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The Impact of Home Computer Use on Children's Activities and Development

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"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)

Abstract

The increasing amount of time children are spending on computers at home and school has raised questions about how the use of computer technology may make a difference in their lives—from helping with homework to causing depression to encouraging violent behavior. This article provides an overview of the limited research on the effects of home computer use on children's physical, cognitive, and social development. Initial research suggests, for example, that access to computers increases the total amount of time children spend in front of a television or computer screen at the expense of other activities, thereby putting them at risk for obesity. At the same time, cognitive research suggests that playing computer games can be an important building block to computer literacy because it enhances children's ability to read and visualize images in three-dimensional space and track multiple images simultaneously. The limited evidence available also indicates that home computer use is linked to slightly better academic performance.

The research findings are more mixed, however, regarding the effects on children's social development. Although little evidence indicates that the moderate use of computers to play games has a negative impact on children's friendships and family relationships, recent survey data show that increased use of the Internet may be linked to increases in loneliness and depression. Of most concern are the findings that playing violent computer games may increase aggressiveness and desensitize a child to suffering, and that the use of computers may blur a child's ability to distinguish real life from simulation. The authors conclude that more systematic research is needed in these areas to help parents and policymakers maximize the positive effects and to minimize the negative effects of home computers in children's lives.

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The time is ripe to assess the impact of home computer use on child and adolescent development. Most American children now have access to home computers and are using them for everything from playing games to doing schoolwork to chatting with friends via e-mail to surfing the Web. In 1999, an estimated 67% of households with children had a computer game system such as Sega or Nintendo,[1] 60% had home computers, and 37% had home access to the Internet—more than twice the percentage with access in 1996.[2] Although children still spend more time watching television than using computers, when a nationally representative sample of children ages 8 to 18 were asked which medium they would choose to bring with them to a desert isle, more chose a computer with Internet access than any other medium, including television.[3]

With the increased role of home computers in children's lives has come increased concern about how children may be affected. Time spent on home computers may displace other activities that have more developmental value, and the merit of the computer-based activities has also been questioned. 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."[4] Although they are increasingly concerned about the influence of the Web on their children and are disappointed with some of the online activities their children engage in—such as games and browsing the Internet to download lyrics of popular songs and pictures of rock stars—parents generally view computers favorably, and even consider children without home computers to be at a disadvantage.[5]

Although research on the effects of children's use of home computers is still sketchy and ambiguous, some initial indications of positive and negative effects are beginning to emerge. This article begins by describing the increasing amount of time children are spending on home computers and the impact of computer use on other activities. This discussion is followed by a survey of the available research about the effects of home computer use on children's activities and development in four broad areas: (1) physical well-being, (2) cognitive and academic skill development, (3) social development and relationships, and (4) perceptions of reality. The article concludes with a summary of the issues requiring further study to better understand what can be done to ensure that children's use of home computers has a positive impact on their lives.

Displacement of Other Activities

When children use home computers instead of watching television, it is generally viewed as positive; but when children use computers instead of participating in sports and social activities, it raises concerns about the possible effects on their physical and psychological well-being. Results from a national survey suggest that in 1999, children between ages 2 and 17 were spending approximately 1 hour 37 minutes per day using the computer and/or playing video games,[1] about 24 minutes more than in 1998.[6] Yet little research exists on how children's growing use of computers may be displacing activities other than television viewing, and the few findings that exist are ambiguous. Some evidence indicates that children who use home computers may watch less television than nonusers, but other evidence suggests that television view-

ing remains the same or might even increase with the use of home computers.

For instance, parents reported in a 1998 national survey by the Annenberg Public Policy Center that children in households without computers watched television an average of 36 minutes longer each day than children in homes with computers (2 hours 54 minutes versus 2 hours 18 minutes, on average).[7] Children in homes with computers also spent less time watching videotapes and more time doing schoolwork and reading magazines or newspapers, compared with children in homes without computers. Even after controlling for families' income and education levels, computer ownership had a significant, albeit weaker, effect—that is, in homes with computers, children spent less time watching television compared with children in families with similar income and education but without home computers. Interestingly, having a home computer did not affect the time spent reading books or playing video games on noncomputer platforms.

Other studies, such as a 1999 study by Nielsen Media Research, suggest that computer use does little to reduce television viewing. The data gathered by Nielsen showed almost no change in household television viewing after households gained Internet access.[8] Indeed, many Americans report that they prefer to use computers and watch television simultaneously. A 1999 study of 10,000 U.S. households by Media Metrix, an Internet and digital media research firm, found that among households with a home computer, 49% used their computers and watched television at the same time.[9]

Still others suggest that, because of the growing trend to link the content of various media—as exemplified by the "tie-ins" between children's television shows, computer games, and Web sites—computer use may not displace television, but may instead lead to an increase in television viewing.[10] (See the article by Montgomery in this journal issue for further discussion of the links between television and the Internet.)

Furthermore, it appears that greater access to home computers may actually be increasing children's total "screen time," that is, time spent using a computer, playing video games, and watching television combined. For example, parents reported in a 1999 survey that children between ages 2 and 17 with access to home computers and video games spent an average of 4 hours 48 minutes per day in front of a television screen or computer monitor. In contrast, parents reported that children without computers or video games spent an average of 3 hours 40 minutes per day in front of a screen, more than an hour less.[1] Another national survey of children ages 2 to 18 found that total reported screen time averaged 4 hours 19 minutes per day, excluding use of the computer for schoolwork. Reported screen time varied greatly by age, however, ranging from 2 to 3 hours per day for ages 2 to 7, to nearly 6 hours per day for ages 8 to 13 (see Figure 1).[11] As the combined amount of time children spend across these various media increases, the likelihood of displacing time spent on organized sports and other social activities also increases, thus exacerbating the impact on children's physical and social well-being.

