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A Short-Term Longitudinal Study of Internet and Computer Game Use by Adolescent Boys and Girls: Prevalence, Frequency of Use, and Psychosocial Predictors

Teena Willoughby
Brock University

Prevalence, frequency, and psychosocial predictors of Internet and computer game use were assessed with 803 male and 788 female adolescents across 2 time periods, 21 months apart. At Time 1, participants were in the 9th or 10th grade; at Time 2, they were in the 11th or 12th grade. Most girls (93.7%) and boys (94.7%) reported using the Internet at both time periods, whereas more boys (80.3%) than girls (28.8%) reported gaming at both time periods. Girls reported a small decrease over time in the frequency of hours spent per day on overall technology use, mostly due to a decrease in gaming. Both linear and curvilinear relations were examined between parental relationships, friendship quality, academic orientation, and well-being measured in early high school and the frequency of technology use in late high school. Being male significantly predicted both computer gaming and Internet use. There also were trends in favor of higher friendship quality and less positive parental relationships predicting higher frequency of Internet use. Importantly, moderate use of the Internet was associated with a more positive academic orientation than nonuse or high levels of use.

Keywords: Internet use, computer game use, psychosocial adjustment, adolescence, gender

Technology is an increasingly important cognitive and socialization agent for contemporary youth (Arnett, 1995). In fact, most adolescents today have access to a variety of technologies such as computers, the Internet, and computer games, with the latter including computer games and games played on platforms like the Microsoft Xbox, Nintendo GameCube, or Sony PlayStation, as well as hand-held, arcade, and cell phone games. Although some attention has been paid to the potential negative effects of excessive Internet and computer game use, understanding why adolescents differ in their involvement in technology use is, for the most part, still in its infancy. There have been clear indications, however, that playing computer games and using the Internet can be both positive and negative for adolescents. For example, concerns have been raised about excessive technology use, particularly because of the relation found between repeated playing of violent computer games and aggressive behavior (e.g., Anderson & Bushman, 2001), but researchers also have hypothesized that computer use may be an important positive agent for cognitive and social development. For example, computer use has been linked to increased visual intelligence skills (Subrahmanyam, Kraut, Greenfield, & Gross, 2000). Examining the full spectrum of frequency of use (i.e., from nonuse to excessive use), then, is critical. The present study addresses this issue by examining prevalence, frequency, and psychosocial predictors of Internet and computer game use among adolescent boys and girls across two time periods (i.e., early and late high school).

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Correspondence concerning this article should be addressed to Teena Willoughby, Department of Child and Youth Studies, Brock University, St. Catharines, Ontario L2S 3A1, Canada. E-mail: twilloug@brocku.ca

The potential benefits of computer use for cognitive development, in particular, have often been raised. Parents report buying computers to enhance their children's educational opportunities and to prepare them for the "information age" (Turow, 1999). Although parents report being worried about the content of their children's television, gaming, and Internet activities, they also appear to embrace computers and the Internet as valuable learning tools (Turow, 1999). Similarly, educators support the use of technology for learning activities (Wood, Mueller, Willoughby, Specht, & DeYoung, 2005). Indeed, computers often are used at home to help children with their schoolwork (Subrahmanyam et al., 2000). Furthermore, computer games have been shown to enhance children's spatial performance skills and have been positively related to reading skills and academic performance (Nichols, 1992; Subrahmanyam & Greenfield, 1994). Given the rapidly increasing prevalence of computer use among children and adolescents, more work is needed to determine the relation of technology use to cognitive development.

In the past, there was concern that spending time playing computer games and using the Internet may lead to increasing levels of social isolation. For example, Lanthier and Windham (2004) found that self-reported negative aspects of Internet use (e.g., negative thoughts, feelings, and experiences) were associated with poor college adjustment. Increased use of the Internet has been reported to be related to higher levels of loneliness and depression (Amichai-Hamburger & Ben-Artzi, 2003; Moody, 2001; Ybarra, Alexander, & Mitchell, 2005). Moreover, Kraut et al. (1998) found that Internet use was associated with small but significant declines in both well-being and the size of the adolescents' social circle over a period of 2 years. In a follow-up study, however, Kraut et al. (2002) found that most of the negative effects had dissipated. More recently, Gross (2004) found no associations between Internet usage and well-being in a sample of 7th and 10th grade students.

In comparison to Internet use, the relation of playing computer games to social development, at least in the short term, has been better documented. Moderate computer game use does not appear to be negatively related to children's social relationships. Indeed, some game playing has been associated with positive social interactions in families and with friends (e.g., Colwell, Grady, & Rhaiti, 1995; Mitchell, 1985). Repeated playing of violent computer games, however, has been related to increased aggressive and delinquent behavior (Anderson & Bushman, 2001; Anderson & Dill, 2000; Zillman & Weaver, 1999), and there is speculation that continued playing of violent computer games may desensitize participants to violence, similar to the effects found with television (Drabman & Thomas, 1974; Subrahmanyam et al., 2000). The relation of technology use to healthy development, therefore, appears to vary according to the frequency of the activity, although more research is needed to better understand that link.

