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Internet use, videogame playing and cell phone use as predictors of children's body mass index (BMI), body weight, academic performance, and social and overall self-esteem

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ABSTRACT

In this research we examined the prediction of children's body mass index (BMI), body weight, academic performance, social self-esteem and overall self-esteem from their IT (information technology) use, specifically, their Internet use, cell phone use and videogame playing, after controlling for the effects of gender, race, age and household income on these measures. Participants were 482 children whose average age was 12 years old. One-third was African American and two-thirds were Caucasian American. Results indicated that IT use did not predict BMI or body weight, contrary to one previous survey and the widespread belief that screen time is responsible for the obesity epidemic among our nation's children. Instead, BMI and body weight were higher for African Americans, older children and children from lower income households. The sole and strong positive predictor of visual–spatial skills was videogame playing, which also predicted lower grade point averages (GPAs). Gender and Internet use predicted standardized test scores in reading skills. Females and children who used the Internet more had better reading skills than did males and children who used the Internet less, respectively. Implications of these findings for future research on the benefits and liabilities of IT use are discussed.

1. Introduction

A large majority of children in the U.S. and around the globe use the Internet (Jackson, 2008; Pew Internet and American Life Project (PEW), 2006). Research on the effects of the Internet and other types of information technology (IT) use on development, though increasing, lags behind the exponential growth in children's actual technology use. Consider, for example, the personal computer of 1995 compared to "loaded" wireless laptop of today. Or consider the landline telephone – once the primary technology for distance communication, compared to today's broadband technology with its ability to see, hear and locate others anywhere around the globe (i.e., Global Positioning System or GPS). Our children are growing up in this world, a world they often know better than do their parents and teachers (Pew, 2005a). In this research we focus on relationships between three types of IT use – Internet use, videogame playing and cell phone use on children's physical (body mass index), cognitive (GPA and scores on standardized tests), social and overall self-esteem.

Despite the exponential increase in information technology use, there is a persistent digital divide separating the technology "haves" from "have nots" (Hargittai, 2008; Hoffman, Novak, & Schlosser, 2001; Jackson, Ervin, Gardner, & Schmitt, 2001; Jackson, Fitzgerald, von Eye, Zhao, & Witt, 2010). In a review of this literature Jackson and her colleagues came to four conclusions concerning the digital divides in the U.S. (Jackson et al., 2010): (1) there are digital divides that center around race, income and education; (2) there are digital divides in the intensity and nature of Internet use that similarly center around race, income and education, but also around gender; (3) the intensity and nature of the Internet use divides will have consequences as far reaching as the initial Internet access divide. Technology will become increasingly less available to those who need it most – underprivileged groups, and increasingly more available to those who need it least – affluent groups; (4) efforts to reduce the digital divides by increasing public access are unlikely to result in digital equity. Rather, direct interventions from public and private organizations are needed to reduce and eliminate all dimensions of the digital divide.

On a related topic, it is estimated that 16% of children in the U.S. are obese, triple the rate of just two decades ago (American Obesity Association (AOA), 2005). The causes of childhood obesity are many and complex but are known to include poor eating habits, soft drink consumption, lack of physical exercise and excessive time in front of a screen (Adams, 2006). Between the ages of 8

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and 18, youth spend more time in front of a computer, television, or videogame screen than in any other activity except sleeping (44.5 h per week; PEW, 2005a). With rare exceptions (e.g., Nintendo's Weii) screen time is a time of high caloric consumption and low physical activity, the perfect combination for weight gain and obesity (AOA, 2005).

Are children benefiting in any way from their screen time, in particular, computer screen time? Reviews of research on the relationship between IT use and cognitive outcomes have produced mixed results (Jackson, 2008). Among the more favorable findings is that Internet use improves cognitive skills, specifically reading skills, but only for children initially low in these skills (Jackson et al., 2006). However, when children are asked to indicate how important home Internet use is to their academic performance they claim it is indispensible and that it greatly enhances the quality of their school work (PEW, 2005a,b).