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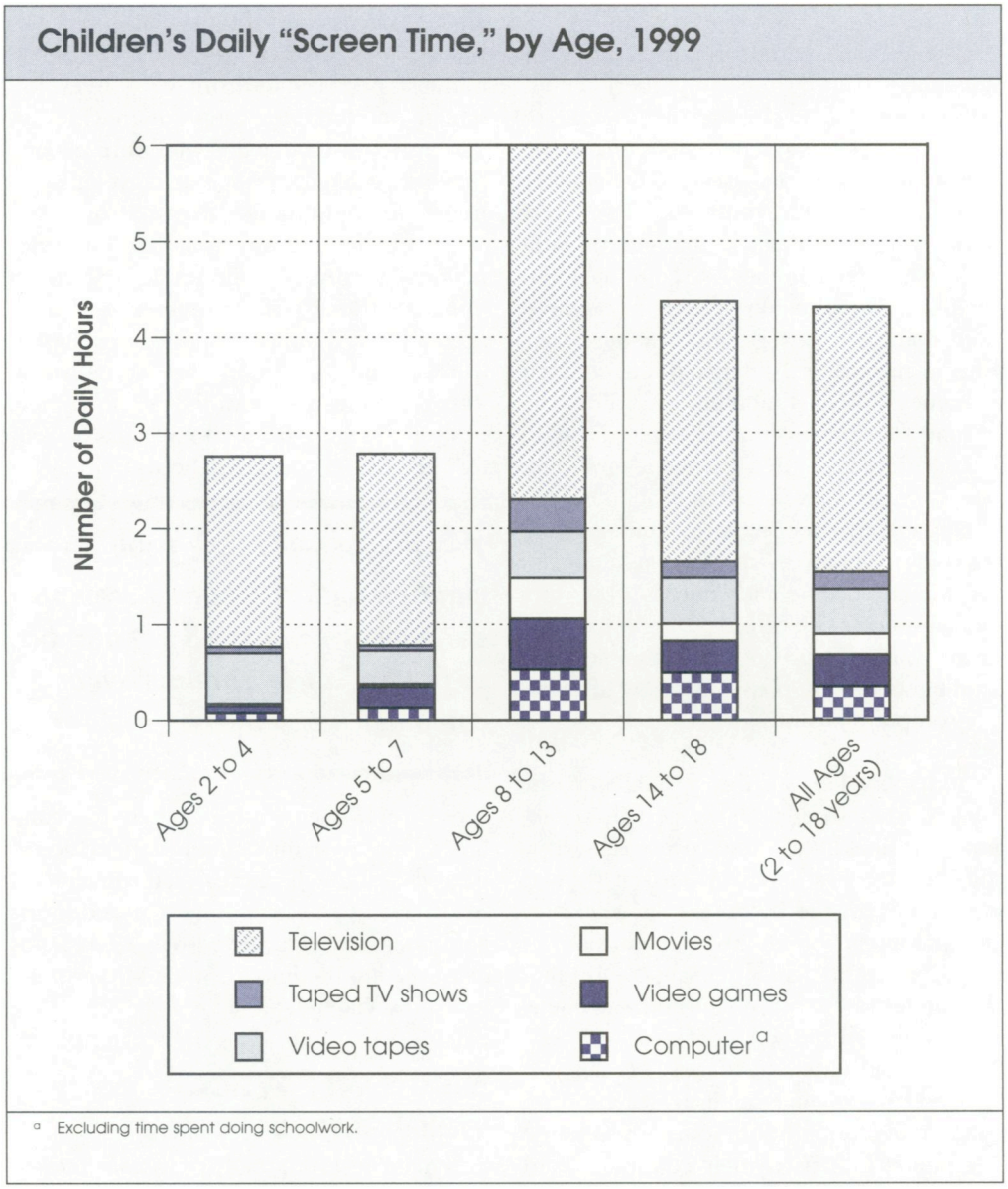
Effects on Physical Well-Being

Systematic research on the physical effects of children's computer use is lacking thus far, but insights can be gained from several sources. Results from the numerous studies on the physical effects of watching television are informative, given the similarities between these media. In addition, research focusing on the physical risks of playing computer games is important, given that games remain the most frequent home computer activity for children across most age groups, despite the proliferation of other software and applications. (See the article by Becker in this journal issue for further details on the demographics of different types of computer use.) These studies suggest that children's extended computer use may be linked to an increased risk of obesity, seizures, and hand injuries.

Figure 1



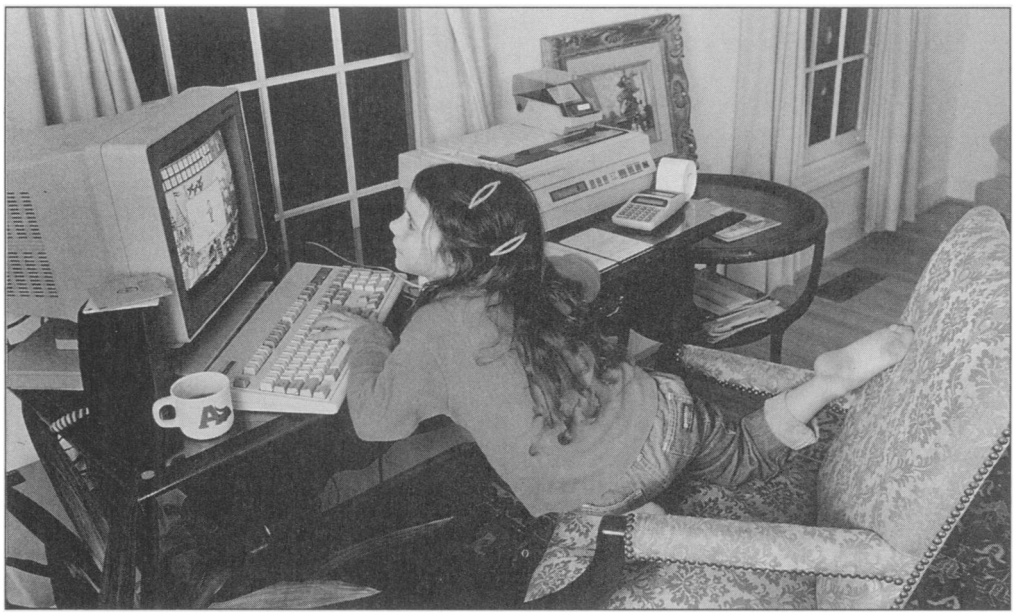
Source: Data from Roberts, D.F., Foehr, U.G., Rideout, V.J., et al. *Kids and media at the new millennium.* Menlo Park, CA: Kaiser Family Foundation, November 1999, p. 20. Based on a national survey of 3,155 children ages 2 to 18, in which children ages 8 to 18 responded directly. Totals are not adjusted for portions of the day in which the child may have used more than one medium at a time, and therefore some double counting may be included.

