0.07, p < .001$). This constellation

432   of results suggests that the effects of IGD on social or physical activities do not provide a

433   compelling alternative account of why IGD undermines health over time to that offered by need

434   satisfaction.

Discussion

436   Internet-based games are among the most popular forms of human recreation and

437   empirical research is still needed to understand possible psychopathology related to their use.

438   The present research rigorously investigated the etiology and outcomes of Internet Gaming

439   Disorder and the findings derived from this prospective study inform our understanding of how

440   this phenomenon is linked to dysregulation and health. Guided by an open science approach,

441   results confirmed a number of our preregistered hypotheses concerning dysregulated online play.

442   In line with predictions we found that the IGD criteria proposed in the DSM-5 (American

443   Psychiatric Association, 2013) were, on an individual and continuous basis, moderately stable

444   over a six month period. Contrary to what we expected, however, none of the participants

445   meeting diagnostic thresholds at the start did so at the end of the study, and only three

446   participants reported more than four IGD criteria at the start and six months later. These findings,

447   that very few, if any, individuals who meet the proposed diagnostic thresholds over time mirror

448   those derived from other large-scale representative studies of problematic gaming research (Festl

449   et al., 2013; Scharkow et al., 2014). These unexpected results do not support a theoretical

450   framing of Internet Gaming Disorder as a chronic psychiatric condition akin to substance abuse

451   disorder as some have argued (e.g., Hasin et al., 2013; Petry et al., 2014); Rather, the

452   constellation of results we uncovered provide evidence that dysregulated gaming is a nuanced

453   phenomenon that requires careful conceptualisation, and one which can be fruitfully studied

454   from a motivational perspective (Deci & Ryan, 2000; Griffiths et al., 2016; Kardefelt-Winther,

455   2014b). These results may also speak to the nature of the proposed disorder. For example, they

456   mirror some research on problematic gambling, another kind of behavioural dysregulation,

457   which shows such difficulties are more episodic than continuous (Slutske, Jackson, & Sher,

458   2003), though it is unclear whether these IGD episodes are chronic across a span of multiple

459   years, similar to models of addiction where the individual is never truly free of the illness but

460   only experiences intermittent expressions of it (Saitz, Larson, LaBelle, Richardson, & Samet,

461   2008), possibly as an expression of maladaptive coping (Kardefelt-Winther, 2014a). With this in

462   mind, further research investigating the nature of IGD as chronic or episodic would be useful.

463   Generally, IGD has been measured in terms of its more or less frequent occurrence across a

464   period of 12 months (Pontes, Király, Demetrovics, & Griffiths, 2014), but a lack of stability in

465   clinical thresholds being met across a six-month period suggest that these symptoms would need

466   to be frequently reoccurring over a 12-month period for them to be captured by these longer-term

467   assessments.

468   Also contrary to our expectations, we did not find that IGD had an observable direct

469   effect on health over time. Although this finding is inconsistent with some results derived from

470   small-scale convenience samples , it is in line with the only other representative longitudinal

471   work which suggests mixed or non-significant lagged effects linking problematic gaming with

472   life satisfaction and perceived success of gamers (Scharkow et al., 2014). This negative finding

473   is especially noteworthy because it indicates that IGD may not, on its own, be robustly

474   associated with important clinical outcomes. As such, it may be premature to invest in

475   management of IGD using the same kinds of approaches taken in response to substance-based

476   addiction disorders, for example with TMS (Meng, Liu, Yu, & Ma, 2014; Shen et al., 2016;

477   Terraneo et al., 2016). Further, this pattern of findings suggests that more high-quality evidence

478   regarding clinical and behavioral effects is needed before concluding this is a legitimate

479   candidate for inclusion in future revisions of the DSM-5.

480   Despite the absence of a direct link with health, additional research findings indicated

481   there is reason for concern when individuals exhibit IGD symptoms. Informed by the human

482   motivation and self-regulation literature on psychological needs (Ryan & Deci, 2000), we

483   predicted and found that those who were not psychologically need satisfied were more likely to

484   evidence symptoms of IGD at a later time. Though the observed relations were not large in

485   magnitude, they suggested that IGD symptoms can emerge from dysregulating environments or

486   dysregulated psychological states brought on by the absence of psychological need satisfaction,

487   in line with other symptoms indicative of psychopathology, such as depression and anxiety (Deci

488   et al., 2001; Talley, Molix, Schlegel, & Bettencourt, 2010; Wei, Shaffer, Young, & Zakalik,

489   2005), disordered eating (Bartholomew et al., 2011), and borderline personality disorder (Ryan,

490   2005).