There is also a glimmer of hope to be found in research on videogame playing. According to research using adult samples, playing videogames enhances visual–spatial skills (Green & Bavelier, 2007), skills thought to provide the "training wheels" for children's later performance in science, technology, engineering and mathematics (STEM areas; Subrahmanyam, Greenfield, Kraut, & Gross, 2001; Subrahmanyam, Kraut, Greenfield, & Gross, 2000). Yet there is substantial evidence that children who play videogames more, particularly violent videogames, have poorer performance in school (GPAs), more aggressive cognition and behavior, and receive more negative teacher ratings than do children who play videogames less or not at all (Anderson, Gentile, & Buckley, 2007; Walsh, Gentile, Walsh, & Bennett, 2006).

Research on the social and psychological effects of technology use, particularly Internet use, has also produced mixed results (Jackson, 2008). Some studies find that Internet use is socially and psychologically isolating, resulting in feelings of depression and loneliness (Adolescent Risk Communication Institute (ARCI), 2005; Amichai-Hamburger & Ben-Artzi, 2003). Other studies suggest that Internet use contributes to social and psychological well-being, primarily by extending social networks (Jackson et al., 2010; PEW, 2005a). Still other findings indicate no relationship between Internet use and children's social or psychological outcomes (see Jackson, 2008, for a review of this literature).

Willoughby (2008) reported the results of a longitudinal study of the effects of both Internet use and videogame playing on adolescent boys and girls in 9th and 10th grades, and again in 11th and 12th grades. She found that most girls (93.7%) and boys (94.7%) used the Internet at both time periods, but far more boys (80.3%) than girls (28.8%) played videogames online at both time periods. Linear and curvilinear relationships were found between parental relationships, friendship quality, academic orientation, and social and psychological well-being, measured in early high school, and the frequency of technology use in late high school. Moderate use of the Internet was associated with a more positive academic orientation than nonuse or high levels of use. High levels of videogame playing were associated with a weaker academic orientation.

The increased use of cell phones among children as well as adults is abundantly clear in every public venue that permits their use. As of 2007, the global cell phone market contained approximately 1.8 billion subscribers (Hamil & Larsenk, 2009) and is forecasted to reach 3 billion by the end of 2010, at which time nearly half of all human beings on the earth will have and use a cell phone (Merry, Domlija, Mackenzie, et al., 2005). Although voice calls currently account for about 80% of cell phone revenue, the short message service (SMS), or text messaging as it is commonly known, is becoming extremely popular, particularly among young users (Crabtree, Nathan, & Roberts, 2003; Haste, 2005; Reid & Reid, 2007). In fact text messaging is expected to dominate mobile messaging in both traffic volume and revenue by the end of this decade (Pritchard, 2004; Reid & Reid, 2007).

Conspicuously absent from the developmental and technology literatures is research on cell phone correlates and consequences for children. It is reasonable to anticipate a positive relationship between cell phone use and social outcomes, such as number of friends and degree of contact with friends as well as positive relationships with parents, to the extent that cell phone use facilitates staying in touch with parents. Several studies using adult participants found a positive relationship between cell phone use and social and psychological well-being (Hamil & Larsenk, 2009). On the other hand a negative relationship is also plausible to the extent that cell phone use interferes with ongoing face-to-face interaction or distracts the user from others physically present (Adolescent Risk Communication Institute (ARCI), 2005). Thus, there is no compelling evidence for predicting a relationship between cell phone use and children's social and psychological well-being (Reid & Reid, 2007).

Four socio-demographic characteristics known to be related to both academic performance and IT use were also included in this research. They are gender, race, age and income. First, males play videogames more than do females (Anderson et al., 2007). Thus, we would expect stronger evidence of videogame effects for males than for females. Second, females perform better in school than do males (K-12), especially on measures of classroom performance (e.g., grade point averages (GPA), course grades) rather than on standardized test scores (Hyde, Lindberg, Linn, Ellis, & Williams, 2008). Third, Caucasian American children perform better in school than do African American children, regardless of how performance is measured (e.g., school performance like GPAs; standardized test scores; Fisher, 2005). Fourth, age effects on school performance have been found, but depend on the measure of school performance, the year of assessment, and the length of the interval between assessments; Fifth, higher family income has been consistently associated with better academic performance and greater IT use by children grades K-12 (Jackson, 2008; National Center for Educational Statistics, 2007; PEW, 2005a).

