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The impact of computer use on children's and adolescents' development

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Abstract

In recent years, electronic games, home computers, and the Internet have assumed an important place in our lives. This paper presents a review of the research on the impact of home computer use on the development of children and adolescents. Time use data are presented along with a discussion of factors such as age, gender, and ethnicity, which impact the time spent on computers as well as the activities engaged in. Research on the impact of computer use on cognitive skill and academic development, social development and relationships, and perceptions of reality and violent behavior is reviewed. The special role of the Internet in the lives of adolescents is brought out using data from the HomeNet study. The paper concludes with recommendations for future study in order to better understand the growing impact of computers on our youth.

Keywords: Children; Computers; Internet

I really want to move to Antarctica — I'd want my cat and Internet access and I'd be happy.
–16 year old HomeNet participant, 1995.

1. Introduction

The time is ripe to assess the impact of home computer use on child and adolescent development. Over the past few years, a growing number of U.S. households have added

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electronic games, home computers, and the Internet to other technologies — the telephone, radio, TV, and stereo system — that consume children's time. Furthermore, the Annenberg Public Policy Center has reported that among U.S. households with children aged 8 to 17, 60% had home computers, and children in 61% of households with computers had access to Internet services; in other words, 36.6% of all households with children had Internet services, more than twice the percentage of that in 1996 (Turow, 1999). When a national sample of children and teenagers was asked to choose which medium to bring with them to a desert isle, more children from 8 to 18 chose a computer with Internet access than any other medium (Rideout, Foehr, Roberts, & Brodie, 1999).

Surveys of parents suggest that they buy home computers and subscribe to Internet access to provide educational opportunities for their children, and to prepare them for the "information-age" (Turow, 1999). Although they are increasingly concerned about the influence of the Web on their children and express disappointment over their children using the computer for activities such as playing games and browsing the Internet to download lyrics of popular songs and pictures of rock stars, they generally consider time wasted on the computer preferable to time wasted on TV, and even consider children without computers to be at a disadvantage (Kraut, Scherlis, Mukhopadhyay, Manning, & Kiesler, 1996).

While the research on whether computers are a positive influence in children's lives is mostly sketchy and ambiguous, some initial findings are beginning to emerge. This article starts with a discussion of the time spent by children on computers and the impact of such computer use on other activities such as television viewing. Then we review the available research on the effects of computer use on children's cognitive and academic skill development, social development and relationships, as well as perceptions of reality and violent behavior.

We present data from the HomeNet project, which was a field trial by researchers at Carnegie Mellon University, who studied household use of the Internet between 1995 and 1998 (Kraut et al., 1996, 1998). By reducing economic and technological barriers to the use of computers and the Internet from home, this study examined how a diverse sample of families would use the technology when provided the opportunity for the first time. Starting in 1995, the study provided 93 families in the Pittsburgh area with home computers and connections to the Internet, then collected data about them for 2 years through in-home interviews, periodic questionnaires, and automatically whenever members of these families went online. The goal was to provide a rich picture of the factors encouraging or discouraging use of the Internet, the manner the Internet was used, and the impact of such use over time. The sample included 208 adults and 110 children and teenagers (ranging in age from 10–19 years), hereafter referred to inclusively as teenagers. Here we present data on teenagers' use of the Internet.

In examining the impact of computer use, we have primarily looked at two popular applications of the computer, including games and the Internet. Because games played on a computer are similar to games played on other platforms (e.g., stand-alone game sets such as Nintendo and Sega or hand-held games, such as Gameboy), we use the term "computer games" inclusively to refer to all kinds of interactive games regardless of platform. Even the distinction between games and the Internet is getting blurry as interactive games can be played on the Internet. With the expected convergence of different media in the near future, assessing the impact of computer technology on children will only get more complex and challenging.

2. Time spent on computers

Understanding the impact of computer use requires good estimates of both the time children spend on computers, and the time taken away from other activities. Time use data on children's use of computers has been gathered mostly through self-reports and reports by parents. Despite their overall usefulness, particularly for sampling a large number of people, self-report data are beset by problems of accuracy and reliability stemming from memory limitations and inaccurate estimations on the part of respondents; these problems are further accentuated when studying children. In contrast to the self-report methods, more reliable methods include the Experience Sampling Method, in which participants were paged and asked to record their activity when paged (Kubey & Larson, 1990) and computer-based means of tracking computer use, where the software records the person using the PC, the applications used, and web sites visited. However, these methods are also more expensive and time-consuming to carry out, and raise concerns regarding privacy.

Parents in the Annenberg survey report that children (between 2 and 17 years) in homes with computers spend approximately 1 h and 37 min a day on computers, including video games (Stanger & Gridina, 1999). In the HomeNet study, machine records of weekly usage averaged across approximately 2 years of data between 1995 and 1998 show that among the teens who had access to the Internet at home, usage averaged about 3 h/week during weeks when they used it, and over 10% used it more than 16 h/week. Teens in the study were much heavier users of the Internet and all its services than were their parents.

The teens used the Internet for schoolwork, for communication with both local and distant friends, and to have fun, especially by finding information related to their interests and hobbies. As seen in Fig. 1, teenagers were more likely than adults to report using the Internet for social purposes. For example, teens were more likely to report using the Internet to communicate with friends, meet new people, get personal help, and join groups.[1] They were also more likely to use the Internet to listen to music, play games, and download software. In contrast, adults were more likely to use the Internet for instrumental purposes such as getting product information, purchasing products, or supporting their employment. Teens also used the Internet for instrumental purposes, such as doing schoolwork and finding educational material.

2.1. Variation in use by age, gender, ethnicity, and social class

The time that a particular child spends on a computer and their activities on the computer may depend on age, gender, ethnicity, and social class. In a national survey of children and teenagers from 2 to 18, the percentage of children who reported (or were reported by their parents) to have used a computer out of school the day before rose with age: from 26% in the 2 to 7 age range, to 44% among the 14- to 18-year-olds (Roberts, Foehr, Rideout, & Brodie, 1999). Interestingly, while more boys than girls reported using (or were reported to use) computers *in school* the day before, there were no gender differences in percentages using a computer *out of school*. However, the percentages of children using a computer the day

[1] These comparisons control for the greater number of hours per week that teens are online compared to adults.