Risk of Obesity

Sedentary pursuits, such as watching television and using the computer, are believed to be an important environmental factor contributing to the fact that 25% of children in the United States are overweight or obese.[12] Although there is no research that systematically documents a relationship between obesity and computer use, evidence does exist that obesity in children is linked to excessive television watching, that is, five or more hours per day.[13] As children spend increasing amounts of time in front of computer monitors—in addition to time spent in front of a television screen—they are likely to be increasing their risk of obesity.[14] Consequently, the American Academy of Pediatrics advises parents to limit time spent with media and to emphasize alternative activities, such as athletics and physical conditioning, as well as imaginative play.[15]

Other Physical Effects

Since the early years of computer game technology—beginning with video games in the 1970s, followed by the growing popularity of stand-alone game systems like Nintendo in the 1980s[16] and the rise of the personal com-



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puter in the 1990s—playing games has been the predominant computer activity for children overall. Studies indicate, however, that playing computer games exposes children to a number of physical risks, including seizures, hand injuries, and changes in heart rate.[17]

For example, some research suggests that playing computer games may trigger epileptic seizures in certain users.[18] One research team reviewed 35 reported cases of video game–related seizures and found that abstinence from video games was the preferred treatment, compared to anticonvulsant medication.[19] It appears that the "flicker frequencies," or quickly flashing images, in some video games can trigger seizures in patients with photosensitive epilepsy. After studying 115 French subjects ages 7 to 30, another research team recommended using a 100Hz television screen (with twice the resolution as a standard television screen) and sitting at least one meter away from the screen to reduce the likelihood of video game–induced seizures.[20]

Excessive computer game playing also has been associated with a form of tendinitis, called Nintendinitis, which is a sports injury characterized by severe pain in the extensor tendon of the right thumb as a result of the repeated pressing of buttons during game play.[21] Currently there is no systematic research on this type of injury or on the impact of computer use in general on children's eyes, backs, and wrists; however, given children's increasing use of computers, sometimes for prolonged periods, it is likely that children will begin to experience the same kinds of injuries frequently reported by adult computer users.[22] To reduce the possibilities of such injuries, children should be given similar instructions as adults regarding safe computer use, including such precautions as taking frequent breaks and positioning equipment properly. In addition, game manufacturers should avoid producing games with flicker frequencies known from clinical experience to induce seizures in epilepsy-prone patients.

Effects on Cognitive Skills and Academic Performance

Computers and the Internet are used widely by children for schoolwork and to obtain information, but whether home computer use can make children "smarter" remains an open question. Nevertheless, playing specific computer games has been found to have immediate positive effects on specific cognitive skills, and use of home computers has been linked to mildly positive effects on academic performance. With the narrowing of the gender gap in home computer use, early fears that girls are turned off by computer technology appear unfounded.

Computer Games and the Development of Cognitive Skills

Cognitive skills are the skills associated with thinking and knowing—the skills required for children to understand language and num-

bers, to reason and problem solve, and to learn and remember. Although the term "cognitive skills" encompasses a broad array of competencies, research on the effects of computer use on cognitive skills has focused on the development of a specific set of visual intelligence skills crucial to the use of computer technology: spatial skills, iconic (or image representation) skills, and visual attention skills.

Computer applications of many kinds, and especially computer games, are designed in ways that emphasize visual rather than verbal information processing. Consider popular action games with their rapid movement, imagery, and intense interaction, plus various activities occurring simultaneously at different locations on the screen. Studies indicate that children who play such games can improve their visual intelligence skills—skills that may provide them with "training wheels" for computer literacy. Such skills may be especially useful in the fields of science and technology, where proficiency in manipulating images on a screen is increasingly important. Of course, computer game playing can enhance a particular skill only if the game uses that skill and if the child's initial skill level has matured to a certain level. Studies showing the effects of various computer games in enhancing selected visual intelligence skills are described in Box 1.[23]

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Much of the research on the cognitive impact of computer games has measured the effects of game playing only immediately after the practice and does not address questions about the cumulative impact of interactive games on learning. However, many computer games use the same skills that are tested in nonverbal (as opposed to verbal) intelligence tests, such as the Wechsler and the Stanford Binet.[24] Thus, exposure to the proliferation of imagery in electronic technologies may have contributed to the selective increases in nonverbal intelligence scores during the past century.[25] For example, a comparison of average scores on the nonverbal test, the Raven Progressive Matrices, among British adults of comparable ages in 1942 versus 1992 showed significant increases for all age groups tested.[26]

Computer Use and Academic Performance

In the early years of home computer ownership during the 1980s, Alfred Bork, a pioneer in the use of computers for instruction, suggested that "the home computer may well become the primary influence upon the educational system of the future."[27] Since then, the rapid evolution of the personal computer has indeed broadened society's vision of computers from devices for programming and playing games, to tools for developing children's skills and motivation in academic areas such as math, science, language arts, and writing. Today, children and teens frequently use home computers and the Internet for their schoolwork,[28] and parents generally believe that computers are an important educational resource.[29] Among teens ages 13 to 17, schoolwork has surpassed games as the most frequent online activity, according to Annenberg's 1999 survey,[2] but there has been only limited research on the impact of home computer use on academic achievement.

What research exists, however, appears to corroborate parents' perceptions that home computer use is related to better academic performance. For example, early home computer use studies found that high school students who used educational software at home scored significantly higher than other students on computer literacy tests.[30] Home computer use has been linked to improvements in general academic performance as well. For example, a longitudinal study published in 1995 which tracked a group of students from seventh through twelfth grade, found that the students with computers at home had higher overall grades and better grades in math and English than those without home computers.[31] Of course, students with home computers are also more likely to have families with greater income and education, factors that are highly correlated with better academic performance. But even just among those with home computers, heavier

Box 1

Effects of Playing Computer Games on Selected Visual Intelligence Skills

- ***"Marble Madness" and effects on spatial skills:*** A study of 61 children, ages 10 to 11, compared the effects of two computer games on the development of spatial skills—the cluster of skills required for children to visualize and manipulate objects or images in their minds.[1] Practice on Marble Madness was found to reliably improve the children's spatial performance, while practice on Conjecture, a computerized word game similar to the TV show *Wheel of Fortune,* did not. The children playing Marble Madness used a joystick to guide a marble along a three-dimensional grid, trying to keep the marble on the path and prevent it from falling off or being attacked by intruders. After playing the game, children were found to have improved their ability to anticipate targets and visualize spatial paths.

- ***"Concentration" and effects on iconic skill:*** A cross-cultural study carried out in Rome and Los Angeles examined the effects of playing a computer game on the development of iconic skills—the skills that enable people to read images such as pictures and diagrams.[2] Researchers found that after playing the game Concentration on a computer, undergraduate students offered more diagrams in their analysis of an animated simulation of electronic circuits, whereas those who played the game on a board offered more verbal descriptions.