There are additional reasons for considering age, gender, race and income in understanding the relationships between IT use and child outcomes such as BMI, academic performance, social self-esteem and overall self-esteem. All of these factors have been implicated in the digital divide, discussed earlier. Older people are less likely to use computers and the Internet than are younger people. Females are more likely than males to use the Internet for communication whereas males are more likely than females to use it to search for information, particularly technology and financial information. African Americans are less likely to use the Internet, even when access is not an issue, and they use it to search for different types of information than do Caucasian Americans. Income is one of the strongest predictors of Internet access and use; the higher the household income the greater the likelihood of both (Jackson, 2008; PEW, 2005a,b).

Thus, the four socio-demographic characteristics were expected to play a role in the relationships between the three types of IT use (Internet use, cell phone use and videogame playing) and the five child outcome measures (body mass index, body weight, academic performance, social self-esteem and overall self-esteem). We adopted an exploratory approach to these questions because findings to date are equivocal and there is no theoretical framework for generating predictions about these relationships.

2. Methods

2.1. Participants and procedures

The sample consisted of 482 children, 227 males (47.1%) and 255 females (52.9%). About one-third was African American

(32.7%) and about two-thirds were Caucasian American (67.3%). Average age was 12.19 years old (standard deviation (*SD* = 0.72), and median grade level was 7th grade (69.2%). Race differences in age indicated that African American children were somewhat older (12.29 years old) than were Caucasian American children (12.14; $F(1, 486) = 4.91$, $p < .05$). The overwhelming majority of children, 84%, reported having a computer at home.

Most participants ($n = 400$) were recruited from 20 middle schools geographically distributed throughout the southern lower peninsula of Michigan. Permissions were obtained from the school district superintendant who provided mailing lists for all 7th graders in that school district, along with a cover letter on school letterhead indicating that the school supported the project (The Children and Technology Project). Participants were told that they would earn $25 for completing each wave of surveys and that there would be six waves of surveys over a 3-year interval, one in the fall and one in the spring, and that one survey was to be completed by the parent and one by the middle school child. In addition, completing the surveys made participants eligible for a grand prize drawing of $500 to be held at the end of wave of surveys. Response rate to the first mailing was 55%.

One hundred additional families, all of whom were African American, were recruited from an after-school program in Detroit, Michigan, called YouthVilleDetroit. Center supervisors provided mailing lists along with a letter of support for the project from the center. One hundred of the 500 families contacted returned the first wave of surveys (20%). Comparisons between YouthVilleDetroit African Americans and those recruited from middle schools revealed no significant differences in socio-demographic characteristics.

Parent/Guardian Surveys and Child Surveys were mailed to the home and returned in a self-addressed, postage-paid envelope. A cover letter described the research as a 3-year longitudinal study of the impact of information technology use on children's development. As indicated earlier, participants were compensated $25 (USD) each time they returned a completed Parent//Guardian Survey and Child Survey, and each of these times they were entered into a lottery for a grand prize drawing of $500 (USD) as an additional incentive for completing the surveys and continuing participation in the project.

2.2. Measures

Children were asked how often they used the Internet, how often they played videogames, and how often they used a cell phone using the following scale for each measure: 1 = I do not use (play) at all, 2 = about once a month, 3 = a few times a month, 4 = a few times a week, 5 = everyday, for less than 1 h, 6 = everyday, for 1–3 h, 7 = everyday, for more than 3 h.

In the first section of the Child Survey participants provided socio-demographic information (e.g., race, gender, age) and information about academic performance. Specifically, children were asked "What grades do you usually get in school?" 1 = Mostly As, 2 = Mostly Bs, 3 = Mostly Cs, 4 = Mostly Ds, 5 = Mostly failing grades. This measure was rescored so that higher values indicated better grades. Next they were asked to indicate their grade point average (GPA), provided a blank space for it. The rationale for including both measures was that children in this age group do not necessarily know what a grade point average is and/or do not know their own grade point average. The lower response rate to the GPA question, evident in the results discussed later, supports the rationale for including both measures. Also as expected, the two measures were highly correlated. Children then indicated their weight (in lb) and height (in ft and in.).