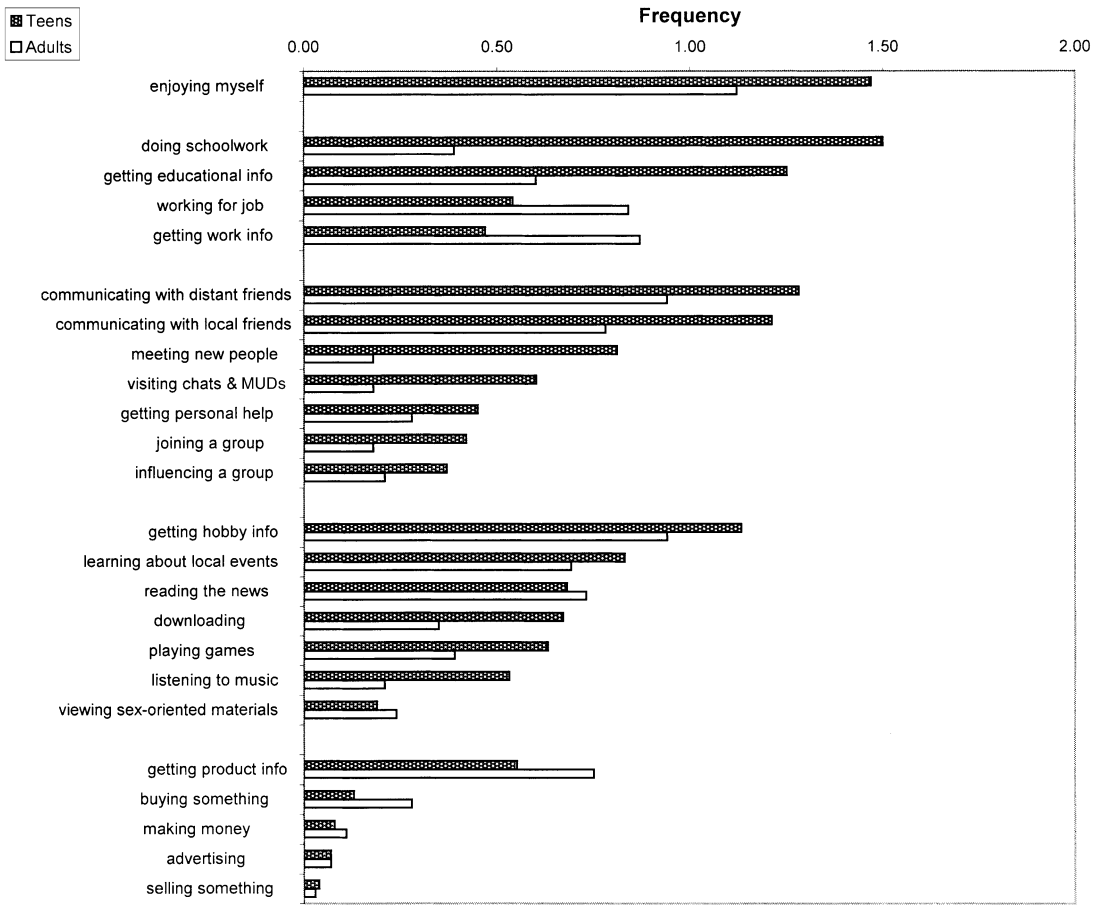

Fig. 1. Teens' and adults' self-reported purposes for using the Internet between 1995 and 1998.

before were significantly higher for White than for Black or Hispanic children. The percentages of children with reported computer use the day before also rose significantly as neighborhood income and parental education increased. Living in a single-family or two-parent household was not a significant factor.

The core audience for computer game systems, such as Nintendo or Sega, has always been boys between the ages of 8 and 14. Boys are 5 times more likely than girls to own a Genesis or Super Nintendo computer game system (Elmer-Dewitt, 1993). Boys have always and continue to spend more time playing computer games (Funk, 1993; Harrell, Gansky, Bradley, & McMurray, 1997; Roberts et al., 1999). The gender disparity in the amount of time spent playing computer games is greater for 14–18-year-olds than for 8–13-year-olds.

With regard to the Internet, boys in the HomeNet study were substantially heavier users than girls even though girls had equal access to the technology (see Table 1). For example, across the 2-year period, on average the teen boys were active on the Internet for 58% of the weeks, compared to 44% for the teen girls. Boys outstripped girls in nearly every type of

Table 1
Metrics of Internet use by generation and gender

Weekly usage measure	Teenage boys	Teenage girls	Adult men	Adult women
Percent active per week	58	44	37	35
Number of Internet sessions	5.30	2.93	1.41	1.45
Hours online	4.00	1.51	0.82	0.57
Session length in minutes	37.98	30.83	33.54	28.13
Hours on e-mail	1.70	0.84	0.25	0.22
Percent online time using e-mail	43	56		
Unique websites visited	11.17	3.89	4.34	1.93
Mail messages sent	3.79	2.51	0.32	0.49
Mail messages received	3.40	1.95	0.22	0.28
Newsgroup messages sent	0.36	0.14	0.01	0.00
Newsgroup messages read	4.55	2.59	0.39	0.17
Listserv subscribed to	0.20	0.28	0.08	0.06
Listserv messages sent	0.03	0.01	0.00	0.00
Percent using a MUD or IRC	38	25	0	0
N (windsorized)	31	44	67	88
N (All)	43	67	92	116

usage, from hours on electronic mail, to web sites visited, to newsgroup messages sent and received. Only in subscriptions to listservs did girls slightly edge out the boys.

Other evidence suggests a more even gender distribution in nongame uses of the computer. For instance, a recent national survey of teenagers between 13 and 17 years, conducted by the Gallup Organization in conjunction with CNN/USA Today and the National Science Foundation, found that although boys were more likely to report playing video games on a daily basis, the same number of boys and girls reported using a computer on a daily basis (Gallup Organization, 1997). Furthermore, both boys and girls reported equal levels of computer usage and expressed equal levels of confidence in their computer skills.[2] Similarly, Roberts et al. (1999) found parity between the two genders for reported use of the computer for schoolwork; indeed, there is a consistent (albeit statistically nonsignificant) trend for older and younger girls to use the computer a bit more for schoolwork than boys.

Indeed, the Internet provides certain activities that strongly contribute to a more equal gender balance in computer use. Again, Roberts et al.'s (1999) data suggest that younger girls and boys (between 8 and 13) use computers similarly *except* in levels of gaming. When in-school and out-of-school use data are aggregated, there are no gender differences in this age group in the use of the computer for chatting, visiting web sites, using e-mail, doing schoolwork, or using the computer to do a job. The picture is similar for the 14- to 18-year-olds, except that older boys visit significantly more web sites than do older girls.