- ***"Robot Battle," "Robotron," and effects on visual attention skills:*** A study compared the effects of computer game expertise on college students' visual attention skills, the skills required to keeping track of several different things at the same time—not unlike a pilot keeping track of a row of several engine dials simultaneously.[3] Researchers measured participants' response time to two events at two locations on a computer screen, where one target icon appeared more often than another. Predictably, participants who were expert players of Robot Battle (scoring above 200,000) had faster response times than participants who were novice players (scoring below 20,000). But after five hours of playing the game Robotron, all participants responded significantly faster to the target at the low probability position on the screen, demonstrating a causal relationship between playing a computer game and improving strategies for keeping track of events at multiple locations.

Endnotes:

1 Subrahmanyam, K., and Greenfield, P.M. Effect of video game practice on spatial skills in girls and boys. Special issue: Effects of interactive entertainment technologies on development. *Journal of Applied Developmental Psychology* (1994) 15:13–32.

2 Greenfield, P.M., Camaioni, L.E., Ercolani, P., et al. Cognitive socialization by computer games in two cultures: Inductive discovery or mastery of an iconic code? Special issue: Effects of interactive entertainment technologies on development. *Journal of Applied Developmental Psychology* (1994) 15:59–85.

3 Greenfield, P.M., deWinstanley, P., Kilpatrick, H., et al. Action video games and informal education: Effects on strategies for dividing visual attention. Special issue: Effects of interactive entertainment technologies on development. *Journal of Applied Developmental Psychology* (1994) 15:105–23.

users performed better academically than light users: students who reported using their home computers for at least 10 hours during the school year for activities unrelated to a class also reported better overall grades, better grades in math and English, and did better on a test of scientific knowledge than those who reported using their home computer less.

In addition, studies of the effects of one computer-based after-school program, The Fifth Dimension, show that children who participated in the program had greater

advances in reading, mathematics, computer knowledge, following directions, and grammar and had higher scores on school achievement tests, compared with children who did not participate.[32] For example, in one well-controlled study, participants had small, but significant increases in reading and math posttest scores compared to nonparticipants. These effects were found even though the program did not involve a structured instructional intervention. Rather, the program emphasized voluntary participation in a mix of recreational and educational activities, and a large proportion of the program's activities included the typical uses of home computers, such as educational software, computer games, and Internet searches and communication.

As the array of nongame applications widens, the gap between the genders in the use of home computers is diminishing. Girls now report using home computers as often, and with as much confidence, as boys.

Narrowing of Gender Gap in Computer Use

Boys traditionally have been heavier users of home computers than girls, mostly because of their interest in playing computer games. Some research has indicated that the gender difference in home computer use spills over to schools, with girls also lagging behind boys in the use of school computers, and even perceiving school computers to "belong more" to boys.[33] As a result, concerns have been raised that girls may not acquire the important computer literacy skills that will keep them academically and professionally on par with males, particularly in the technology-based careers of the future. Recent data suggest, however, that as the array of nongame applications widens, the gap between the genders in the use of home computers is diminishing. Girls now report using home computers as often, and with as much confidence, as boys.

The core audience for computer game systems, such as Nintendo or Sega, always has been boys between ages 8 and 14. Compared to girls, boys spend more than twice as much time per week playing computer games[34] and are five times more likely to own a computer game system.[35] In a study of self-reported leisure time activities of 2,200 third and fourth graders, computer games topped the list of activities among boys: 33% of boys reported playing computer games, compared with fewer than 10% of girls.[36] Initially it was thought that this disparity was the result of the games' violent themes and lack of female protagonists.[37] A more likely reason, however, is the difference between the genders in their play preferences: boys tend to prefer pretend play based on fantasy, whereas girls tend to prefer pretend play based on reality—a rare theme for computer games, even those designed specifically for girls (see Box 2).[38]

But as uses of computers have expanded beyond games, the disparities between genders in home computer use have diminished. A 1997 national survey conducted by the Gallup Organization found that among teens ages 13 to 17, boys were still more likely than girls to report playing video games, but the same number of boys and girls reported using a computer each day.[39] Furthermore, boys and girls reported equal levels of computer usage and expressed equal levels of confidence in their computer skills.[40] Other research has similarly found parity between the genders in the reported use of home computers for schoolwork and other nongame applications, especially with respect to certain Internet activities. For instance, a 1999 national survey found that except for playing games, 8- to 13-year-olds reported no gender differences in the in-school and out-of-school use of computers for chatting, visiting Web sites, using e-mail, doing schoolwork, or using the computer to do a job.[11] The picture is similar for 14- to 18-year-olds, except that older boys visit significantly more Web sites than do older girls.

Thus, contrary to early fears, recent trends suggest that girls have no inherent problem with computer technology—they merely require functions that fit their interests. It remains to be seen, however, whether girls' adoption of the newer applications of computer technology will result in their increased participation in technology-based careers in the future.

Box 2

Video Games for Girls

Barbie Fashion Designer, a computer game that has become extremely popular with girls, enables players to design and construct outfits for Barbie that can be printed, assembled, and actually worn by the doll. The game has sold upwards of 1.75 million copies since its introduction in September 1996. (To give some perspective, Myst, the best-selling computer game ever, has sold 5.5 million units since 1994.) In contrast, other efforts by the software industry to appeal to girls by creating nonviolent computer games with female protagonists, for example, have been largely unsuccessful. Although a number of other Barbie games have become best sellers among girls, the phenomenal success of Barbie Fashion Designer relative to other Barbie games does not appear to stem from the mere presence of Barbie and its nonviolent content, but from the fact that it contained features that fit in with girls' play and their tastes in reading and literature in general. By helping girls create outfits for Barbie, the computer became a creative tool that fit well with girls' preferences for more reality-based pretend play that reflects their everyday experiences.

Source: Subrahmanyam, K., and Greenfield, P.M. Computer games for girls: What makes them play? In *From Barbie to Mortal Kombat: Gender and computer games.* J. Cassell and H. Jenkins, eds. Cambridge, MA: MIT Press, 1998.