491   In line with this idea and the research reviewed above, it may also be that endorsing IGD

492   criteria may be characteristic of a broader and more pervasive problem with self-regulation.

493   Indeed, work with individuals who exhibit gambling disorder, the only non-substance related

494   addiction which is recognized in the DSM-5, shows a lifetime prevalence rate of 61% for mood

495   disorders, 75% for alcohol use, and 48% for drug use, rates higher than in the general population

496   and which reflect a history of dysregulation (D. C. Hodgins, Peden, & Cassidy, 2005). Given we

497   did not test comorbidity with other clinical disorders, or lifetime prevalence of other clinical

498   disorders in those who exhibit IGD symptoms, future research doing so would greatly enhance

499   our understanding of the nature of the disorder and its treatment.

500   As expected, we found small yet consistent reciprocal relations existing with needs, such

501   that those who exhibited symptoms of IGD were less likely to be need satisfied later. This

502   observed pattern of joint causality between needs and IGD suggests that the dynamics underlying

503   unhealthy behaviors mirror those observed in other life contexts (Forest et al., 2011). In addition,

504   the confirmation of this hypothesis indicates that dysregulated gaming may be detrimental to

505   experiencing psychological need satisfaction through other avenues and may crowd out more

506   psychologically edifying pursuits (Chen et al., 2015); For example, IGD symptoms may directly

507   interfere with pursuing other meaningful life goals that satisfy needs (Niemiec, Ryan, & Deci,

508   2009). Alternatively or in addition to this, the experience of compulsion and obsession may

509   directly leave individuals feeling that they have less choice, more isolated and lonely, and

510   ineffective (Lalande et al., 2015).

511   Our data were collected from two time points but with a certain reasonable assumption,

512   we can infer potential mediational process from the cross-lagged model that we tested (Liettle et

513   al., 2007). Indeed, findings from the prespecified model suggested that need satisfaction

514   mediated the effects of IGD symptoms on health; that is, the results indicated that IGD decreases

515   health through lowering need satisfaction. In other work, such need satisfaction have been shown

516   to relate to the health criteria we have tested in this study; that is, better mental health (Ryan &

517   Deci, 2001), better physical health (Reinboth et al., 2004; Sheldon et al., 1996; Thompson &

518   Prottas, 2006), and better psychosocial functioning (H. S. Hodgins et al., 1996; Moller & Deci,

519   2010; Patrick et al., 2007; Weinstein et al., 2011). The current work extends this literature by

520   suggesting that such costs to health are accrued when dysregulating or pathological behaviors

521   undermine need satisfaction. Further, it informs the IGD and the behavioral addiction literatures

522   by highlighting that IGD symptoms lead to lower health partly because they undermine need

523   satisfaction.

524   Interestingly, in exploratory analyses we found that all three psychological needs served

525   to link IGD to health. Although the three needs are often tested in sum (e.g., La Guardia et al.,

526   2000), additional information can be gained by evaluating their separate impacts on wellness

527   (Sheldon et al., 1996; Weinstein & Ryan, 2010), and they have been shown to differentially

528   affect psychological outcomes in certain contexts (e.g., Legate, DeHaan, Weinstein, & Ryan,

529   2013). Evidence that each has a direct effect excludes the possibility that, as an example, IGD

530   induces a feeling of loneliness (absence of relatedness need) that is so robust it carries results

531   using the full measure of need satisfaction.

532   Our final two models assessed whether social and physical activity accounted for the link

533   between IGD symptoms and health, an especially important test given these activities may have

534   been responsible for the indirect effects through psychological needs observed in earlier

535   analyses. The data did not support this conclusion, and instead showed none of the expected

536   relations between IGD symptoms and later costs to social and exercise behaviours. These

537   findings are in line with a mixed literature in this area (Boone et al., 2007), including descriptive

538   research which identifies that 83% of adolescents feel more connected to their friends through

539   their technology use, and suggesting that 68% say they have received social support using

540   technology in tough or challenging times (Lenhart et al., 2015). It is also consistent with findings

541   that gaming can at times promote physical activity (Lanningham-Foster et al., 2006), and work

542   which fails to identify a consistent relation between gaming and physical activity (Kremer et al.,

543   2014; Mentzoni et al., 2011). In this study, we found that dysregulated gaming did not result in

544   actual social isolation or physical inactivity, and that the subjective experience of psychological

545   need satisfaction continues to link IGD to health even controlling for these activities. Yet it

546   might be that IGD symptoms interfere with other meaningful activities not tested in this research

547   that might undermine need satisfaction and provide a more direct account of why IGD

548   undermines health. For example, as discussed above IGD may interfere with the pursuit of

549   meaningful goals, or with academic or work responsibilities. In future work, researchers may test

550   the possibility that engagement in other daily activities might provide a better account than

551   physical or social activity.