[2] Overall, boys reported slightly more time on computers in the past week compared to girls (4.7 vs. 4.1 h). This difference was due to a small number of boys who reported using the computer for more than 20 h/week.

2.2. Significance of the gender gap in computer game playing

Despite the trends in other aspects of computer use, computer games continue to be more popular among boys. It is hard to know the extent to which this is cause or effect of game design and marketing. For example, in an address at CILT99, the CEO of Lucas Learning admitted that their products are designed exclusively for boys (Frank Evers, 1999, personal communication). Because computer game playing might be a precursor to computer literacy, and the belief that computer literacy will be increasingly important for success in society, the "gender imbalance" in computer game playing has been a topic of much recent discussion.

Efforts of the software industry to create girl games with nonviolent themes and female protagonists have largely been unsuccessful with the exception of *Barbie Fashion Designer*. Based on an examination of research on games that girls and boys design and on research on their play styles, and television and reading preferences, Subrahmanyam and Greenfield (1998) proposed that the Fashion Designer was successful because it contained features that fit in with girls' play and their tastes in reading and literature. In contrast to boys' pretend play, which tends to be based on fantasy, girls' pretend play tends to be based more on reality, involving themes with realistic–familiar characters (Tizard, Philips, & Plewis, 1976). Thus, by helping girls create outfits for Barbie, the computer became a creative tool that fits well with girls' preferences for more reality-based pretend play. The success of the Fashion Designer along with the growing popularity of the Internet among girls suggests that they are not turned off by computer technology. Instead, they just need applications that appeal to their interests.

2.3. Displacement of other activities

The little research on whether time on computers displaces other activities such as television viewing, sports, and social activities has mainly focused on the relation between computer use and television viewing. According to the 1999 Annenberg survey of parents regarding Media in the Home (Stanger & Gridina, 1999), children still watch more television (2.46 h/day) than they use computers (0.97 h/day) and video games (0.65 h/day). Although comparisons of media use in homes with and without computers were not made, data suggested that the majority of the homes (68.3%) had both a television and a computer. The survey by Roberts et al. (1999), based on aggregating in-school and out-of-school media uses, confirms the pattern of greater time spent watching television than using computers. The preference for the computer mentioned earlier may therefore be more a portent of things to come, rather than a reflection of current usage.

Nonetheless, when children in homes with and without computers have been compared, it is reported that children who use computers may watch less television than nonusers (Stanger, 1998; Suzuki, Hashimoto, & Ishii, 1997). For instance, the 1998 National Survey of Parents and Children on "Television in the Home" by the Annenberg Public Policy Center (Stanger, 1998) found that children in households with computers watched television an average of 2.3 h per day compared to the children in homes without computers, who watched an average

of 2.9 h per day.[3] Other studies suggest that computer use does not reduce much television viewing. For example, a study by Nielsen Media Research (1998) found little change in household television viewing after the household gained Internet access. Instead, many Americans report a preference for simultaneous television and computer use. For example, Media Metrix (1999) found that among households with a home computer, 49% used their computer and watched television simultaneously. Because of the growing trend to link the content of various media, computer use may even lead to an increase in television viewing (Coffey & Stipp, 1997). We need more research on the impact of computer use on television viewing as well as on other activities.

3. Computer games and the development of cognitive skills

Many computer applications, especially computer games, have design features that shift the balance of required information-processing, from verbal to visual. The very popular action games, which are spatial, iconic, and dynamic, have things going on at different locations. The suite of skills children develop by playing such games can provide them with the training wheels for computer literacy, and can help prepare them for science and technology, where more and more activity depends on manipulating images on a screen. We now summarize the experimental evidence for the role of computer games in developing cognitive skills. Although the term "cognitive skills" encompasses a broad array of skills, most of the research has focused on components of visual intelligence, such as spatial skills and iconic representation. These skills are crucial to most video and computer games as well as many computer applications.

Computer hardware and software evolve so quickly that most of the published research on the cognitive impact of game playing has been done with the older generation of arcade games and game systems. Despite advances in interactive technology and the capabilities of current computer games, the fundamental nature of computer games has remained unchanged. The current generation of games continue to include features that emphasize spatial and dynamic imagery, iconic representation, and the need for dividing attention across different locations on the screen. Therefore, the nature of the effects of computer game playing that stem from structural features of the medium would likely remain the same — although the strength of the effects on visual intelligence could change with increasing sophistication of the graphics.

3.1. Spatial representation

Spatial representation is best thought of as a domain of skills rather than a single ability (Pellegrino & Kail, 1982) and include skills such as mental rotation, spatial visualization, and the ability to deal with two-dimensional images of a hypothetical two- or three-dimensional

[3] Controlling for parental income and education yielded a weaker, but significant relationship such that computer ownership was related to less television viewing, suggesting that having a home computer does influence the amount of television watched by children.

space. Skills in utilizing two-dimensional representations of hypothetical space are central to a variety of computer applications, including programming and computer and video games. As these skills may be important to being able to "read" and utilize the information on computer screens, repeated practice on these applications (particularly computer and video games) may enhance selected spatial skills.

Overall, the research suggests that spatial skills are related to video game playing (Greenfield, 1996; Okagaki & Frensch, 1994; Subrahmanyam and Greenfield, 1996).[4] In a study of 10-1/2- to 11-1/2-year-olds, Subrahmanyam and Greenfield (1996) found that practice on a computer game (Marble Madness) reliably improved spatial performance (e.g., anticipating targets, extrapolating spatial paths) compared to practice on a computerized word game called Conjecture. Marble Madness involved guiding a marble along a 3-dimensional grid using a joystick, skills that are key components of visual spatial tasks.

Not every video or computer game will help develop any or all spatial skills. Computer game playing will only enhance a particular spatial skill if the game utilizes that skill. In principle, skills can only be enhanced by game playing if these skills have reached a certain level of maturation. However, to our knowledge, only one study comparing the cognitive impact of games on children of different ages has been carried out and they found no changes in effects between fifth, seventh, and ninth grade students (McClurg & Chaille, 1987). All three age groups showed improved mental rotation, a spatial skill, as a result of playing two computer games.

3.2. Iconic skills

Another skill embodied in computer games is iconic or analog representation — or the ability to read images, such as pictures and diagrams. Indeed images are frequently more important than words in many computer games. In a cross-cultural study carried out in Rome and Los Angeles, Greenfield, Camaioni et al. (1996) found that playing a computer game shifted representational styles from verbal to iconic. In the study, undergraduate students played the game *Concentration* either on a computer or on a board. Those who had played the game on the computer used more diagrams in their descriptions of an animated computer simulation, whereas those who played the game on a board offered more verbal descriptions. Both iconic and spatial representations are crucial to scientific and technical thinking; these modes of representation enter into the utilization of all kinds of computer applications.