Of interest, there has been surprisingly little discussion on how abstaining from technology use might be related to psychosocial development. In a survey of 1,340 secondary school students, Madell and Muncer (2004) found that 17% of the students considered themselves to be nonusers of the Internet. Although that high a figure might be expected to decrease over time given the increasing prevalence of Internet use, 22% of these students indicated that they were not interested or motivated to use the Internet. If use of computers is positively related to academic orientation, nonuse of computers and the Internet may be a concern. In fact, given the findings from past research suggesting that use of computer games and the Internet might be associated with enhanced cognitive development, the relation between academic orientation and Internet and computer use might be curvilinear, with greater academic orientation associated with moderate use rather than nonuse or excessive use (see Rocheleau, 1995, for a study of home computer use that supports this hypothesis).

Furthermore, with the pervasiveness of technology use among the adolescent population today, particularly use that includes interactions with peers (e.g., gaming, chat rooms, e-mail), it could be anticipated that nonusers might have weaker friendships and lower well-being than those who use technology moderately. Adolescents who use technology at a high level also might have weaker friendships and lower well-being than those who use technology moderately, given that more time spent on the computer could be a result of less time spent with friends. Finally, researchers have suggested that moderate use of technology (e.g., gaming) is associated with time spent playing with parents (e.g., Mitchell, 1985), so there also might be a curvilinear relation between quality of relationship with parents and technology use, with positive parental relationships related more to moderate use than nonuse or excessive use. The present study specifically tested these hypotheses.

Previous research also has highlighted that boys are more likely to engage in computer game playing than girls (Subrahmanyam, Greenfield, Kraut, & Gross, 2001). In fact, gender differences in adolescents' use of technology in general have often been reported. For example, a gender gap in favor of males has been reported in frequency of Internet use with Romanian (Durndell & Haag, 2002) and American university students (Schumacher & Morahan-Martin, 2001) and English secondary school students (Madell & Muncer, 2004), as well as Israeli school children (Nachmias, Mioduser, & Shelma, 2000). In contrast, Odell, Korgen, Schumacher, and Delucchi (2000) and Jackson, Ervin, Gardner, and Schmitt (2001) did not find a significant gender difference in frequency of Internet use among American undergraduates.

Researchers have suggested that gender differences in technology use may exist because educational institutions often promote computer use among boys more than girls and because many children first experience technology through computer games, which tend to be more attractive to boys than girls given their violent and competitive content (Cone, 2001). Others have suggested that boys may prefer the fantasy-based pretend play found in computer games, whereas girls prefer reality-based pretend play (Subrahmanyam & Greenfield, 1998). Still others have suggested that computers and the Internet may not provide the social interaction that girls seek (Chen, 1986). Indeed, girls' online activities appear to be weighted more toward communication activities such as e-mail and chat rooms (e.g., Odell et al., 2000). Most of the research examining gender differences in Internet use, however, has not been conducted with adolescent populations (but see Gross, 2004, and Madell & Muncer, 2004). Given the equivocal nature of the findings across diverse populations and the fact that technology is increasingly becoming an accepted part of life with today's adolescent population in particular, a current exploration of adolescents' Internet use is needed. It may be, as Gross (2004) suggested, that gender differences in use will dissipate over time. The current study examined gender differences in prevalence and frequency of hours spent per day in Internet and computer use across two time periods, first when the adolescents were in 9th or 10th grade (i.e., early high school) and then again when they were in 11th or 12th grade (i.e., late high school).

In summary, using a simple two-wave longitudinal design, this study extends previous research in two ways. First, changes in prevalence and frequency of computer game and Internet use from early to late high school were examined among adolescent boys and girls. Given the pervasiveness and rapidly changing nature of technology today, it was not clear whether there would be significant changes in prevalence and frequency of Internet and computer game use from early to late high school. However, it was expected that boys would report more computer game playing than girls but that gender differences would be negligible in the use of the Internet. The second major goal of the study was to examine gender as well as key psychosocial adjustment variables measured in early high school as predictors of frequency of Internet and computer game use in late high school. More specifically, the present study investigated whether the quality of relationships with parents and friends, academic orientation, and well-being would significantly predict frequency of Internet and computer game use in a linear fashion or whether there might be a curvilinear relation between these variables and technology use. Given the equivocal nature of previous research examining predictors of Internet and computer game use, specific predictions were not made for these analyses, although it was anticipated that Internet use in particular would have a curvilinear relation with academic orientation, given the link between the Internet and educational/learning tasks.

Method

Participants

Students from eight high schools encompassing a school district in Ontario, Canada took part in the study. This study was part of

a larger project examining youth lifestyle choices. At Time 1, all students in six of the high schools, Grade 9 and 10 students in one of the high schools, and Grade 10, 11, and 12 students in the last high school were asked to participate in the study (decisions not to recruit all grades in the two latter schools were made by school administration). The overall participation rate was 83% (N = 5,524); nonparticipation was due to student absenteeism (14.2%), parental refusal (2.1%), or student refusal (.7%). At Time 2, 21 months later, all students in the same eight high schools were asked to participate in the study. The participation rate was 84% (N = 6,124); nonparticipation was due to student absenteeism (13%) or refusals (1.4% of parents, 1.3% of students).