552   It is important to note that much of the existing literature on IGD has relied on

553   convenience samples of young adult volunteers drawn from online gaming forums (e.g., Pontes,

554   Király, Demetrovics, & Griffiths, 2014). This approach that differs markedly from studying the

555   phenomenon in a representative sample of adults of all ages. Though the former approach

556   presents serious challenges for generalisability and the two populations may be different in terms

557   of how they cope with daily experiences (e.g., Compas, Connor-Smith, Saltzman, Thomsen, &

558   Wadsworth, 2001; Garnefski, Legerstee, Kraaij, Van Den Kommer, & Teerds, 2002), we expect

559   that the mechanisms which we have examined here – namely basic psychological needs to have

560   similar explanatory power in both. This is in no small part because nearly 40 years of SDT

561   research has studied the impact of need satisfaction in diverse populations and across

562   developmental stages in non-digital contexts. Indeed, psychological needs are shown to be

563   comparably important in terms of both self-regulation and coping for children, adolescents, and

564   adults (see review in Ryan & Deci, 2017).

565   **Limitations**

566   The present research has a number of limitations which future research can address to

567   improve our empirical understanding of self-regulation and IGD. First, the study presented relied

568   on self-reports provided at two time points. The use of respondents for explanatory and criterion

569   data collected misses the opportunity for considering converging and diverging information from

570   the broader social context (Campbell & Fiske, 1959; Cronbach & Meehl, 1955), and the

571   inferences we draw in these structural models rests on an assumption of equilibrium. Given the

572   reliance on a brief self-report measure, we may not have fully examined the construct of

573   psychological distress given the clinical framework conceptualizes this as "clinically significant

574   impairment or distress." In future research both aspects of this criterion – that is, significant

575   impairment and distress – must be evaluated carefully and separately. For example, it might be

576   that an individual with IGD does not experience distress, but his or her game playing disrupts

577   academic or professional performance in a meaningful way. Previous research has shown that

578   such questions may vary in suitability as self-reports – that is in some cases but not all

579   individuals are able to make accurate self-assessments (Clancy & Gove, 1974; Murphy &

580   Schachar, 2000; Weiss et al., 1998). Future studies could therefore collect reports of health and

581   behaviour from friends, family, or caregivers as well as direct behavioural observations of

582   gaming patterns using gaming logs and collected data at a greater number of time intervals so

583   that an equilibrium assumption can be relaxed in modeling to infer mediation processes.

584   Second, the present data cannot speak to the motivation dynamics of the specific games

585   participants played (e.g. Przybylski, Rigby, & Ryan, 2010). Given that the current data suggest

586   motivational factors such the absence of basic need satisfaction is part of problematic play,

587   future studies of Internet Gaming Disorder should examine motivational factors outside of and

588   within games. Third, the study focused on a sample of American adults. Particular concerns have

589   been expressed about the potential effects of Internet gaming on cohorts we did not study,

590   including young people and those living in Eastern societies (American Psychiatric Association,

591   2013). Our sample of individuals from the general population may not have been sensitive to the

592   dynamics underlying extreme and rare cases of problematic gaming, which may show a different

593   pattern of play (for example, these players may exhibit a more continuous nature to their

594   disordered play). Future studies could examine the health and dysregulated play correlates of

595   IGD in samples of younger participants such as school aged children and in other cultural

596   milieus such as Eastern societies where the social nature of online games differ. Fourth, the study

597   design involved a six-month long latency between measures, which allowed for testing lasting

598   effects but may not have been particularly sensitive to immediate causal effects on or by IGD.

599   This is especially problematic if the nature of the disorder involves short-term increases and

600   declines in symptoms over a period of days. Future studies testing the model across varied

601   latencies will be important, for example using daily diary methodology that is more sensitive to

602   experiences as they occur (Wheeler & Reis, 1991).