Effects on Social Development and Relationships

The use of home computers not only can influence children's cognitive and academic skills, but can also shape children's social interactions and development. In children's interactions with parents and other adult authority figures, one obvious effect has been the frequent reversal of the traditional parent-child relationship with the computer-savvy child taking on the role of teacher to the parent. Several studies have found, for example, that teenagers are more likely to help their parents with computers than parents are to help their children—with boys disproportionately helping their fathers and girls disproportionately helping their mothers.[41] In addition, some have hypothesized that the equality in online communications among computer users of all ages tends to erode authority structures, with the result that children will be less accepting of parental authority.[42]

With respect to interactions with peers, the effects of computer use again appear to depend as much on the type of activity engaged in while on the computer as on the amount of time spent in front of a screen. Because of the importance of interacting with others to gain social competence, concerns have been raised that children who form "electronic friendships" with computers instead of friendships with their peers might be hindered in developing their interpersonal skills.[43] More than one-fifth of all children between ages 8 and 18 report having a computer in their bedroom,[11] suggesting that the computer often may be used in solitude, robbing children of time for other social activities and interfering with the development and maintenance of friendships. Indeed, one recent survey found that, among junior high and high school students, more than 60% of all their computer time is spent alone.[11] However, much of children's "alone time" on computers appears actually to be spent extending social relationships by connecting with others through interpersonal communication applications via the Internet. An overview of the research examining the social effects of children's use of computers—from the impact of game playing on friendships and aggressive behavior to the impact of the Internet on relationships and psychological well-being—is provided below.

Social Effects of Playing Computer Games

As mentioned earlier, game playing has long been the predominant use of home com-

puters among children—especially among younger boys. Although the available research indicates that moderate game playing has little social impact on children, concerns nonetheless have been raised about excessive game playing, especially when the games contain violence. Research suggests that playing violent computer games can increase children's aggressive behavior in other situations.

Moderate Game-Playing Appears Benign

Existing research indicates that moderate game playing does not significantly impact children's social skills and relationships with friends and family either positively or negatively. Studies often found no differences in the "sociability" and social interactions of computer game players versus nonplayers,[44] but a few studies found some mildly positive effects. For example, one study found that frequent game players met friends outside school more often than less frequent players.[45] Another study of 20 families with new home computer game sets explored the benefits and dangers of playing games and found that computer games tended to bring family members together for shared play and interaction.[46]

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 hours per week or more.[35] It has been suggested that spending a disproportionate amount of time on any one leisure activity at the expense of others will hamper social and educational development.[47] Indeed, one study of fourth- to twelfth-grade students found that those who reported playing arcade video games or programming their home computer for more than an hour per day, on average, tended to believe they had less control over their lives compared with their peers.[48] In addition, some evidence suggests that repeated playing of violent computer games may lead to increased aggressiveness and hostility and desensitize children to violence.[49]

Links to Violent Behavior Raise Concerns

Although educational software for home computer use includes many games that encourage positive, pro-social behaviors by rewarding players who cooperate or share, the most popular entertainment software often involves games with competition and aggression,[50] and the amount of aggression and violence has increased with each new generation of games.[51] 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.[52] One survey of seventh- and eighth-grade students found that half of their favorite games had violent themes.[34] Yet parents often are unaware of even the most popular violent titles, despite the rating system from the Entertainment Software Ratings Board in place since September 1994 (see Box 3). In a 1998 survey, 80% of junior high students said they were familiar

Box 3

Computer Game Rating System

Since 1994, computer games have carried the ratings of the Entertainment Software Ratings Board (ESRB). The ESRB ratings of age appropriateness (for example, early childhood, teen, mature) appear on the front of the computer game box. On the back of the box, ESRB provides descriptors of game content in various areas of concern, such as violence, language, sex, and gaming. The ESRB uses the following phrases to describe violent content in games:

- **Mild Animated Violence:** Contains scenes involving cartoon/animated/pixilated characters in the depiction of unsafe or hazardous acts or violent situations.
- **Mild Realistic Violence:** Contains scenes involving characters in the depiction of unsafe or hazardous acts or violent situations in realistic or photographic detail.
- **Comic Mischief:** Contains scenes depicting activities that have been characterized as slapstick or gross vulgar humor.
- **Animated Violence:** Contains depictions of aggressive conflict involving cartoon/animated/pixilated characters.
- **Realistic Violence:** Contains realistic or photographic-like depictions of body parts.
- **Animated Blood and Gore:** Animated/pixilated or cartoon-like depictions of mutilation or dismemberment of body parts.
- **Realistic Blood and Gore:** Representations of blood and/or gore in realistic or photographic-like detail.
- **Animated Blood:** Animated/pixilated or cartoon-like depictions of blood.
- **Realistic Blood:** Representations of blood in realistic or photographic-like detail.

Source: Entertainment Software Ratings Board. *Rating categories and content descriptors.* Available on the ESRB Web site at http://www.esrb.org/rating.html.

with Duke Nukem—a violent computer game rated "mature" (containing animated blood, gore, and violence and strong sexual content), but fewer than 5% of parents had heard of it.[53]

In the wake of violent incidents involving children and teens, such as the massacre at Columbine High School in Littleton, Colorado, in 1999, concern over the violent content of computer games has taken on an increasing sense of urgency for many parents, educators, and policymakers. The Columbine case particularly has highlighted the role of video games because the shooters were 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."[54] In fact, the Web site of one of the shooters had a customized version of Doom that resembled a simulation of the later attack on Columbine High.[55]

Numerous studies have shown that watching violent television programs and films increases children's and adults' aggression and hostility[56]; thus, it is plausible that playing violent computer games would have similar effects. The research on violent computer games suggests that there is, indeed, an association between playing such games and increased aggression, and that the critical variable is a preference for playing aggressive games, rather than the amount of time spent playing.[57] Several experimental studies suggest that playing a violent game, even for brief periods, has short-term transfer effects, such as increased aggression in children's free play,[58] hostility to ambiguous questions,[59] and aggressive thoughts.[60] For example, one study of third and fourth graders found that those children who played a violent game (Mortal Kombat II) responded more violently to three of six open-ended questions than did children

Box 4

Communication Options via the Internet

- **Electronic mail (e-mail):** Notes and letters sent electronically from one user to one or more others. E-mail uses technology to store and forward messages, so that messages sent at one time can be received at a later time, when the sender is no longer online. Although most electronic mail consists entirely of text, recent e-mail services can include pictures, sound files, and other multimedia documents.
- **Listservs:** Address lists for the distribution of e-mails related to particular topics.
- **Usenet news groups:** Electronic bulletin boards on particular topics where e-mail messages can be posted; users can access messages without being specifically identified as an addressee.
- **Chat rooms:** Communication system organized around particular topics that allows users to exchange e-mails in real time; they can be either public with open access or private with restricted access.
- **Multiuser domains:** Real-time communication systems similar to chat rooms, but organized around role-playing games.
- **Instant Messages (or "buddy lists"):** Software that informs the user when friends or colleagues are online and enables private, one-to-one, text-based conversations.

who played a nonviolent computer game (basketball). Furthermore, it has been found that children who have a preference for and play aggressive computer games demonstrate less pro-social behavior, such as donating money or helping someone.[61]

Studies of television have found that continued exposure to violence and aggression desensitizes children to others' suffering,[62] but studies of computer games have not yet explored such a link. At least since the 1980s, however, both the U.S. and British military have used violent video games for training, reportedly to desensitize soldiers to the suffering of their targets and to make them more willing to kill.[63]

Social Effects of Communicating via the Internet

Using computers to communicate with others is an increasingly popular activity—especially among teen girls.[64] Teens frequently make social contacts online through the various options now available on the Internet (see Box 4). Research suggests that the social effects of such computer use may depend, in part, on whether these online social contacts are with family and friends, or with strangers and acquaintances.