The present results are based on 1,591 students who completed the survey at both time points. At Time 1, these participants (50% male, 50% female) were in Grades 9 or 10 (i.e., early high school) and had an average age of 14.82 years (SD = 0.82). At Time 2, these participants were in Grades 11 or 12 (i.e., late high school) and had an average age of 16.49 years (SD = 0.68). The remaining students who completed the survey were not included in the present study because they had completed the survey at only one time period, either because they had graduated from high school before the Time 2 data collection, because they were in elementary school at Time 1, or because their grade did not complete the survey at Time 1 due to an administrative decision (see above). Consistent with the broader Canadian population (Statistics Canada, 2001), 92% of the adolescents were born in Canada and the most common ethnic backgrounds reported other than Canadian were Italian (34%), French (20%), British (15%), and German (11%). Data on socioeconomic status indicated mean levels of education for mothers and fathers falling between "some college, university or apprenticeship program" and "completed a college/apprenticeship/technical diploma." Further, 73% of the longitudinal respondents reported living with both birth parents, 11% with two parents (including one birth parent), 14% with one birth parent (mother or father only), and the remainder with neither parent (e.g., other relatives, foster parents, guardians, etc.).

Procedure

A passive parental consent procedure was used in this study to ensure a representative sample (see Weinberger, Tublin, Ford, & Feldman, 1990, for a discussion on how active parental consent procedures may result in overrepresentation of well-functioning adolescents and families). Active informed assent, however, was obtained from the adolescent participants. Several strategies were applied in order to ensure parental awareness of the study. First, parents were provided with written correspondence mailed directly to each student's home prior to the survey administration outlining the study; this letter indicated that parents could request that their child not participate in the study (prior to the Time 2 survey, an automated phone message was also left at each student's home phone number). Second, several parent information sessions were held throughout the school district. Third, there was extensive media coverage outlining the study.

At Time 1 (i.e., early high school), the self-report questionnaire was administered to students in classrooms by trained research staff. To ensure standardization of procedures across classrooms, at least one research staff person was present in each classroom during survey administration. To ensure that all students could participate regardless of their literacy level, the survey was read to students with literacy difficulties. Students were informed that their responses were completely confidential. At Time 2 (approximately 21 months following the first survey administration—late high school), the same procedure was used to administer the survey.

Measures

Details on measures are outlined in Table 1. Single-item questions were used to assess participant sex and the number of computers in the home. Parental education was an average of two items (one per parent). Higher scores indicated more educated parents.

The quality of relationships with friends was a composite of two scale scores. The first comprised items adapted from Gauze, Bukowski, Aquan-Asse, and Sippola (1996) relating to the quality of companionship, support, security, closeness, and conflict with one's "best friend;" the second scale comprised items relating to attachment to one's friends, adapted from Armsden and Greenburg (1987). Scores were reverse coded if applicable, standardized, and combined such that higher scores indicated weaker friendships.

The quality of relationship with parents was a composite of three scale scores and two questions relating to parental involvement: Paternal and maternal attachment were measured separately with items from the Inventory of Parent and Peer Attachment (Armsden & Greenburg, 1987); parental knowledge was assessed using items related to how much one's parents/guardians really know about how the respondent spends their free time; and parental involvement was measured with two questions relating to frequency of talking with parents and frequency of having fun with parents. Scores were reverse-coded if applicable, standardized, and combined such that higher scores indicated less positive relationships.

Well-being was a composite of five standardized scores: Depression-related symptoms were measured using the Center for Epidemiologic Studies Depression Scale (Radloff, 1977); social anxiety-related symptoms were assessed using items from Ginsberg, LaGreca, and Silverman (1998); self-esteem was measured using the Rosenberg self-esteem scale (Rosenberg, 1965); daily hassles were assessed based on the frequency of experiencing 25 potential life stressors/hassles including finances, friends and peers, school work, and self-image; and life satisfaction was assessed with the question "I am happy with my life." Scores were reverse-coded if applicable, standardized, and combined such that higher scores indicated less positive well-being.

Academic orientation was a composite of standardized scores for ratings of typical school grades, educational aspirations, frequency of planning ahead, frequency of being bored at school, and the perceived importance of doing well at school. Scores were reverse coded if applicable, standardized, and combined such that higher scores indicated a weaker academic orientation.

The assessment of frequency of computer game use was an average of two items: "How many hours do you spend playing computer games on an average school day and on an average weekend?" Higher scores indicated a higher frequency of gaming. Internet use frequency was an average of two items: "How many hours do you spend going on the Internet on an average school day and on an average weekend?" Higher scores indicated a higher

Table 1
Description, Means and Standard Deviations of Study Measures (N = 1,591)