603   In addition, despite recruiting a large sample, the number of participants endorsing

604   multiple IGD criteria was quite low. This low prevalence limits the complexity of models that

605   can be applied to the data at this scale, and is a generally unacknowledged problem in the field

606   (for an exception see: Festl et al., 2013). Given that resource intensive large-scale data are

607   needed to accurately study the phenomenon, we strongly suggest that researchers pool their

608   efforts and openly share their data, code, and materials. This will limit duplicate and divergent

609   efforts arising from less systematic approaches. Finally, the study only examined links between

610   IGD and motivational and health outcomes. If indeed IGD is a pervasive or special case of

611   behavioural dysregulation it should have a material and pervasive influence on self-control in

612   other domains (Chen et al., 2015; Deci & Ryan, 2000; Steel & Blaszczynski, 1998). Therefore,

613   future studies could also examine the relations between IGD and psychosocial functioning in

614   school, work, and other recreational contexts.

Conclusions

616   The possibility that future revisions of the Diagnostic and Statistical Manual of Mental

617   Disorders may codify Internet Gaming Disorder as a psychiatric condition meriting clinical

618   attention and resources is controversial (Aarseth et al., 2016). Given the high professional and

619   reputational stakes, studies purporting to investigate the phenomenon must complement robust

620   theory with transparent scientific practices. The present work represents our concerted effort to

621   this end. We used self-determination theory as a lens to study the need and health consequences

622   of IGD and utilized a robust open-science empirical approach. Our use of SDT, open materials,

623   open data, and clearly distinguished confirmatory hypotheses (i.e., pre-registered) and

624   exploratory analyses informs the existing literature. By building on this foundation, our findings

625   speak meaningfully to the etiology and health impacts of IGD. They suggest that IGD has

626   dynamics of dysregulations brought on by the absence of psychological need satisfaction in

627   one's environment, and that it has implications for health, but only by undermining need

628   satisfaction further.

629   This work also provides some data to guide future work in this area. For example, we

630   found evidence that individual IGD symptoms may remain stable over a brief period of time, yet

631   individual diagnoses appear not to be. Support for the basic psychological needs for competence,

632   autonomy, and relatedness lead to declines in IGD over time, though we did not observe direct

633   effects of IGD on health over time. Tentative evidence consistent with motivational theory

634   suggested IGD may have an indirect effect on health insofar as it undermines need support, yet

635   further research is needed to determine the conditions under which such links endure. Only when

636   such steps are taken will we know if the attention that researchers and clinicians give to the

637   potential darker aspects of this immensely popular Internet-based activity is fully justified.

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Summary of study hypotheses and exploratory analyses.