3.3. Visual attention

Another skill incorporated in playing computer and video games is divided visual attention, the skill of keeping track of a lot of different things at the same time. Greenfield, deWinstanley, Kilpatrick, and Kaye (1996) explored the effect of video game expertise on

[4] For an in depth discussion of video game effects, please see Greenfield, P. M. & Cocking, R. R. (Eds.) (1996). *Interacting with video*. Norwood, NJ: Ablex. (Reprinted from *Journal of Applied Developmental Psychology, 15* (1), 1994) (reprint; Special Issue: Effects of interactive entertainment technologies on development).

strategies for divided visual attention among college students. Divided attention was measured by measuring participants' response time to two events of varying probabilities at two locations on a computer screen. Participants who were expert computer game players had faster response times than novices. Playing an action game also improved strategies for keeping track of events at multiple locations. Overall the study showed that more skilled video game players had better developed attentional skills than less skilled players.

Although this research focused on college students, computer and video game playing could have similar effects on children and help develop the skills for occupations that require expertise in divided visual attention (e.g., instrument flying, military activities, and air traffic control). However, there is no research that actually documents a link between video game playing, attentional skills, and success in academic performance or specific occupations. Furthermore, much of the research on the impact of computer games on cognitive skills has only measured the effects of game playing immediately after practice, and does not address questions about the cumulative impact of interactive games on cognition.

Nonetheless, selective increases in nonverbal or performance IQ (Flynn, 1994) scores during the last century seem to relate, in part, to the proliferation of imagery and electronic technologies in the environment that has occurred in this period of time (Greenfield, 1998). Many computer games develop the same skills that are tested in nonverbal IQ tests such as the Wechsler and the Stanford–Binet. Okagaki and Frensch (1996) found improvements in the skill of spatial visualization among males as a result of playing the video game Tetris. The skill of spatial visualization developed by the video game Tetris and the Object Assembly subtests of the Wechsler intelligence tests for children and adults are similar. Future experimental research should be designed to test whether there is a direct, causal connection between repeated computer game playing and rise in nonverbal IQ performance.

4. Home computer use and academic performance

In this section we examine the impact of computer use on children's performance in academic areas such as math, science, language arts, and writing. Teenagers in the HomeNet sample reported that the most common educational use of computers was simple word processing for school assignments. In addition, students used links to the web to find information for various class reports. For example, one student found information on Pittsburgh's role in the underground railroad for a Black history month assignment. While students in clubs (e.g., the school newspaper) sometimes used Internet communication to coordinate meetings or to distribute shared materials (e.g., assignments or stories), this was far less common than using the computer for writing, printing, and research. Stand-alone educational software programs aimed at fostering children's creative expression, memory, and spatial awareness were used even less frequently.

Surveys indicate that parents generally believe computers to be an educational resource. According to Turow (1999), 70% of the parents in households with computers said that children can discover fascinating and useful things on the Internet and 60% said that children without access to the Internet were at a disadvantage compared to their peers who had Internet

access. Parents in the HomeNet study said they appreciated the new educational resources that the Internet provided their children, but at the same time worried about erosion of standards (e.g., reading short articles online rather than books) and about the credibility of online information. One mother marveled at the wealth of information that her middle-school aged son was able to discover, but also worried that the sheer abundance of the information was devaluing research and critical thought. Others worried that the information was biased and unbalanced.

Several studies provide preliminary evidence that computer use is positively correlated with academic achievement, but fails to clarify this relationship. Sparks (1986) reported significant differences between the computer literacy scores of high school students who had educational software at home and those who did not. She further determined that presence of video games and word processing software on a student's home computer were not significant factors in computer literacy scores. Computer use by a male adult in the home was positively correlated with male and female students' computer literacy scores.

Rocheleau (1995) analyzed survey responses from 7th to 12th graders. Students with home computers reported higher overall grades and better grades in math and English than did students without home computers. Given that a home computer is correlated with parent education and SES levels, it is noteworthy that when only children with home computers were examined, heavier users reported better overall grades, better grades in Math and English, and did better on a test of scientific knowledge. Another study that compared the out-of-school activities of 5- to 12-year-old students deemed generally academically "successful" and "unsuccessful" found that unsuccessful boys spent more time watching television and playing video games than their academically high-achieving peers (Madden, Bruekman, & Littlejohn, 1997).

One program of note is that of Cole (1996), who has been experimenting with the use of electronic communication and games with children in both classroom and after-school settings for nearly 15 years. The after-school programs are called "The Fifth Dimension," and include the typical uses of home computers, such as educational software, computer games, searching the Internet, and multiuser dungeons (MUD) activities. Subject matter includes social development, geography, communications, reading, writing, math, social studies, health, technology, language, and problem solving (Blanton, Moorman, Hayes, & Warner, 1997). The electronic games and Internet activities are based in a total social and cognitive environment that includes a ladder of challenges. Program effects include advances in reading and mathematics, computer knowledge, following directions, grammar and school achievement tests (Summary of cognitive evaluation studies, n.d.). Although Cole's programs are set in after-school settings, his results indicate that well designed games and Internet activities for home use can have a lasting impact on children's academic performance.

The emergence of the Internet and resulting educational innovations has spawned research focused on the educational impact of projects that integrated home and school computer use through school-driven, technology-enriched curricula (McGarvey, 1986; McMahon & Duffy, 1993). Initially, qualitative studies praised programs like the Classroom of Tomorrow and the Buddy System Project, citing descriptive evidence that home-school computer curricula increased parent–teacher interaction, bolstered students' self-esteem and motivation for learning, and greatly facilitated learning for students with ADHD and other learning

disabilities. However, later follow-ups, attempting to quantify these findings, have found no significant relationship between academic achievement and participation in such projects (Miller & McInerney, 1995). Given that the evidence shows mild positive effects of home computer use on academic performance, we need research to understand fully these effects.

5. Effects on social development and relationships

In the following sections, we examine the various ways in which computer use impacts social development, from the impact of game playing on the development of friendships and family relationships to the impact of the Internet on relationships and psychological well-being.