Household income was assessed on the Parent/Guardian Survey. Parents/Guardians were asked to indicate their total net annual household income on the following scale: 1 = under $20,000; 2 = $20,000–49,999; 3 = $50,000–79,999; 4 = $80,000–99,999; 5 = $100,000–149,999; 6 = $150,000–200,000; 7 = over $200,000. Chi-square analyses were used to examine child gender and race differences in net annual household income. Both effects were significant (gender, $\chi^2(6) = 17.07$, $p < .01$; race, $\chi^2(6) = 41.93$, $p < .001$). The gender effect indicated that parents of males were more likely to be in the lowest income level (32.9%) than were parents of females (21.2%). The race effect indicated that African American parents (43.1%) were more likely to be in the lowest income level than were Caucasian American parents (18.7%). Only 5.2% of African American parents were in the three highest income levels compared to 13.9% of Caucasian American parents. There were no gender or race differences in parent education level.

Reading and mathematics skills were assessed using the Wide Range Achievement Test, Revision 3 (WRAT-3) released in 1993. Visual-spatial skills were assessed using the Wide Range Assessment of Visual Motor Abilities Section 2, Matching. The WRAT has been used for over 60 years and its reliability and validity are well established using diverse samples of thousands of participants. The three WRAT tests were administered face-to-face in small groups (1–5 children) at the children's middle schools, usually in the media center. Trained undergraduates administered the tests and hand-scored them immediately upon completion. Order of test type was randomized such that approximately one-third of the children completed the reading test first, one-third completed the mathematics test first, and one-third completed the visual–spatial test first. Order had no effect on the results and will not be discussed further. For all three tests higher scores indicate greater skills.

Harter's Self-Competence Scale (Harter, 1982) was used to measure social self-esteem. The format was modified from the original 4-box format to 1–3 rating scales where 1 = not/never true of me, 2 = somewhat/sometimes true of me and 3 = very/often true of me. The reason for the modification was that in our previous research using a similar sample the majority of children had difficulty understanding the 4-box format and frequently skipped this section of the survey or provided meaningless responses (e.g., checking all boxes to the extreme left). An example of the social self-esteem measures is "I have a lot of friends."

Rosenberg's self-esteem scale (Rosenberg, 1989) was used to measure overall self-esteem. Children rated themselves on 10 items using the same 1–3 scale used to measure social self-esteem. A sample item is "I have a lot of good qualities."

3. Results

Descriptive statistics for the three body size measures – body weight (lb), height (ft) and the body mass index (computed as follows: BMI = weight (lb)/height $(ft)^2$ are presented in Table 1 along with the five academic performance measures, three IT use measures and the socio-demographic characteristics of income and age.

Average child weight was 114 lb. Multivariate analysis of variance indicated that African American children weighed significantly more, $F(1, 423) = 34.55$, $p < .001$, and had higher BMIs, $F(1, 423) = 34.49$, $p < .001$, than did Caucasian American children. The two groups were only marginally different in height, favoring Caucasian Americans ($F(1, 432) = 46.14$, $p < .07$. There was no main effect of gender or interaction between gender and race on these body characteristic measures. To further explore the BMI and body weight differences between the races analysis of covariance was performed, using household income as the covariate. Even after controlling for household income, race was related to body weight and the BMI, $F(3, 406) = 4.19$, $p < .01$, $F(3, 406) = 10.49$, $p < .001$);

Table 1
Descriptive statistics for body mass index (BMI), body weight, height, academic performance, age, income and IT use.

	Mean	*SD*	*N*	Minimum	Maximum
Body mass index (BMI)	22.08	4.96	427	13	47
Body weight (lb)	114.27	28.63	455	60	260
Height (ft)	4.76	0.44	443	4	6
Visual-spatial skills	29.92	5.63	351	10	44
Reading skills	28.13	5.44	351	12	49
Mathematics skills	21.46	5.84	351	3	76
Grades in school	4.14	1.69	478	1	5
GPA	3.29	0.67	315	1	4
Age	12.19	0.72	485	11	16
Income	2.57	1.70	468	1	7
Internet use	3.97	1.43	473	1	7
Cell phone use	2.94	1.88	480	1	7
Videogame playing	3.85	1.75	479	1	7