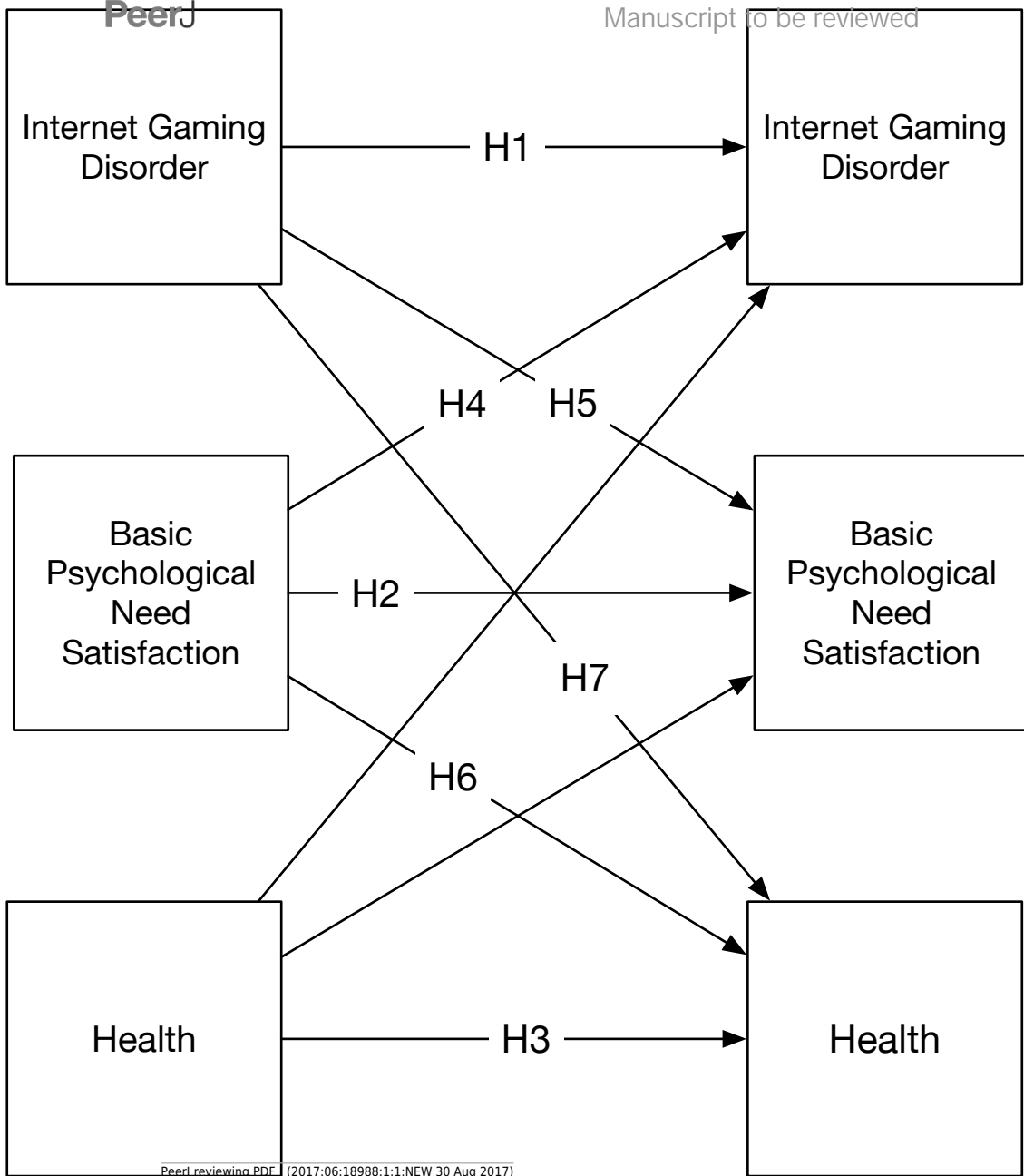
		Time 1 Variables	Influence	Time 2 Variables
Confirmatory Hypotheses	1.	IGD	Direct Positive on	IGD
	2.	Need Supports	Direct Positive on	Need Supports
	3.	Health	Direct Positive on	Health
	4.	Need Supports	Direct Negative on	IGD
	5.	IGD	Direct Negative on	Need Supports
	6.	Need Supports	Direct Positive on	Health
	7.	IGD	Direct Negative on	Health
Exploratory Analyses	1.	Need Supports	Mediate the Negative effect of IGD on	Health
	2.	Competence	Mediate the Negative effect of IGD on	Health
	3.	Relatedness	Mediate the Negative effect of IGD on	Health
	4.	Autonomy	Mediate the Negative effect of IGD on	Health
	5.	Physical Activity	Direct Positive on	Health
	6.	Social Activity	Direct Positive on	Health
	7.	Physical Activity	Mediate the Negative effect of IGD on	Health
	8.	Social Activity	Mediate the Negative effect of IGD on	Health