5.1. Impact on friendships and family relationships

Interaction with peers has an impact on children's interpersonal skills, their poise, and social competence (Dworetzky, 1996). By age 7, children tend to spend as much time with peers as they do with adults (Griffiths, 1997). Because of the solitary nature of most computer activities, concerns have been raised that children might form "electronic friendships" with the machine, instead of friendships with their peers, hindering the development of interpersonal skills. The fact that more than one-fifth of all children between 8 and 18 report having a computer in their bedroom (Roberts et al., 1999) indicates that the computer may often be used in solitude; indeed, Roberts et al. found that, among junior high and high school students, over 60% of all computer time is spent alone. Of course, some of this time is spent in fostering electronic relationships through e-mail.

Few studies have examined the effect of children's time on computers on their social skills and friendships. The extant research suggests that frequent game players actually meet friends outside school more often than less frequent players (Colwell, Grady, & Rhaiti, 1995). In addition, no differences have been found in the social interactions (Phillips, Rolls, Rouse, & Griffiths, 1995) of computer game players vs. nonplayers. In other words, game playing did not impact the social networks and characteristics of interactions among children. Less is known, however, about the long-term effects of excessive computer use among the 7% to 9% of children who play computer games for 30 h/week or more (Griffiths & Hunt, 1995).

The impact of computer use on family dynamics is also of interest. In an early study conducted during the 1980s, 20 families with new home computer game sets were interviewed for their opinions about the benefits and dangers of playing games (Mitchell, 1985). The results suggested that computer games did have an impact on family interaction — they brought the members together for shared play and interaction. An important question is whether this is still true now that computers and game sets have multiplied in numbers, have become more routinized in the home, and are usually located in personal spaces, such as bedrooms. Current research on this topic is needed.

Children and teens are often more sophisticated than their parents in their knowledge of and ability to navigate on computers. For instance, 62% of teenagers between ages 13 and 17 said that they could operate electronic equipment or computer software without any help, and 54% reported that they or a sibling were responsible for programming the VCR in their family

(U.S. Teens and Technology, 1997). In the HomeNet study, teenagers were more likely to help their parents with computers than parents were to help their children, with boys disproportionately helping their fathers and girls disproportionately helping their mothers (Kiesler, Lundmark, Zdaniuk, Kraut, Scherlis, & Mukhopadhyay, 1998). Further research is needed to assess the impact that such role reversals may have on family dynamics and interactions.

5.2. Use of computers for communication

Research indicates that in households with access to the Internet, use of the computer to communicate with others (via e-mail, chat rooms, etc.) is an increasingly popular activity, especially among teens. In May 1999, teens said that after doing homework, use of e-mail and participating in chat rooms were their most frequent activities on the Internet (Turow, 1999)

Similarly, teenagers in the HomeNet sample reported that keeping up with both local and distant friends was a very important use of the Internet for them (see Fig. 1). Interpersonal communications via electronic mail (e-mail) were more important to them than information acquisition via the web. Many of the keep-in-touch communications described by teens involved small talk–gossip and news of the day, with a here-and-now flavor. These communications exist for the pleasure they bring, rather than for their instrumental benefits. A teenage girl, who was keeping up with a pen pal she met online, described the small-talk nature of her conversations with him as "stupid stuff — what's happening in his life; what's happening in my life."

The popularity of using the Internet for interpersonal communication also sustained interest longer than other types of activities — that is, use of e-mail dropped less over the first 2 years online than did other uses of the Internet, such as linking to web sites. Teens and adults who used e-mail more heavily than they used the web were more likely to still be using the Internet after their first year. These observations suggest that e-mail is the primary Internet application that keeps both teens and adults coming back to the computer.

The limited data available also indicate that use of computers for communication is particularly strong among girls, helping to equalize the gender imbalance in computer use. For example, a questionnaire posted on the Internet in February 1997 by the creators of Plug In!, an adolescent forum on AOL, elicited responses from more girls than boys — of the 290 respondents (age range: 10 to 19 years, mean age: 15 years), 184 (or 63.4%) were girls, whereas 106 (or 36.5%) were boys. Subrahmanyam and Greenfield (1998) suggest that the attraction of girls to the communication functions of computers, as on this AOL site, may stem from the fact that communication fits better with the interests of girls than of boys. This preference for communication uses among girls was confirmed by the HomeNet study. Table 1 shows that although girls used the Internet less than boys, they spent more of their time online sending and receiving e-mail (56% for girls vs. 43% for boys).

Although it is clear that the Internet is frequently used for social purposes by teens, it is not immediately obvious whether these social uses add to or diminish teenagers' stock of social resources. The influence depends in part on whether the social uses of the Internet supplement or substitute for other sources of social contact that teens have. Some research analyses focusing on the Internet have demonstrated that use of the computer is associated with declines in social involvement and the psychological well-being that goes with social

involvement. For example, analyses of longitudinal data from the HomeNet study (Kraut et al., 1998) found that as participants spent more time online, they experienced greater declines in social and psychological well-being. In particular, greater use of the Internet was associated with small, but statistically significant, declines in social involvement as measured by communication within the family and the size of people's social networks, and with increases in loneliness, the psychological state associated with social involvement. Greater use of the Internet was also associated with increases in depression.[5] Among teenagers, greater use of the Internet was also associated with declines in social support.

There are at least two plausible and theoretically interesting mechanisms for the initial effects of declining social involvement and increasing loneliness, but there is little evidence from current research to establish which, if either, is correct. The first is that the time that people devote to using the Internet substitutes for time that they had previously spent engaged in social activities. This interpretation is consistent with the finding that people who use the Internet more spend less time talking to other household members, but is ambiguous to the extent that time on the Internet is spent communicating with others. This leads to a second explanation, which is that by using the Internet people are substituting poorer quality social relationships for better ones, that is, substituting weak ties for strong ones (Krackhardt, 1994).

5.2.1. "Strong tie" vs. "weak tie" relationships

Among the HomeNet participants, all of whom were Internet neophytes, the majority of online social relationships had their roots outside of the Internet and predated their access to the Internet. Thus, online communications were used primarily to keep up with close friends and close family members, what sociologists term "strong ties" (Granovetter, 1973). In addition, use of the computer for e-mail in these online relationships supplemented the telephone and face-to-face visits, but rarely replaced these older communication modes. For example, teens in the study told researchers they would hurry home from school to have e-mail conversations with the friends they had just left. After going off to college, students frequently used e-mail to correspond with their parents and high school friends.