In one recent study, the HomeNet project, researchers conducted an in-depth analysis of the effects of acquiring access to the Internet among a group of 93 families (see Box 5). The study found that 10- to 19-year-olds (referred to inclusively as "teens") were especially likely to report using the Internet for social purposes. Compared with the adults in the study, teens—and especially girls—liked using the Internet for communicating with friends, meeting new people, getting personal help, and joining groups.[65] Teens told researchers that keeping up with both local and distant friends was an important use of the Internet for them, and they often used the Internet for keep-in-touch communications involving small talk, gossip, and news of the day, with a "here-and-now" flavor. As discussed further below, the two-year study documented that, despite the use of the Internet for such social purposes, teens who spent more time online experienced greater declines in social and psychological well-being during their first year with access to the Internet. Over time, however, these effects appeared to diminish.

Evidence of Initial Increases in Loneliness and Depression

Among both teens and adults in the HomeNet project, greater use of the Internet

Box 5

The HomeNet Project

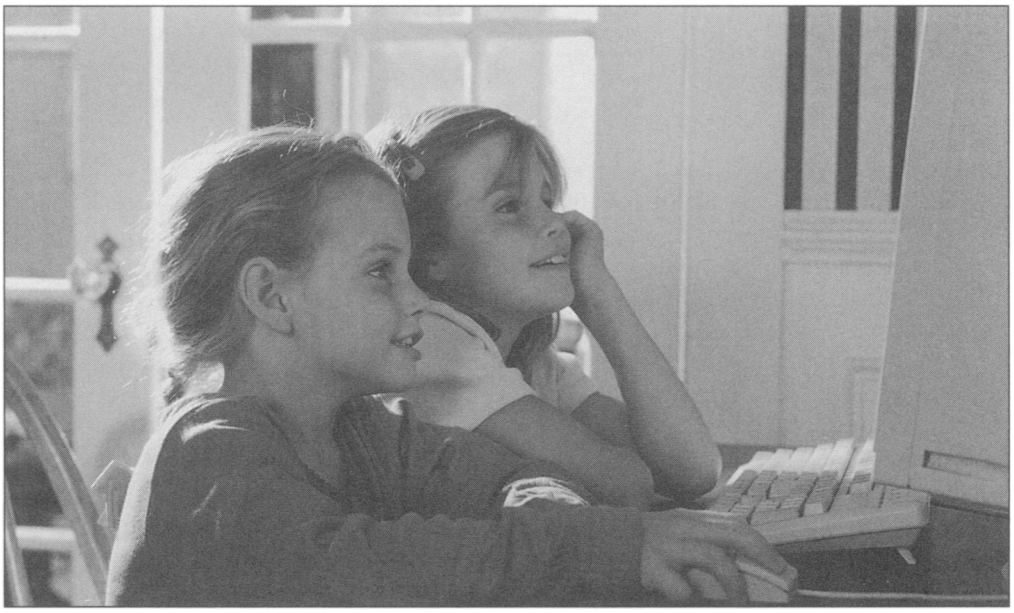
The HomeNet Project was a field trial by researchers at Carnegie Mellon University, studying home use of the Internet by 93 families in the Pittsburgh area between 1995 and 1998. By reducing economic and technological barriers to the use of computers and the Internet from home, the study sought to learn how a diverse sample of families would use the technology when provided with the opportunity for the first time. Starting in 1995, the study provided the families who were participating, including 208 adults and 110 older children ages 10 to 19, with home computers and connections to the Internet. Data about how these family members used the Internet were then collected for two years through in-home interviews, periodic questionnaires, and machine records that garnered information automatically whenever family members went online. The goal of the study 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 machine records of weekly usage, averaged across approximately two years of data, show that among the sample of HomeNet children studied, Internet usage averaged about 3 hours a week during weeks when they used it, and more than 10% used it more than 16 hours per week. Children in the study were much heavier users of the Internet and all its services than were their parents.

Sources: Kraut, R., Scherlis, W., Mukhopadhyay, T., et al. The HomeNet field trial of residential Internet services. *Communications of the ACM (1996)* 39:55–63; and Kraut, R., Patterson, M., Lundmark, V., et al. Internet paradox: A social technology that reduces social involvement and psychological well-being? *American Psychologist* (1998) 53:1017–31.

during the first year of access was associated with small but statistically significant declines in social involvement as measured by communication within the family, size of social networks, and feelings of loneliness.[66] Greater use of the Internet also was associated with increases in depression. In this study, those who were lonely or depressed were not more drawn to the Internet. Rather, the HomeNet results suggest that using the Internet in itself caused the declines in social well-being.[67] It is unclear, however, whether these effects were because the time spent using the Internet was substituting for time previously spent engaged in social activities, or because social relationships created online provided less social support than those grounded in the offline world.[68]

The majority of HomeNet participants' online social relationships had their roots outside the Internet. Thus, online communications among HomeNet participants, all of whom were Internet neophytes, were used primarily to keep up with close friends and close family members—what sociologists term "strong ties."[69] Using the computer for e-mail in these online relationships generally supplemented telephone and face-to-face visits, but rarely replaced these older communication modes. 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 to keep up with high school friends.

HomeNet participants communicated online mostly with "strong tie" relationships, but they also created new online relationships with strangers they met through the use of Usenet news groups, listservs, multiuser domains (MUDs), and chat rooms (see Box 4). Although adults made more of their new online relationships through Usenet newsgroups and listservs, 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. Adolescence in the United States is typically characterized by experimentation with social relationships and an expansion of peer groups; thus, teens' use of the Internet for such social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experimentation is consistent with this developmental stage in their lives.[70]

Online communications with strangers and acquaintances, however, represent relatively "weak tie" relationships that typically provide less social support than offline relationships with family and friends.[71] Along with participants in other studies, HomeNet participants reported they felt less close to those they communicated with online compared to those they communicated with face-to-face. Less time was spent "together" in online relationships, and such relationships tended to exist for a shorter time.[72] Strong relationships can be built from contacts made online, but generally such relationships require revealing one's "real self" (as opposed to role playing, as is often the case in a MUD or chat room) and benefit from being reinforced by contacts offline.[73] In the HomeNet study, however, the online relationships created by participants typically remained in the electronic domain, rarely resulting in face-to-face meetings.[74]

Thus, teens in the HomeNet study spending greater amounts of time online in their first year of access may have experienced increased loneliness and depression because they spent more time in MUDs and chat rooms, communicating with "weak ties" with whom they had no offline contact, and less time communicating with "strong ties," who tend to provide stronger social support.