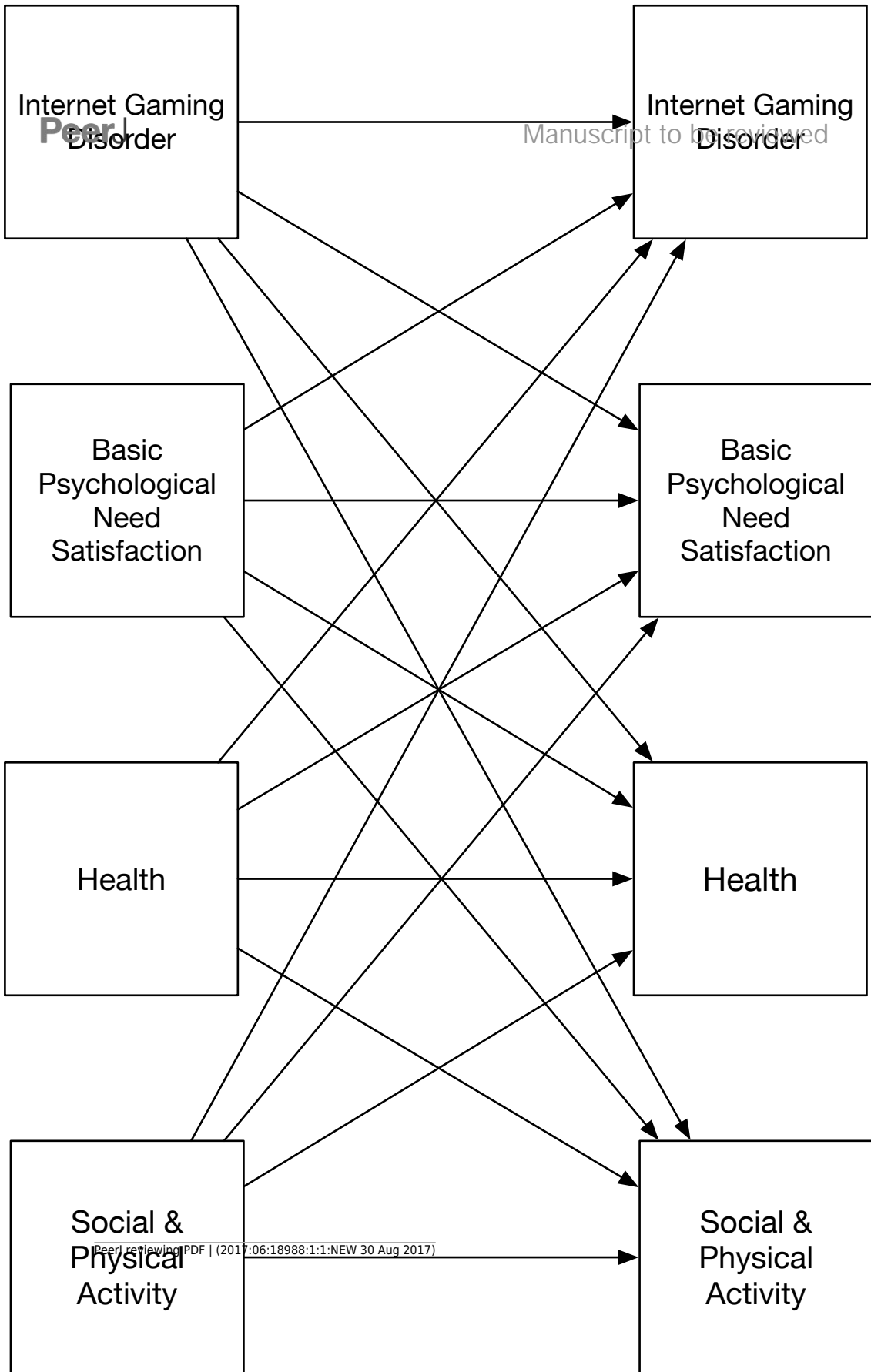
Indirect effects of Internet Gaming Disorder on health as mediated by basic psychological need supports.

Note. All path coefficients are statistically significant at the $p < .05$ level. All coefficients are represented by unstandardized slopes. Our preference was to report standardized coefficients but it is difficult to precisely estimate the confidence interval of standardized indirect effects (Cohen, Cohen, West, & Aiken, 2013).

	IGD to Need Satisfaction		Need Satisfaction to health		Indirect effect	
	b	95% CI	*b*	95% CI	*b*	95% CI
Psychological Need Satisfaction	-0.06	-0.09, -0.03	0.07	0.04, 0.10	-0.004	-0.007, -0.002
Autonomy Need Satisfaction	-0.07	-0.11, -0.03	0.05	0.02, 0.07	-0.003	-0.006, -0.001
Competence Need Satisfaction	-0.06	-0.09, -0.02	0.06	0.02, 0.07	-0.003	-0.005, -0.000
Relatedness Need Satisfaction	-0.06	-0.10, -0.03	0.05	0.03, 0.08	-0.003	-0.006, -0.001

Two-wave model testing cross-lagged effects of IGD, basic psychological need satisfaction and health.

Note. H1-H7 Denotes Hypotheses 1 through 7. Nested models include covariances between measures at baseline and six-month follow-up.

Exploratory two-wave models testing cross-lagged effects of IGD, basic psychological need satisfaction, health, and social and physical activity.

Note. Separate models examined social and physical activity. Tested models include covarainces, between measures at baseline and at six-month follow-up.

Confirmatory two-wave model showing standardised effects of IGD, basic psychological need satisfaction, and health.

Note. H1-H7 Denotes Hypotheses 1 through 7. Nested models include covariances between measures at baseline and six-month follow-up.