Domain	*Variable*	*Items*	*Scale range*	*Alpha*	*M*	*SD*
Gender	Sex	1	1 (male) or 2 (female)		1.50	0.50
Parental education	Parental education	2	1 (not finish high school) to 6 (professional/grad degree)		3.46	1.14
No. of computers in home	No. of computers in home	1	1 (none) to 4 (four or more)		2.71	0.79
Friendship quality	Best friends	18	1 (almost always or always) to 4 (almost never or never)	.89	1.96	0.46
	Friendship attachment	18	1 (almost always or always) to 4 (almost never or never)	.90	1.92	0.44
Parental relationships	Maternal attachment	17	1 (almost always or always) to 4 (almost never or never)	.89	2.06	0.42
	Paternal attachment	17	1 (almost always or always) to 4 (almost never or never)	.90	2.20	0.44
	Parental knowledge	9	1 (they always know) to 4 (they never know)	.91	2.02	0.62
	Fun with parents	1	1 (almost every day) to 4 (almost never)		2.75	0.80
	Talk with parents	1	1 (almost every day) to 4 (almost never)		2.18	0.90
Academic orientation	Grades	1	1 (A+) to 6 (below 50%)		2.62	0.83
	Aspirations	1	1 (not finish high school) to 6 (professional training)		4.55	1.33
	Planfulness	1	1 (almost always or always) to 4 (almost never or never)		2.70	0.74
	Bored at school	1	1 (all the time) to 4 (almost never or never)		2.14	0.77
	Importance of academic success	1	1 (very important) to 5 (not at all important)		1.55	0.71
Well-being	Depression	20	1 (none of the time) to 5 (most of the time)	.90	2.28	0.46
	Social anxiety	14	1 (almost never or never) to 4 (almost always or always)	.93	1.74	0.56
	Self-esteem	10	1 (strongly agree) to 5 (strongly disagree)	.88	2.81	0.34
	Daily hassles	25	1 (almost never bothers me) to 3 (often bothers me)	.87	1.76	0.32
	Life satisfaction	1	1 (almost always or always) to 4 (almost never or never)		1.63	0.73
Frequency of computer game use	Early high school (Time 1)	2	1 (not at all) to 5 (5 or more hours)		2.14	1.08
	Late high school (Time 2)	2	1 (not at all) to 5 (5 or more hours)		2.02	1.09
Prevalence of computer game use	Early high school (Time 1)	1	1 (yes) to 2 (no)		1.30	0.46
	Late high school (Time 2)	1	1 (yes) to 2 (no)		1.36	0.48
Frequency of Internet use	Early high school (Time 1)	2	1 (not at all) to 5 (5 or more hours)		3.03	1.00
	Late high school (Time 2)	2	1 (not at all) to 5 (5 or more hours)		3.05	0.94
Prevalence of Internet use	Early high school (Time 1)	1	1 (yes) to 2 (no)		1.04	0.20
	Late high school (Time 2)	1	1 (yes) to 2 (no)		1.02	0.14

frequency of going on the Internet. To assess prevalence of computer game and Internet use, participants were asked to indicate "yes" or "no" to the question of whether they played computer games and used the Internet. Technology use was assessed at Time 1 and Time 2.

Treatment of Missing Data

Some students did not finish the entire study questionnaire. The amount of missing data was directly related to survey length, that is, missing values were greatest towards the end of the survey. Anticipating this pattern, three versions of the study survey were used at both Time 1 and Time 2 administrations such that the survey sections placed in the final third of the survey were evenly distributed across the three versions (with the exception of demographic information, which always appeared on the first page). Consequently, missing data was distributed across survey sections. For multi-item scales, composite scores were computed for participants who responded to at least 50% of the relevant items. For respondents who did not give a sufficient number of responses within a multi-item scale or did not provide a response to a single-item measure, missing values were imputed. In total, 18% of the data was missing due to either nonresponse or an insufficient number of responses. Missing data were imputed using the expectation-maximization (EM) algorithm in SPSS (see Schafer & Graham, 2002).

Results

The primary analyses included an examination of (a) changes over time in prevalence of computer and Internet use, (b) changes over time in frequency of computer and Internet use, and (c) psychosocial predictors of frequency of computer and Internet use in late high school. Analyses were conducted with parental education and number of computers in the home as control variables,

given the past research suggesting that these factors may be important influences in technology use (e.g., Rocheleau, 1995; Subrahmanyam et al., 2000). A focus on gender also was included in each analysis.

Changes Over Time in Prevalence of Computer Game and Internet Use

The first goal of the study was to examine changes over time in the prevalence of computer game and Internet use from early to late high school. Prevalence estimates were assessed from survey items indicating whether or not adolescents reported playing computer games and using the Internet. Thus, prevalence scores were dichotomous (coded as yes or no) and tests to explore significant differences in prevalence across gender and time (early high school, late high school) were conducted separately for computer games and the Internet using chi-square analyses. Table 1 displays the means and standard deviations for each of the study measures.

Most adolescents (93.9% of boys, 94.7% of girls) reported using the Internet in both early high school and late high school. Only 8 adolescents (0.2% of boys and 0.8% of girls) reported not using the Internet at either time period, while 1.6% of boys and 1.3% of girls reported using the Internet only in early high school and 4.2% of boys and 3.3% of girls only in late high school. Clearly, Internet use is prevalent among both boys and girls, with no significant differences between boys and girls in prevalence levels for both early and late high school, $\chi^2(1, N = 1{,}591) = .17$, $p > .05$, for early high school and $\chi^2(1, N = 1{,}591) = .06$, $p > .05$, for late high school. In addition, there was an small increase in prevalence of use from early to late high school, which was significant only for girls, $\chi^2(1, N = 788) = 38.52$, $p < .05$.

In contrast, only 80.3% of boys and 28.8% of girls reported playing computer games at both time periods, while 9.1% of boys and 21.1% of girls reported playing in early high school only and 6.5% of boys and 11.7% of girls in late high school only. Importantly, 4.1% of boys and 38.1% of girls reported not playing computer games at either of the two time periods. Overall, therefore, both boys and girls reported less prevalence of computer gaming than Internet use, and boys indicated higher prevalence of playing computer games than girls both in early high school, $\chi^2(1, N = 1{,}591) = 290.55$, $p < .05$, and in late high school, $\chi^2(1, N = 1{,}591) = 369.69$, $p < .05$. Moreover, there was a decrease in prevalence of computer game playing from early to late high school, which was significant for both boys and girls: $\chi^2(1, N = 803) = 54.47$, $p < .05$, for boys and $\chi^2(1, N = 788) = 93.70$, $p < .05$, for girls.