While most communications involved "strong tie" relationships, new online relationships in the HomeNet sample were also created, representing relatively weak ties with strangers, acquaintances, or nonintimate kin. Research shows that these types of social contacts typically provide less consequential social support than more intimate ties (Wellman et al., 1996). The creation of such "weak tie" relationships reflect the fact that, in contrast to earlier telecommunications technologies for interpersonal communication, the Internet contains several popular communications applications that encourage strangers to communicate with each other, including Usenet news groups, listservs, MUDs, and chat rooms. The important similarity among these services is that they provide public spaces on the Internet where people gather, meet each other, communicate or observe others communicating, and occasionally form new relationships.

[5] Results show that social involvement and psychological well-being measured before respondents got their Internet connections did not predict how much they subsequently used the Internet. Therefore, these findings imply that the direction of causation is more likely to run from use of the Internet to declines in social involvement and psychological well-being, rather than the reverse.

In the HomeNet study, those who participated more in Usenet news groups, MUDs, and chat rooms were more likely to report using the Internet for meeting new people. Adults made more of their new online relationships through Usenet news groups and listservs, meeting people as a side-benefit of more nonsocial motivations to get information about hobbies or work. In contrast, teens made more of their new online relationships through MUDs and chat rooms, which they said they frequented for the express purpose of interacting with strangers.

Compared with adults, teenagers were found to be heavier users of MUDs and chat rooms, even after accounting for teens' greater use of the Internet overall, and were more likely to report using the Internet to meet new people. Because adolescence in the United States is typically characterized by experimentation with social relationships and an expansion of peer groups (Brown, Mounts, Lamborn, & Steinberg, 1993), teens' use of the Internet for this social experimentation appears consistent with their developmental needs.

Research on the relative strength of online relationships is unclear. The HomeNet study suggested that when online relationships exist, they are typically "weaker" than comparable relationships people report having off-line. For example, participants in the HomeNet study reported feeling less close to the person with whom they had the most frequent electronic communication than to the person with whom they had the most frequent face-to-face communication. Similarly, participants in a study by Parks and Roberts reported that they spend less time "together," either in person or by computer, with someone they meet online, than they did in their "real world" relationships, and they described their online relationships as existing for a shorter time (Parks & Roberts, 1997). Moreover, compared with their real world relationships, participants reported that the online relationships had less breadth and predicted that they would be less likely to endure. In the HomeNet study, the online relationships created by the participants typically remained in the electronic domain. Less frequently did relationships that started online result in face-to-face meetings, but there were some exceptions. One teenage boy in the sample dated one of the girls he met in an AOL chat room and took her to his senior prom, although he did not keep up contact with her afterwards.

Data from other studies reveal different trends. For example, McKenna and Bargh (1998) report that socially anxious and lonely people find more honest and intimate human relationships with others on the Internet than in the real world, and they tend to successfully integrate these online relationships into their offline lives. Rather than examine newcomers to the Internet as in the HomeNet study, McKenna and Bargh surveyed experienced Internet users who had chosen to engage in online communications. They surveyed people who had posted a message to 1 of 20 randomly selected Usenet newsgroups. Of the 333 female and 234 male respondents, who ranged in age from 13 to 70 years (mean = 32 years), and who had been on the Internet from 1 to 443 months (mean length of experience = 34 months), 63% had spoken to someone they met via the Internet on the telephone, 56% had exchanged pictures of themselves, 54% had written a letter through the post, and 54% had met with their Internet friend in a face-to-face situation. Furthermore, those who locate their "real selves" online vs. offline, that is, people who "share aspects of themselves with internet friends that they cannot, or do not, express with people in their daily non-'Net lives' are more likely to form strong

attachments with online acquaintances, and to integrate these people into their offline lives'' (McKenna, 1999, p. 1).

5.2.2. Changes in effects over time

Among the participants in the HomeNet study, use of the Internet over time did not have the same effects that it had initially. That is, during respondents' first year or two, the more hours they were using the Internet per week, the more their psychological and social well-being declined. During the next 12 months, further use of the Internet was associated with smaller declines in psychological and social well-being or even improvements. For example, initially, a greater amount of time spent online was associated with increases in loneliness, but subsequently was associated with declines in loneliness.

There are three competing explanations for these diminished effects or even reversals. First, as with many learning processes, early exposure may have larger consequences than later ones (Argote & Epple, 1990). Because the initial exposure is completely novel, it generates greater changes in behavior on the part of users than does later exposure. Second, people may be using the Internet more wisely later in their experience than they did early on. For example, the novelty of Internet access may have tempted users to spend more time online than was good for them to, to frequent web sites that did not really interest them, and to communicate with weak ties who didn't really engage them. As the novelty wore off, people may use the Internet in ways that are better aligned to their true interests.

Third, over time the Internet as a technology and set of resources is also changing. For example, during 1995 and 1996, when respondents were using the Internet for the first time, MUDs and chat rooms were the two most popular services that could be used to communicate with other people in real time. Because these services connected anyone who logged into a common site, they increased the likelihood that users would communicate with strangers. In 1997 and 1998, two new AOL real time communication services gained in popularity: *Instant Messenger* and *ICQ*. Both of these services allow users to identify a list of people and to be notified when they go online. These ''buddy lists'' increase the likelihood that people will communicate with others they already know. In addition, the growth in the online population over the past few years means that the close friends and relatives of the HomeNet participants were more likely to have an Internet account in 1998 than in 1995. Distinguishing between these alternative explanations and understanding the vast spectrum of people's experiences with the Internet, as reflected in different studies, will require additional research.

5.3. Effects on perceptions of reality

Simulated worlds created by electronic games, computers, and, more recently, the Internet are broadening the breadth of children's experiences from real to virtual. Through electronic games, children interact with simulated characters and creatures; through the Internet, teens assume multiple identities to interact with strangers — and even robots — in the simulated worlds of MUDs and chat rooms. At an extreme, real life is now reduced to two letters, ''rl,'' and real world experiences are merely a window on the computer screen. Next, we discuss how this shift affects children's development, and especially, their perceptions of reality and violence.

5.4. Shift from real life to simulation

Computerized games and the Internet are moving children into a world where the distinction between real life and simulation is not always distinct. One impact of this blurring of reality and virtual reality may be that children will have more difficulty in distinguishing between what is real and what is simulated. In addition, they may become desensitized to behaviors perpetrated in artificial and simulated worlds, such as aggression, violence, and killing.