Changes in Effects Over Time

After having Internet access for about a year, however, HomeNet participants no longer experienced declines in social well-being or increased loneliness, despite continued use of the Internet. As with many learning processes, initial exposure may have generated dramatic changes in behavior that lessened over time.[75] For example, the novelty of Internet access may have initially tempted teens to spend more time online than was good for them, to frequent Web sites that did not really interest them, and to communicate with others in "weak tie" relationships which did not really engage them. Then, as the novelty wore off, teens may have begun using the Internet more wisely, in ways better aligned with their true interests, such as communicating online more with those with whom they had "strong tie" relationships.

In addition, the Internet itself has changed over time. During 1995 and 1996, for example, when HomeNet 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, in contrast, two new real-time communication services gained in popularity: Instant Messenger and ICQ ("I seek you"). Both of these services allow users to identify a list of people and to be notified when

anyone on that list goes online. Such buddy lists, as they are known, increase the likelihood that people will communicate with others whom they already know. In addition, the growth in the proportion of the population online 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. Thus, many different factors—from the preferences of teens for certain types of online activities to the evolution of the technology itself—influence the nature of online communications and the social effects of computer use on children and teens.

Effects of Greater Access to Information

As the Internet puts an increasing amount of information at children's fingertips, adults have begun to question whether such information encourages violent and sexually promiscuous behavior. For instance, information about building bombs is freely available on the Internet, and one of the Columbine students responsible for the massacre in April 1999 had detailed bomb-making instructions on his Web site. In a poll immediately following the incident, 76% of adults said they wanted Internet service providers to do more to monitor Web sites to identify potentially dangerous individuals, and 68% said they thought the federal government should do more.[54] Yet the extent to which increased availability of information over the Internet contributes to violent behavior has not been systematically studied.

Similarly, the prevalence of sexually explicit material available on the Internet, including sexually explicit dialogue and the use of imagery to simulate sexual activity (or "cybersex") by children and teens, is also a major concern that has attracted little study. Some online communications about sex are educational and informative, such as public listservs, message boards, and Web sites that offer teens the opportunity to share questions, concerns, and experiences regarding sex.[76] At the same time, some adults are concerned that these discussions, along with the preponderance of online flirting and cybersex among young people, will induce premature sexual activity. 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 conversations either in instant messages or private or restricted chat rooms. Interviews with girls who participate in such online activity, however, indicate that the information about sex gleaned from the Internet, including online sexual experiences, may actually encourage greater caution and patience when making sexual choices in real life.[76] Thus, it is important to examine both the informative and social role of online interaction.

In sum, existing research suggests that the social effects of children's computer use vary widely, depending on the amount of time spent, type of activity engaged in, and the nature of content or information delivered. For example, the evidence suggests that computer games are most likely to lead to negative effects when the content of the games is violent. Online communications may cause loneliness and depression when they involve "weak tie" relationships, such as those resulting from encounters in MUDs and chat rooms. And finally, increased access to sexual content via the Web may encourage premature sexual activity, but there are indications that it also may encourage better sexual decision making. Still, many possible social effects are as yet unexplored.

Existing research suggests that the social effects of children's computer use vary widely, depending on the amount of time spent, type of activity engaged in, and the nature of content or information delivered.

Effects on Perceptions of Reality

Simulated worlds created by electronic games, computers, and the Internet are expanding 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 ("bots," computer programs that represent themselves as people)—in the simulated worlds of MUDs and chat rooms.[77] Computerized games and the Internet move users into a world where the distinction between real life and simula-

tion may not be clear, especially for children. Researchers have begun to examine how this shift from reality to simulation may influence children's development.

For example, one noted researcher, Sherry Turkle, found that some children may have difficulty understanding the boundaries between real and artificial life when engaged in simulation computer games.[78] Such confusion concerning what it means to be "alive" occurred among children of all ages. For example, one 10-year-old thought that the creatures in the computer game 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." Even one 15-year-old said that the whole point of SimLife 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."

One never knows whether one is interacting with a "real self" or with someone's alternative identity. In such a MUD, the distinction between fantasy and reality is truly blurred.

Beyond games played on traditional computer screens, the rise in popularity of small interactive game-toys, such as virtual pets, represent a new level of integration of computer simulation into the social world of children.[79] A virtual pet is a hand-held, interactive electronic game, somewhat more popular among girls, that requires the owner to take care of it to prevent it from "dying." Similar to other computer games and devices, it beeps to attract attention and displays various icons on a screen whose meanings and functions must be deciphered—in this case, indicating the virtual pet's immediate need for food, sleep, play, or medicine.[80] To a much greater extent than other computer games, however, children are encouraged to think of virtual pets as "real."[81]

Role-playing games on the Internet reinforce this integration of simulated life into real life. In MUDs, for example, computer-generated characters interact with characters operated by real people and sometimes fool people into thinking they are human.[77] Even the characters operated by real people are often mixtures of fantasy and reality. In a study of LamdaMOO, one of the largest and oldest role-playing systems, participants between the ages of 15 and 45 reported communicating primarily through characters that tended to be slightly idealized, fanciful, or distorted versions of themselves, and about half the respondents reported communicating at least sometimes under multiple identities.[82]

In another analysis of MUDs based on an extensive set of interviews, Turkle described the role playing of a Midwestern college junior who communicated as four different characters across three different MUDs—a seductive woman, a macho cowboy, a rabbit of unspecified gender, and a furry animal. The student explained how the various computer screens, or windows, make it possible to turn portions 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."[83]

Such role playing might seem a developmental outgrowth of children's fantasy play, which evolves into adult drama and film; however, unlike most theatrical role playing, 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 is truly blurred.[84] The few studies that have examined how computer role-playing games affect perceptions of reality and subsequent interactions with others in the real world suggest the effects can be quite strong. For example, in a study of the participation in a violent virtual reality game, researchers found that college students who were immersed in the simulation were more likely to have aggressive thoughts than those who merely observed the game.[85] The effects may be even stronger for younger children, who are less able to discriminate between fantasy and reality.