Also of interest was exploring differences between adolescents who played computer games and used the Internet in early high school but not in late high school, and vice versa. Seven one-way analyses of variance were conducted to examine differences first between the two computer game groups and then between the two Internet groups in parental education, number of computers in the home, gender, friendship quality, parental attachment, academic orientation, and well-being scores. Given the large number of comparisons, a Bonferonni correction was used to maintain an overall alpha level of .05. Across the set of comparisons, ps $< .007$ were considered statistically significant. For the computer game comparisons, there were no significant differences, largest $F(1, 384) = 6.13$, $p = .014$, partial $\eta^2 = .01$, for academic orientation. For the Internet comparisons, the number of computers reported in the home in early high school differed between the groups, $F(1, 81) = 19.24$, $p < .001$, partial $\eta^2 = .19$, such that adolescents who used the Internet only in late high school reported fewer computers in their home in early high school than adolescents who used the computer only in early high school.

Changes Over Time in Frequency of Hours per Day Spent Playing Computer Games and Using the Internet

Changes over time in the frequency of hours per day that the adolescent boys and girls spent playing computer games and using the Internet was also examined. Overall, both boys and girls reported using the Internet an average of 1 to 2 hours a day (M = 3.05 and 3.02, respectively). Boys also reported playing computer games close to 1 or 2 hours a day ($M = 2.66$), whereas girls reported playing between "not at all" and "less than 1 hour a day" ($M = 1.49$). To assess whether there were changes in the frequency of hours per day that adolescent boys and girls spent playing computer games or using the Internet from early to late high school, a repeated measures analysis of covariance was conducted on the frequency scores with time (early high school and late high school) and type of technology use (Internet and computer games) as the within-subjects variables, gender as the between-subjects variable, and parental education and number of computers in the home as covariates. Both covariates were significant, $F(1, 1587) = 16.76$, $p < .001$, partial $\eta^2 = .01$, for parental education, and $F(1, 1587) = 45.28$, $p < .001$, partial $\eta^2 = .03$, for number of computers. Lower parental education and a higher number of computers in the home both were associated with higher frequency of use overall. Main effects of type, $F(1, 1587) = 29.11$, $p < .001$, partial $\eta^2 = .02$, and gender, $F(1, 1587) = 370.16$, $p < .001$, partial $\eta^2 = .19$, also were significant, with Internet use more frequent than computer gaming and boys reporting more frequent use overall than girls. These main effects, however, were qualified by a significant Time × Gender interaction, $F(1, 1587) = 4.41$, $p < .05$, partial $\eta^2 = .01$, and a significant Type × Gender interaction, $F(1, 1587) = 562.42$, $p < .001$, partial $\eta^2 = .25$.

Post hoc analysis of the Time × Gender interaction revealed that frequency of overall use for boys did not differ across early high school ($M = 3.06$) and late high school ($M = 3.04$), $F(1, 802) = .60$, $p > .05$, partial $\eta^2 = .00$, but overall frequency of use for girls decreased over time ($M = 2.46$ in early high school and 2.36 in late high school), $F(1, 787) = 14.99$, $p < .001$, partial $\eta^2 = .02$. Post hoc analyses of the Type × Gender interaction indicated that boys ($M = 2.85$) played computer games more frequently than girls ($M = 1.59$), $F(1, 1589) = 858.89$, $p < .001$, partial $\eta^2 = .35$, but boys ($M = 3.25$) did not significantly differ from girls ($M = 3.24$) in frequency of Internet use, $F(1, 1589) = .08$, $p > .05$, partial $\eta^2 = .00$.

Psychosocial Predictors of Frequency of Internet and Computer Game Use in Late High School

Another major goal of this study was to examine whether gender as well as the quality of relationships with parents and peers, academic orientation, and well-being, measured in early high school, predicted frequency of Internet and computer game use in late high school. Preliminary examination of the correlations

among study variables (see Table 2) indicated that there was considerable stability in frequency of hours spent per day playing computer games from early to late high school ($r = .66$) and moderate stability in frequency of hours spent per day using the Internet from early to late high school ($r = .36$). Pair-wise correlations with $ps < .01$ indicated that greater frequency of computer game use in both early and late high school was associated with a greater number of computers in the home, less positive friendship quality, and weaker academic orientation. Higher frequency of Internet use in early high school was associated with a greater number of computers in the home, less positive parental relationships, and less positive well-being. In contrast, a higher frequency of Internet use in later high school was associated with only a greater number of computers in the home. In addition, consistent with past research (e.g., Lerner et al., 2005; Scales, Benson, & Leffert, 2000), boys reported significantly more positive well-being scores, $F(1, 1589) = 23.61$, $p < .001$, partial $\eta^2 = .02$, but less positive friendship quality, parental relationship, and academic orientation scores than girls: $F(1, 1589) = 405.31$, $p < .001$, partial $\eta^2 = .20$; $F(1, 1589) = 6.06$, $p < .05$, partial $\eta^2 = .01$; and $F(1, 1589) = 33.93$, $p < .001$, partial $\eta^2 = .02$, respectively.