One of the first computer games to thrust children into the realm of simulation was *SimCity*, soon followed by *SimAnt*, and *SimLife* (1992). The game of SimLife is a simulation of evolutionary processes. As one 13-year-old put it, "You get to mutate plants and animals into different species. You get to balance an ecosystem. You are part of something important." (Turkle, 1995, p. 169). On the other hand, Turkle found that some children, and even adolescents, may have difficulty understanding the boundaries between real and artificial life (p. 169). For example, one 10-year-old thought that the creatures in SimLife were "a little alive in the game," and that if you turned off the modem, they would go away, but if the modem stayed on, the creatures could "get out of your computer and go to America Online." Such confusion concerning the definition of life was not limited to young children. A 15-year-old said that the point of the game was to show that you could "get things that are alive in the computer," and that just as "we get energy from the sun, the organisms in the computer get energy from the plug in the wall."

The rise in popularity of small interactive game-toys, such as virtual pets, represent a new level in the integration of computers into the social world of children through simulation (Richard, 1998; Turkle, 1995). A virtual pet is a hand-held, gender-neutral interactive electronic game that requires the owner to take care of it to prevent it from "dying." The game is somewhat more popular among girls, most likely due to its theme of nurturance. It beeps to attract attention and displays various icons to indicate its immediate needs for food, sleep, play, or medicine.

Like other computer games and software, virtual pets have specific cognitive requirements: the screen presents an iconic code whose meanings and functions must be mastered by the child, contributing to cognitive socialization to the world of computers. The beeps socialize the child to respond to the same signal that they will respond to as "wired" adults with beepers, cell phones, and voice-mail (Richard, 1998). To a much greater extent than other computer games, children are stimulated to think of the virtual pets as "real." This is because the virtual pets require constant attention to stay alive, so children must take the game with them wherever they go. Indeed, some parents use virtual pets as training to take care of a real animal.

The actual psychological effects of virtual pets have not been studied systematically. Nonetheless, the popularity of simulation, or "virtual life," has continued with the advent of the "Furby," which is an electronic toy with fur, eyes, and ears, a 200 word vocabulary, and the ability to interact in its environment to a limited extent.[6]

[6] These simulations/virtual toys should not be confused with the new "smart toys" for girls such as "Friend.link," the electronic note-passing hand-held machine, or "Password Journal," in which a voice-recognition feature replaces a lock and key. These toys are communication devices and are part of real life, the way paper note passing and diaries are, and we do not expect them to raise the issue of confusion that the simulations/virtual pets might.

Systematic research is needed to assess the impact of such simulations and virtual pets on children.

The phenomenon of integrating simulated life into real life in the domain of electronic games is being reinforced on the Internet. There, robot-like programs "run around" MUDs interacting with "real" characters operated by real people, but sometimes indistinguishable from them (Turkle, 1995). Based on an extensive set of interviews, Turkle (1995) discusses the identity issues created by role-playing in MUDs. People create multiple characters as they participate in different or even the same MUD. For example, one Midwestern college junior interviewed by Turkle played four different characters across three different MUDs: a seductive woman, a "macho cowboy" type, a rabbit of unspecified gender, and a furry animal. He described how the various computer screens, or windows, make it possible to turn pieces of his mind on and off: "I just turn on one part of my mind and then another when I go from window to window. . .'rl' [real life] is just one more window, and it's not usually my best one" (Turkle, 1995, p. 13).

This effect is a continuation of a phenomenon that was begun by television. In the 1970s, Newsweek reported interviews with children who thought the real world was boring compared with the televised world (Waters, 1977). At about the same time, Joshua Meyrowitz (1985) pointed out that televised characters, especially on recurring series, were becoming a part of our social world and influencing human relations and politics in the real world. In relation to children and families, Meyrowitz thought that television's behind-the-scenes look at adults in general and parents in particular would break down children's respect for adult authority. Similarly, he saw other hierarchical authority structures being broken down in the same way: male–female, White–Black are two examples he develops. Perhaps the equality between people of all ages and statuses in the screen world of computers further breaks down authority structures and promotes even more equality than television did. Such equality could cause problems in socializing the next generation: children might be less willing to accept their parents' ability and right to guide and direct their actions. This is an important issue for future research.

There is some suggestion that the Internet is reaching an increasingly young audience and socializing them to form multiple identities in a simulated social world that is reaching an increasingly young audience. Although most MUD players are in their teens or twenties, it is no longer unusual to find MUDs where 8- and 9-year-olds "play" such grade-school icons as Barbie or the Mighty Morphin Power Rangers (Turkle, 1995).

There are others who suggest, however, that most *MUDs are not used for experimenting with identities.* For example, Schiano and White (1998) conducted observations, interviews, and a survey of users in LamdaMOO, one of the largest and oldest role-playing systems. Respondents estimated that they spent approximately 60% of their time online in social interaction, a percentage that was reliably higher for females than for males and that increased with the length of time participants had been frequenting LamdaMOO. Even though LamdaMOO allows participants to log in under multiple identities, approximately 50% of participants reported having only a single identity under which they communicated. For most people this identity was a slightly idealized, fanciful, or distorted view of themselves. Of the 50% of participants who communicated under multiple identities, most had only a single additional character. In observations made of over 4000 different

individuals over a 2-week period, over 75% used only a single character during that period, and of the minority who assumed multiple characters, over 80% of their participation occurred while they logged in under their main character. Thus, one can calculate that during this 2-week period, less than 5% of the online behavior in LamdaMOO represented people acting out multiple alternative identities. The strong majority of respondents reported that most of the time they communicated by "being yourself" rather by "role playing." Such a role-playing system might seem a developmental outgrowth of children's fantasy play, which eventuates in adult drama and film. However, what appears different is, first, that people have an opportunity to play an improved or otherwise modified version of themselves, something that theatrical roles rarely if ever afford. Second, a role-playing system such as LambdaMOO presents a unique social situation in another way: One never knows whether one is interacting with a character that is a real self or with a character that is someone's alternative identity. In such a MUD, the distinction between fantasy and reality, so hard-won in childhood, may be blurred.

A related concern is the prevalence of sexually explicit dialogue, and even simulated activity by children and teens on the Internet. Numerous public listservs, message boards, and websites, including sites geared towards more mature populations, offer teens the opportunity to share questions, concerns, and experiences regarding sex with both peers and adults. In addition, online flirting and cybersex, whether based on real or role-played identities, are very common among young people. It is difficult to assess the extent or impact of these interactions because they often occur, not in the public space of MUDs, but in private chats. Again, we need research to understand the informative and social role of online interaction.