Note: IT is information technology. *SD* is standard deviation. BMI = weight (lb)/height (ft)^2.
Sample sizes ranged from 315 to 481. For all academic performance measures, higher values indicate better performance. Income (parent provided) is net annual household income: 1 = under $20,000 (*n* = 125, 26.7%); 2 = $20,000–49,999 (133, 28.4%); 3 = $50,000–79,999 (116, 24.8%); 4 = $80,000–99,999 (42, 9%); 5 = $100,000–149,999 (40, 8.5%); 6 = $150,000–200,000 (10, 2.1%); 7 = over $200,000 (2, 0.4%). Internet use, cell phone use and videogame playing were measured on 1–7 scales: Internet use: 1 = I do not use (25, 5.2%); 2 = about once a month (42, 8.9%); 3 = a few times a month (99, 20.5%); 4 = a few times a week (161, 33.3%); 5 = every day, but for less than 1 h (61, 12.6%); 6 = every day for 1–3 h (70, 14.5%); 7 = every day, for more than 3 h (15, 3.1%). Cell phone use: 1 = I do not use (86, 38.8%); 2 = about once a month (41, 8.5%); 3 = a few times a month (50, 19.4%); 4 = a few times a week (87, 18.0%); 5 = every day, but for less than 1 h (71, 14.8%); 6 = every day for 1–3 h (27, 5.6%); 7 = every day, for more than 3 h (18, 13.8%). Videogame playing: 1 = I do not play (62, 12.8%); 2 = about once a month (42, 8.7%); 3 = a few times a month (90, 18.6%); 4 = a few times a week (139, 28.8%); 5 = every day, but for less than 1 h (42, 8.7%); 6 = every day for 1–3 h (65, 13.5%); 7 = every day, for more than 3 h (39, 8.1%).

African Americans still scored higher on these measures than did Caucasian Americans.

Descriptive statistics in Table 1 indicate that the standardized test scores were lower in mathematics than in visual–spatial skills or reading skills. Grades in school averaged around "mostly Bs," and GPAs among participants who provided this information were also around B. Videogame playing was by far the most frequent IT activity, followed by Internet use and then cell phone use. Average household income was about $50,000 (USD) with a median income between $20,000 and $49,999.

Table 2 contains the results of the hierarchical regression analyses to predict BMI, body weight, and cognitive development (i.e., the five academic performance measures), social self-esteem and overall self-esteem from the three IT use measures after controlling for the four socio-demographic characteristics (gender race, age, income) entered in Step 1. Three socio-demographic characteristics predicted both BMI and body weight. African Americans, older participants and lower income participants had higher BMIs and weighed more than did Caucasian Americans, younger participants and more affluent participants, respectively. Importantly, none of the IT use measures predicted BMI or body weight.

Similar analyses were used to predict academic performance (GPA, grades in school, reading, mathematics and visual–spatial skills), social self-esteem and overall self-esteem. Age, gender, race and household income predicted grades in school but none of the IT use measures contributed to this prediction. Younger children, males, African American children and children from lower income households had lower grades in school than did older children, females, Caucasian American children and children from higher income households, respectively. Similar results were obtained for the GPA measure of school performance, with the exception of age. Females, Caucasian American children and children from higher income households had higher GPAs than did males, African American children and children from lower income household, respectively.

Two characteristics predicted visual–spatial skills; being male and playing videogames. More videogame playing predicted better visual–spatial skills, and males had better visual–spatial skills than did females. Gender and IT use also predicted school performance but quite differently than they predicted visual–spatial skills. Females and children who used the Internet more had better reading skills than males and children who used the Internet less. Income again was a significant predictor, with higher household incomes predicting better reading skills.

Mathematics skills were not predicted by any of the IT use measures. Instead, it was household income and race that strongly predicted this skill. Children from more affluent homes and Caucasian American children performed better in mathematics than did children from poorer homes and African American children, respectively.

IT use was the only predictor of social self-esteem. Children who played videogames more had lower social self-esteem than did children who played videogames less. Children who used cell phones more had higher social self-esteem than did children who used cell phones less.

Similarly, overall self-esteem was predicted only by IT use. Children who used cell phones more had higher overall self-esteem than did children who used them less. In addition, children who used the Internet more and children from more affluent households had higher overall self-esteem than did children who used the Internet less and children from less affluent households, respectively.

Table 2
Hierarchical regression analyses to predict body mass index (BMI), body weight, academic performance, social self-esteem and overall self-esteem from technology use, controlling for gender, race, age and income.