Hierarchical multiple regressions were then conducted to assess the relation between both gender and the psychosocial indices measured in early high school and the frequency of computer game and Internet use measured in late high school. In both the analysis for Internet use and the analysis for computer game use, parental education, and number of computers in the home were included in Step 1 of the regression model as covariates. Frequency of use in early high school was included as Step 2. The next step included gender and all the psychosocial indices (i.e., friendship quality, parental relationships, academic orientation, and well-being). Further, to assess possible nonlinear effects, curvilinear terms for friendship quality, parental relationships, academic orientation, and well-being were added in the final step of each regression model. Continuous measures were standardized and curvilinear (squared) terms were computed based on standardized scores. Results are shown in Tables 3 and 4.

For computer game use in late high school, a total of approximately 50% of the variance was accounted for by the variables entered in the models. The first three steps were significant, but the inclusion of the curvilinear terms in Step 4 was not significant. Overall, lower parental education ($\beta = -.05$, $p = .014$), greater computer game use in early high school ($\beta = .56$, $p = .000$), and being male ($\beta = -.29$, $p = .000$) were significant predictors of computer game use in late high school. In addition, there was a trend in favor of weaker academic orientation predicting higher frequency of computer game use.

For Internet use in late high school, all steps, including the final step with the curvilinear terms, were significant with a total of approximately 15% of the variance accounted for by the variables entered in the model. Greater Internet use in early high school ($\beta = .33$, $p = .000$) and being male ($\beta = -.07$, $p = .01$) were significant predictors. In addition, a trend was found for having

Table 3
Regression of Psychosocial Indices on Computer Game Use in Late High School

T1 index	Step 1	Step 2	Step 3	Step 4
	Parameter estimates (β)			
Parental education	$-.076^{**}$	$-.037^{\dagger}$	$-.050^{*}$	$-.050^{*}$
No. of computers in home	$.096^{***}$	.009	.011	.011
Computer game use		$.720^{***}$	$.557^{***}$	$.558^{***}$
Gender			$-.290^{***}$	$-.286^{***}$
Friendship quality			.014	.019
Parental relationships			.003	.004
Academic orientation			$.042^{\dagger}$	$.043^{\dagger}$
Well-being			−.015	−.023
Friendship quality curvilinear				−.011
Parental relationship curvilinear				−.003
Academic orientation curvilinear				−.001
Well-being curvilinear				.012
	Model fit			
R^2	.011	.441	.498	.499
ΔR^2	$.011^{***}$	$.430^{***}$	$.057^{***}$	.000

Note. T1 = Assessed at Time 1 (i.e., early high school).
$^{\dagger} p < .08$. $^{*} p < .05$. $^{**} p < .01$. $^{***} p < .001$.

Table 2
Correlations Among Study Measures (N = 1,591)

Variable	1	2	3	4	5	6	7	8	9	10
1. Parental education	—									
2. No. of computers at home	$.14^{***}$	—								
3. Friendship quality	−.04	−.04	—							
4. Parental relationships	$-.15^{***}$	.04	$.29^{***}$	—						
5. Academic orientation	$-.24^{***}$	$-.09^{**}$	$.20^{***}$	$.39^{***}$	—					
6. Well-being	$-.11^{***}$	.03	$.20^{***}$	$.35^{***}$	$.19^{***}$	—				
7. Frequency of Internet use in early high school	−.04	$.18^{***}$	−.04	$.15^{***}$	$.07^{*}$	$.11^{***}$	—			
8. Frequency of Internet use in late high school	$-.06^{*}$	$.11^{***}$	−.02	$.06^{*}$	−.02	.01	$.36^{***}$	—		
9. Frequency of computer game use in early high school	−.05	$.11^{***}$	$.30^{***}$	.05	$.12^{***}$	−.01	$.18^{***}$	$.17^{***}$	—	
10. Frequency of computer game use in late high school	−.02	$.08^{**}$	$.29^{***}$	$.07^{*}$	$.15^{***}$	−.04	$.06^{*}$	$.21^{***}$	$.66^{***}$	—

$^{*} p < .05$. $^{**} p < .01$. $^{***} p < .001$.

Table 4
Regression of Psychosocial Indices on Internet Use in Late High School

T1 index	Step 1	Step 2	Step 3	Step 4
Parameter estimates (β)				
Parental education	−.027	−.001	−.016	−.010
No. of computers in home	.109***	.047*	.036	.040†
Internet use		.333***	.334***	.328***
Gender			−.063*	−.067*
Friendship quality			−.035	−.052†
Parental relationships			.042	.045†
Academic orientation			−.064*	.046†
Well-being			−.016	−.023
Friendship quality curvilinear				.028
Parental relationship curvilinear				−.007
Academic orientation curvilinear				−.045**
Well-being curvilinear				.011
Model fit				
R^2	.013	.134	.141	.147
ΔR^2	.013***	.120***	.007*	.006*

Note. T1 = Assessed at Time 1 (i.e., early high school).
† $p < .09$. * $p < .05$. ** $p < .01$. *** $p < .001$.

more computers in the home, more positive friendship quality, and less positive parental relationships. Further, a significant curvilinear effect for academic orientation ($\beta = -.05$, $p = .005$) indicated that adolescents who reported either nonuse or high levels of Internet use were more likely to report a weaker academic orientation than adolescents reporting a more moderate level of Internet use (see Figure 1).