5.5. Impact of computer use on violent behavior

As computer games become more graphic, violent, and pervasive, and as the Internet puts an increasing amount of information at children's fingertips, questions surround their role in encouraging violent behavior. These questions have taken on an increasing urgency in the wake of violent incidents, such as the 1999 massacre at Columbine High School in Littleton, CO, in which children killed children. The Columbine case has particularly spotlighted the role of video games as the shooters, Eric Harris and Dylan Klebold, were later described as being "obsessed with the violent video game Doom — in which the players try to rack up the most kills — and played it every afternoon" (Glick & Keene-Osborn, 1999). In this section, we review the limited research on the links between computer games, access to the Internet, and violent behavior.

Although home education games encourage positive prosocial behaviors (when players cooperate or share they are often rewarded), many popular entertainment software (action and adventure games) involve competition and aggression. Although violence is an integral part of computer games today (Provenzo, 1991), this was not always the case. The first game, *Pong*, was nonviolent. Aggression started in the second generation with *Breakout*, which involved destruction, but no human aggression. The next generation of popular games, such as *The Empire Strikes Back*, involved human aggression, and became more personal, with hand-to-hand combat, in games such as *Mortal Kombat*. Violence continues to reign in the current generation of action games that include titles such as *Doom*, *Duke Nukem*, *Mace*, and *Mortal Kombat 2*. A content analysis of recent popular Nintendo and

Sega Genesis computer games found that nearly 80% of the games had aggression or violence as an objective (Dietz, 1998).

While many children are familiar with and even seem to prefer violent computer games, parents are generally ignorant of such games. In a survey of 7th- and 8th-grade students, Funk (1993) found that half of their favorite games had violent themes. Many parents are unaware of even the most popular violent titles; for example, a survey found that while 80% of junior high students said they were familiar with *Duke Nukem*, a violent computer game rated "mature," a survey of more than 500 parents found that fewer than 5% had ever heard of it (Goldberg, 1998).

Given the amount of violence in computer games, the amount of time children spend playing these games, and their liking for violent games, an important question is their deleterious impact on children. Central among these concerns is the fear that playing an aggressive or violent computer game could increase children's aggressive behavior in other situations. Based on the evidence that watching violent media (television and films) increases children's (Friedrich-Cofer & Huston, 1986) and adults' (Zillman & Weaver, 1999) aggression and hostility, it is plausible to hypothesize that playing violent computer games would have similar effects. Indeed, the limited research on the effects of playing violent computer games suggests that there may be an association between playing such games and increased aggression.

Several experimental studies suggest that playing a violent game, even for brief periods of time, can generate short-term transfer effects such as increased aggression in children's free play (Cooper & Mackie, 1986; Irwin & Gross, 1995; Schutte, Malouff, Post-Gorden, & Rodasta, 1988; Silvern & Williamson, 1987), increased aggressive/hostile responses on ambiguous, open-ended questions (Kirsh, 1998), and increased aggressive ideation (Graybill, Kirsh, & Esselman, 1985). For example, Kirsh reported that 3rd- and 4th-grade children who played *Mortal Kombat 2*, a violent game, responded more violently to open ended questions than did children who played a nonviolent basketball game. Children who prefer and play aggressive computer games also demonstrate less prosocial behavior, such as donating money or helping someone (Chambers & Ascione, 1987; Wiegman & van Schie, 1998). Since the 1980s, the military in both the United States and Britain has used violent video games for military training (Kiddoo, 1982). Finally, virtual reality may be the best stand-in for increasing levels of graphic realism found in computer games. Calvert and Tan (1996), for example, found that playing (vs. observing) a violent virtual reality game led to more aggressive thoughts and arousal in college student players. Virtual reality can potentially have stronger effects than computer games because the player is immersed in the simulation; the effects could also be stronger for younger children, who may have a weaker discrimination between fantasy and reality.

Self-report research on the relation between amount of computer game playing and aggressive behavior is somewhat ambiguous. For instance, Fling et al. (1992) report that amount of computer game play (as measured by questionnaires) was positively correlated with self-reported aggression as well as teachers' ratings of aggression among 6th through 12th graders. However, when van Schie and Wiegman (1997) had participants (10 to 14 years) record their out-of-school activities on a daily basis for a week, there was no relation between amount of computer game playing and peer nominations of aggressive behavior. van

Schie and Wiegman suggest that the critical variable might be children's preference for aggressive computer games; in other words, those who liked aggressive computer games were rated as more aggressive by their peers.

Along with the possibility that playing violent computer games could increase aggressive behavior and decrease prosocial behavior, continued exposure to violence and aggression in computer games may also desensitize children to violence. Although this effect has been shown with television (Rule & Ferguson, 1986), it has not been explored with computer games. However, there have been reports in the popular press that the U.S. military has used video games for combat training to make recruits more willing to kill (Platoni, 1999). The military appears to have used violent video games to desensitize soldiers to the suffering of their targets. Similarly, few studies exist that examine the extent to which the increased availability of information over the Internet contributes to violent behavior. For instance, information about building bombs is freely available on the Internet and Columbine student Harris had detailed bomb making instructions on his website (Walsh, 1999).

In sum, while the research on the effects of playing violent computer games is limited, preliminary evidence suggests that playing such games may lead to increased aggressiveness and hostility. The training experience of the U.S. military also suggests that violent games may desensitize players of violent computer games to the suffering of their victims.

6. Conclusions and future directions

Available estimates of time use vary and are mostly based on self-reports, suggesting the need for more reliable estimates. Teenagers use the computer more than younger children or adults. Use is also greater for boys compared to girls, for Whites compared to Black or Hispanic children, and for children in households with higher parental income and education. Children still seem to be spending more time watching television than using computers, although computer users watch less television than noncomputer users.

Although playing specific computer games has immediate positive effects on specific spatial, iconic, and attentional skills used by the game, we need more research to see if long term computer and Internet use (both game and nongame) can lead to long term improvements in cognitive skills and academic achievement. Also, we need research to understand the cognitive and social effects of the newer generation of video games and other software, especially the multiuser games now available on the Internet.

While much of the time on computers is spent alone, moderate computer use does not negatively impact children's social skills and activities. On the contrary, e-mail and the Internet may actually help maintain interpersonal communication and sustain social relationships. However, we need to determine the impact of excessive computer and Internet use on children and adolescents' loneliness, social relationships, and psychological well-being.

Our review suggests a need to explore more fully the relation between violent games and children's aggression, particularly whether repeated game playing can desensitize children to the impact of violent behavior. Finally, the increasing dominance of simulated worlds (vs. real world experiences) in children's daily experiences and their impact on

children's and adolescents' developing identities and sense of reality are topics meriting serious attention.

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