	F_{change}	R^2	Gender	Race	Age	Income	Internet	Cell phone	Videogames
BMI	0.01	.33**	.06	−.23**	.11†	−.13*	.01	.03	−.03
Body weight	0.30	.09	.07	−.21**	.15**	−.11†	.00	.04	.03
Grades in school	1.24	.22**	.20**	.25**	−.12*	,24**	.06	−.04	−.06
GPA	2.14	.25**	.15*	.21**	−.05	.24**	.09	−.03	−.13†
Visual-spatial skills	7.34	.09	−.19**	.06	−.04	.10	.05	−.05	.27**
Reading skills	13.91	.14*	.14*	.05	.02	.15*	.32	−.04	.07
Math skills	0.88	.12*	−.03	.20**	−.06	.24**	.02	.05	−.08
Social self-esteem	4.48	.03	.04	−.02	−.02	.11*	.06	.15**	−.07
Overall self-esteem	1.31	.03	.03	−.05	−.02	.15*	.06	.01	−.09

Note: Values other than F_{change} and R^2 are standardized beta coefficients. df_{error} ranged from 332 to 450 with the exception of GPA, for which df_{error} was 299. For race, 1 is African American and 2 is Caucasian American. For sex, 1 is male and 2 is female.
† $p < .05$.
* $p < .01$.
** $p < .001$.

4. Discussion

This research addressed the question of whether IT use, defined as Internet use, cell phone use and videogame playing, is related to children's body mass index (BMI), body weight, academic performance, and social and overall self-esteem when the influence of socio-demographic characteristics on these outcomes is taken into account. Contrary to one survey finding and popular beliefs (Adams, 2006; PEW, 2005a), technology use was unrelated to BMI or body weight after controlling for the effects of socio-demographic characteristics on these measures. African American children, older children, and children from lower income households weighed more and had higher BMIs than did Caucasian American children, younger children, and children from higher income households, respectively. Thus, although children may be spending more time at the screen, screen time is not responsible for the obesity explosion in America's youth (cf. Adams, 2006).

On the other hand, technology use had some desirable effects on child outcomes. Children who used the Internet more scored higher on standardized tests of reading skills and higher overall self-esteem (Hunley, Evans, & Delgado-Hachey, 2005; Jackson et al., 2006; Judge, Puckett, & Bell, 2006). Children who used cell phones more had higher social self-esteem compared to children who used them less.

Videogame playing appears to be a double edged sword. It strongly contributed to children's visual–spatial skills (Green & Bavelier, 2007), skills believed to be the foundation for the later learning in science, technology, engineering and mathematics (STEM areas; Subrahmanyam et al., 2000). Yet there was no relationship between videogame playing and mathematics test scores and, consistent with previous research, a negative relationship between videogame playing and grades in school (Walsh et al., 2006). Videogame playing was also negatively related to social self-esteem, suggesting that videogame playing is best construed as a "solitary" activity but rather that a social one. It not only undermines academic performance but also the development of social skills needed to achieve a positive social self-concept.

Somewhat surprising was the absence of a relationship between visual–spatial skills and mathematics skills (Subrahmanyam et al., 2000). It may be that the contribution of visual–spatial skill to mathematics skills comes later in the educational process when more abstract principles of mathematics are considered. Children may need to develop more sophisticated cognitive networks before the contribution of visual–spatial skills to mathematics skills becomes evident.

Cell phone use was unimportant to academic performance in our sample of middle school children. Nor did it influence social self-esteem. However, it is important to note that cell phones were used infrequently (2.94 on a 7-point scale) by our sample of middle school children. Survey research indicates that cell phone use increases as children move from pre-teens to adolescents and young adults (Merry, Domlija & Mackenzie, 2005). The effects of cell phone use on teens and young adults may provide new insights into its consequences. Thus, one immediate challenge for future research is to examine cell phone use in teens and young adults using finely tuned measures that address the motivation for and consequences of cell phone use in these age groups.

There is no question that the ever increasing presence of IT is already changing the way we go about everyday life. More research is needed to investigate the causes and consequences of IT use as the evolution from the real world to the virtual world accelerates. Individual differences in the effects of using IT will need to be incorporated into a model of the antecedents and consequences of IT use. As Sara Kiesler, a leading authority in the field of human–computer interaction, once said "studying the Internet is like trying to hit a moving target" (Kiesler, 1997). Nevertheless, the potential for the Internet and other information technologies to produce positive or negative outcomes for children and adults encourages more research on if, when and how it results in significant effects.

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