Follow-Up Analysis of Academic Orientation and Frequency of Internet Use

Post hoc analysis of the relation between Internet use and academic orientation was conducted to explore whether there were specific components of the composite academic orientation variable that predicted frequency of Internet use. Recall that the composite academic orientation variable consisted of measures of school grades, educational aspirations, frequency of planning ahead, frequency of being bored at school, and perceived importance of doing well at school. Bivariate correlations between these measures ranged from .19 (feeling bored and educational aspirations) to .43 (grades and importance of doing well at school).

A hierarchical multiple regression was conducted to assess the relation between each type of academic orientation and frequency of Internet use in late high school. Again, parental education and number of computers in the home were included in Step 1 as covariates, and frequency of Internet use in early high school was included as Step 2. The next step included the five measures of academic orientation. To assess nonlinear effects, curvilinear terms for each measure were added in the final step (see Table 5 for results). The final curvilinear step was significant. Feeling bored at school and educational aspirations were significant predictors, such that more boredom at school and higher educational aspirations were associated with greater frequency of Internet use.

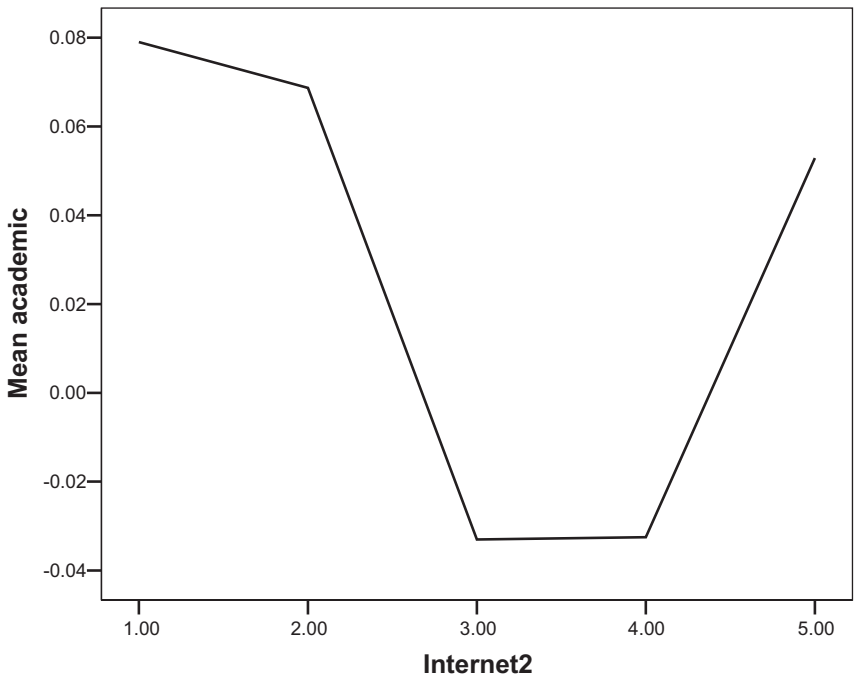

Figure 1. Graph of mean academic orientation scores by frequency of Internet use in late high school. Academic = standardized score for academic orientation (higher score indicates weaker academic orientation in early high school). Internet2 = frequency of Internet use in late high school (higher score indicates more frequent use of the Internet).

Table 5
Regression of Academic Orientation Indices on Internet Use in Late High School

T1 index	Step 1	Step 2	Step 3	Step 4
		Parameter estimates (β)		
Parental education	−.027	−.001	−.024	−.022
No. of computers in home	.109***	.047*	.044	.046†
Internet use		.333***	.331***	.334***
Marks			−.053†	−.048†
Educational aspirations			.089**	.103**
Planning ahead			.048†	.030
Feeling bored at school			−.053*	−.061*
Importance of doing well at school			−.008	.028
Marks curvilinear				−.040*
Educational aspirations curvilinear				.007
Planning ahead curvilinear				−.030†
Feeling bored at school curvilinear				.022
Importance of doing well at school curvilinear				−.014
		Model fit		
R^2	.013	.134	.141	.148
ΔR^2	.013***	.120***	.007*	.007*

Note. T1 = Assessed at Time 1 (i.e., early high school).
† $p < .09$. * $p < .05$. ** $p < .01$. *** $p < .001$.

Importantly, a significant curvilinear relation was found between school grades and Internet use, such that more moderate and higher use was associated with higher grades than nonuse of the Internet. A curvilinear trend also was found for planning ahead. Overall, however, the most consistent measure to explain the curvilinear relation between the composite academic orientation variable and Internet use appears to be school grades.

Discussion

In the present sample of high school students, reported use of the Internet was more frequent than playing computer games, with adolescents reporting Internet use an average of 1 to 2 hours a day in contrast to an average of less than 1 hour a day for computer game use. Further, boys maintained this level of frequency of technology use over time, whereas girls reported a small significant decrease in hours spent per day on overall technology use from early high school to late high school, mostly due to a decrease in frequency of hours spent gaming. Given that opportunities for technological involvement have been continuously expanding, this may be a historical change rather than a developmental difference, but the two are of course confounded in the present design. A sizeable group of adolescents (45%) reported not playing computer games in early high school and/or late high school, and more boys than girls reported gaming. In contrast, almost all adolescents (94%) reported using the Internet in early high school and/or late high school and there were no differences between boys and girls in prevalence or frequency of use. Consistent with Gross (2004), gender differences in prevalence and frequency of hours spent using the Internet appear to have dissipated.