Whereas most studies of MUDs describe the experiences of older children and adults, younger children also are beginning

to participate more frequently in MUDs, where they learn how to form multiple identities and relate to a simulated social world. Turkle observed even eight- and nine-year-olds entering MUDs and playing such grade-school icons as Barbie or the Mighty Morphin Power Rangers.[86] As simulation becomes more prevalent in children's daily lives—from playing video games to caring for virtual pets to role playing in MUDs—it becomes increasingly important to understand the impact of these virtual experiences on children's developing identities and views of the world.

Conclusions, Policy Implications, and Future Research Needs

Children's daily use of computers is increasing both at school and at home. Although children still spend more time watching television than using computers, use of home computers is growing rapidly, adding to their total "screen time." And although boys traditionally have used home computers more than girls, mostly to play games, girls are catching up as they use Internet communication activities to send and receive e-mail, play with software such as Barbie Fashion Designer, and care for computer-simulated virtual pets. Thus, both boys and girls will increasingly face the issues identified in this article, but a great deal is still unknown.

The strongest evidence examining how home computer use affects children builds on the studies of television concerning physical effects and violent content. The evidence on physical effects links the sedentary nature of computer use to an increased risk of obesity. Children should limit their time with media and should be taught to use computers safely to avoid the types of eye, back, and wrist injuries that have plagued adult computer users. In addition, the evidence on violent content links exposure to violent computer games to increased aggressive behavior. Stronger actions are needed on the part of policymakers and software developers to reevaluate the content of games targeted to children, to help parents choose appropriate games for their children, and to monitor violent content on the Web.

For the most part, however, research in this field is still in its infancy, and most of the findings in this article are only suggestive. There is a pressing need for more systematic research across the broad range of topics discussed to better understand the effects of computer use on children's physical, intellectual, and social development. The following are some of the most pressing of these research issues.

First, most time-use data have been gathered through self-reports or, in the case of children, self-reports and reports by parents, usually in telephone surveys. Despite their overall usefulness for sampling large numbers of people, self-report survey data are beset by problems of accuracy and reliability stemming from memory limitations and inaccurate estimations by respondents—especially when children are involved. More reliable methods of data collection exist, such as using the computer itself to track who is using the computer, the applications used, and the Web sites visited.[87] But such methods have not been widely used because they are more expensive and time-consuming to carry out—and they raise concerns regarding privacy. Nevertheless, to derive more accurate estimates of the time children spend on home computers and the Internet and of the time children are not spending on other activities, such as reading, sports, and real-world social pursuits, however, more research using computer tracking is needed.

Research especially is needed on the newer generation of video games and Internet applications that are now available, such as multiuser online games, MUDs, and instant messaging.

Second, although computers and the Internet are widely used by children for schoolwork and to obtain information, more and better evidence is needed to support the claim that home computer use can improve school performance. More research is necessary to determine if use of home computers can have significant, long-term effects on cognitive skills and academic achievement.

And third, children and adolescents are spending increasing amounts of time using

home computers to play multiuser games and to communicate with others through the Internet. There is a pressing need for research to determine the impact of excessive computer and Internet use on their loneliness, social relationships, and psychological well-being. Research especially is needed on the newer generation of video games and Internet applications that are now available, such as multiuser online games, MUDs, and instant messaging.

Clearly, much more research is needed, but the research will never be perfect. We must begin to take steps now that can help maximize the positive effects and minimize the negative effects of home computers in children's lives.

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64. See note no. 2, Turow; see also note no. 11, Roberts, Foehr, Rideout, et al.; note no. 38, Subrahmanyam and Greenfield; and note no. 1, Stanger and Gridina.

65. These comparisons hold true even when controlling for the greater number of hours per week that teens are online compared to adults. Use of the Internet for social purposes was especially strong among girls who, though spending less time on the Internet than boys overall, spent more of their online time sending and receiving e-mail messages.

66. The study included measurements of the number of minutes members of the panel reported talking to other household members, the number of people they reported keeping up with (both locally and nationally), and their levels of daily-life stress, depression, and social support.

67. Results show that the variables of social involvement and psychological well-being measured before respondents got their Internet connections did not predict how much they subsequently used the Internet. Because initial social involvement and psychological well-being were generally not associated with subsequent use of the Internet, 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.

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78. See note no. 77, Turkle, p. 169.

79. See note no. 77, Turkle; see also Richard, B. Digitaler grossanFgriff auf die seelen junger menschen (spiegel). Die sorge um ein virtuelles wesen (tamagotchi). Paper presented at the Self-Socialization, Child Culture, and Media Conference. Germany, University of Bielefeld, 1998.

80. See note no. 79, Richard.

81. The popularity of such simulation, or "virtual life," has continued with the advent of the very popular Furby, an electronic toy with fur, eyes, and ears; a 200-word vocabulary; and the ability to interact with its environment to a limited extent.

82. Schiano, D.J., and White, S. The first noble truth of cyberspace: People are people (even when they MOO). In *Proceedings, CHI '98: Human factors in computing systems.* New York: Association of Computing Machinery, 1998, pp. 352–59. In observations made of more than 4,000 different individuals over a two-week period, more than 75% used only a single character during that period. Of the minority who assumed multiple characters, more than 80% of their participation occurred while they logged in under their main character, suggesting that the use of multiple characters might not be as common as believed.

83. See note no. 77, Turkle, p. 13.

84. Dorr, A. No shortcuts to judging reality. In *Watching and understanding TV: Research on children's attention and comprehension.* P.E. Bryant and S. Anderson, eds. New York: Academic Press, 1983; see also Greenfield, P.M. *Mind and media: The effects of television, video games, and computers.* Cambridge, MA: Harvard University Press, 1984. These works discuss the blurring of reality and fantasy in the television medium.

85. Calvert, S.L., and Tan, S.L. Impact of virtual reality on young adults' physiological arousal and aggressive thoughts: Interaction versus observation. In *Interacting with video.* P.M. Greenfield and R.R. Cocking, eds. Norwood, NJ: Ablex, 1996, pp. 67–81.

86. See note no. 77, Turkle, p. 11.

87. PC Meter data uses computer tracking. See note no. 10, Coffey and Stipp. Alternatively, in the Experience Sampling Method, participants are paged and asked to record their activity when paged. See Kubey, R., and Larson, R. The use and experience of the new video media among children and young adolescents. *Communication Research* (1990) 17:107–30.