Not surprisingly, even in the context of a multivariate regression analysis that included multiple potential predictors, gender (being male) was a strong predictor of frequency of computer game use, as was lower parental education. Also expected was the finding that frequency of computer game use in early high school was the strongest predictor of frequency of use in late high school. Of interest, weaker academic orientation showed a trend for prediction of frequency of computer game use in late high school. The direction of the effect, however, is not clear. It could be that adolescents with weaker academic orientations are drawn more to computer gaming, but it also may be that repeated gaming leads to weaker academic orientation. In addition, the associations between these predictors and computer game use were linear, in that higher scores on the predictors were associated with higher frequencies of game use.

Overall, half of the variance in frequency of computer game use in late high school was explained through the inclusion of gender and the psychosocial indices, as well as use in early high school and the control variables. In contrast, only 15% of the variance in Internet use in late high school was explained with the inclusion of these variables in the final model. Clearly, a more comprehensive picture of the predictors of adolescent Internet use awaits further study. An interesting finding with the regression results for Internet use in late high school, however, was that in the context of all the other variables included in the model, higher friendship quality but weaker parental relationships both showed trends favoring significance in the prediction of frequency of Internet use. These seemingly contradictory findings may be due to the fact that adolescents tend to report using the Internet most often for online chat discussions and e-mail (Gross, 2004; Madell & Muncer, 2004). These activities, presumably, involve interactions with their friends (see Gross, 2004, for support for that hypothesis). More Internet use, however, could leave less time for parental interactions, or, alternatively, more time on the Internet may be a result of adolescents turning to the Internet because of less positive parental interactions. Furthermore, these results suggest online interactions may now be an important context for interactions with friends. Nonusers of the Internet, therefore, are less involved in these peer interactions.

Gender (being male) and frequency of Internet use in early high school also were significant predictors of frequency of Internet use in late high school. Most importantly, the curvilinear term for academic orientation significantly predicted Internet use. No other curvilinear terms significantly predicted Internet use. Moderate use of the Internet, therefore, was associated with a more positive academic orientation than nonuse and high levels of use. This finding supports arguments by researchers that Internet use is related positively to academic and learning tasks. Follow-up analyses of the subcomponents of the academic orientation composite (school grades, educational aspirations, frequency of planning ahead, frequency of being bored at school, and perceived importance of doing well at school) indicated that the curvilinear finding may be related most consistently to school grades, with higher marks associated with moderate Internet use. Again, causal statements can not be made based on these findings, but it is clear that adolescents who do not use the Internet for learning tasks, as well as excessive users of the Internet, are at a disadvantage academically. In fact, many homework assignments increasingly involve

accessing information from the Internet, so it may not be a surprise that nonuse of the Internet is associated with lower grades.

Why would adolescents not use the Internet? The finding in the present study that only 8 adolescents did not use the Internet at both time periods suggests that it is not lack of availability of the Internet that is responsible for nonuse. What may matter more is ease of availability, such as having easy access to a computer at home. In fact, a predictor of Internet use was the number of computers in the home. In addition, adolescents in the present study who used the Internet only in late high school reported fewer computers in their home in early high school than students who used the Internet only in early high school. Ease of access likely will be less of an issue as computers and the Internet continue to become more affordable for families. Less clear, however, is why adolescents who used the Internet in early high school did not continue to use it in late high school. Further research is needed to identify whether encouraging adolescents to use the Internet for school projects and assignments might enhance their academic orientation.

An important limitation of the present study stems from the reliance on self-report. Reports of technology use would benefit from corroboration from other informants (e.g., friends, peers, parents). It is not clear, however, whether anyone other than the adolescent can provide an accurate assessment of their online use given that much of the activity may be conducted alone, although the inclusion of peer assessment may be a key factor in increasing our understanding of adolescents' online interactions with friends and peers. In addition, although the participants in the present study included a large sample of enrolled students from a school distinct, findings may not generalize to other geographic regions, including those with differing ethnic and/or demographic mixes.

In summary, Internet use appears to differ in qualitative ways from computer gaming. Using the computer to access the Internet can include gaming, but adolescents may use the Internet predominantly for communication purposes and for accessing information, often for educational purposes (Gross, 2004; Madell & Muncer, 2004). As such, the Internet in particular appears to have the potential to have both positive and negative impacts on adolescent development. Although others have found a link between computer games and cognitive development (e.g., Subrahmanyam & Greenfield, 1994), there was a trend for weaker academic orientation predicting gaming in the present study. Further work is needed to assess the situations in which computer gaming may be positively related to development. In fact, one area that should be pursued in future research is whether there is any benefit for adolescents who engage in multiplayer as opposed to single player computer games. This characteristic of computer game playing may be a particularly important factor when examining the link between gaming and social development. Overall, however, the results of the present study highlight the need to pay attention not only to the implications of excessive use of technology but also to nonuse. Only with further understanding of these issues can parents, educators, and policy makers maximize the positive impact of technology on adolescent development.

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