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Seven Fears and the Science of How Mobile Technologies May Be Influencing Adolescents in the Digital Age

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Abstract

Close to 90% of U.S. adolescents now own or have access to a mobile phone, and they are using them frequently. Adolescents send and receive an average of over 60 text messages per day from their devices, and over 90% of adolescents now access the Internet from a mobile device at least occasionally. Many adults are asking how this constant connectivity is influencing adolescents' development. In this article, we examine seven commonly voiced fears about the influence of mobile technologies on adolescents' safety (e.g., cyberbullying and online solicitation), social development (e.g., peer relationships, parent–child relationships, and identity development), cognitive performance, and sleep. Three sets of findings emerge. First, with some notable exceptions (e.g., sleep disruption and new tools for bullying), most online behaviors and threats to well-being are mirrored in the offline world, such that offline factors predict negative online experiences and effects. Second, the effects of mobile technologies are not uniform, in that benefits appear to be conferred for some adolescents (e.g., skill building among shy adolescents), whereas risk is exacerbated among others (e.g., worsening existing mental health problems). Third, experimental and quasi-experimental studies that go beyond a reliance on self-reported information are required to understand how, for whom, and under what conditions adolescents' interactions with mobile technologies influence their still developing social relationships, brains, and bodies.

Keywords

mobile technologies, adolescent development, cyberbullying, parental monitoring, peer relationships, online safety, multitasking, cognitive performance, sleep

Adolescents spend much of their day texting, exploring the web, and interacting with their mobile devices (Rideout, Foehr, & Roberts, 2010). Most adolescents are using mobile technologies and are doing so frequently: 88% of adolescents in the United States now own or have access to a mobile phone and 91% of adolescents report going online from these devices at least occasionally, with 24% of adolescents reporting that they go online "almost constantly" (Lehart, 2015). The question is no longer whether adolescents are using mobile technologies but rather how, why, and with what effects. With adolescents sending and receiving an average of 67 text messages per day from their phones (Lenhart, 2015), and with 80% of adolescent mobile phone owners reporting that they sleep with their phone (Lenhart, Ling, Campbell, & Purcell, 2010), many parents, educators, and policy makers are asking whether adolescents' frequent use of mobile technologies is having a negative influence on their development. *Mobile* (or *new*) *technologies* are defined throughout as mobile devices that provide almost constant connection to others and the online world, including access to social networking tools, text messaging, and the Internet.[1]

Common Fears About the Effects of Adolescents' Use of Mobile Technologies on Development

Concern among adults over how young people are using their time is not a new phenomenon. Generations of parents, teachers, and other adults have worried about whether exposure to new forms of media—including the

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radio (Heisler, 1948; Longstaff, 1936), comic books (Thrasher, 1949), television (Maccoby, 1951), video games (Egli & Meyers, 1984), and violent media (Anderson et al., 2010; Ferguson & Kilburn, 2010)—is harming children. In this review, we evaluate the most recent set of fears about adolescents' interactions with new technologies. The list of fears we review is not exhaustive; rather, the selections are based on the following: (a) results from large-scale surveys of parents detailing aspects of new technologies that concern parents the most, (b) in-depth interviews with parents of adolescents participating in our own studies of adolescents using mobile phones, and (c) a review of recent media coverage related to adolescents' use of new technologies.

Parents responding to large-scale surveys consistently cite online safety as a primary concern (boyd & Hargittai, 2013; Madden, Cortesi, Gasser, Lenhart, & Duggan, 2012). For example, in a recent survey of 1,000 parents of children between 10 and 14 years of age, 63% of parents reported being extremely concerned that their child may meet a stranger online, and 1 in 3 parents were extremely concerned that their child would be a victim of cyberbullying (boyd & Hargittai, 2013). Many parents (69%) also report being worried about their adolescents' online activities and how their children are managing their reputations online (Madden et al., 2012). In our own interviews with 141 parents of young adolescents (Russell, Odgers, & Wang, in press), parents also commonly voiced concerns about not being able to keep pace with their tech savvy adolescents and being unable to effectively monitor their children's online behavior and safety.

When identifying commonly expressed fears, we also considered how adolescents' use of new technologies has been framed in the popular press, as media coverage can both capture, albeit not always accurately, and influence societal fears. Common themes that emerged included the following: concerns about cyberbullying and its effects on victims (e.g., see Hoffman's, 2010, article "As Bullies Go Digital, Parents Struggle to Catch Up" in *The New York Times*), fears that time spent on devices is interfering with adolescents' ability to develop effective social and relationship skills (e.g., see Turkle's, 2011, book *Alone Together: Why We Expect More From Technology and Less From Each Other* and Fowlkes's, 2012, piece "Viewpoint: Why Social Media Is Destroying Our Social Skills" in *USA Today*), concerns that multitasking on devices is impairing cognitive performance (e.g., see Conley's, 2011, article "Wired for Distraction: Kids in Social Media" in *Time Magazine*), and claims that device usage is causing adolescents to lose sleep (e.g., see Holson's, 2014, piece "Social Media's Vampires: They Text by Night" in *The New York Times*). Although several additional fears emerged from our examination of media coverage,[2] the seven fears selected for this review (see Table 1) reflect areas in which there was evidence that parents were also concerned about the issue (vs. representing only the views of a reporter or a single high-profile story) and for which there was sufficient research to conduct a balanced review of the topic.

A Focus on the Adolescent Period

In our review of the potential negative effects of mobile technologies, we focus on the *adolescent period*, broadly defined as between 12 and 20 years of age, for three reasons. First, there is a close congruence between the key features of how mobile devices are typically used and critical developmental tasks required during adolescence. For example, communication among peers naturally increases in terms of both frequency and intensity during adolescence (Larson & Richards, 1989; Raffaelli & Duckett, 1989). Friendships are viewed as critical venues for the development of life-long social and relationship skills (for more discussion, see, e.g., Hartup, 1996; Hartup & Stevens, 1997; Newcomb & Bagwell, 1995), and mobile technologies facilitate constant connectivity with peers while also providing new tools for communication. Second, even though adolescents are not alone in their high usage of mobile devices, they are seen as a potentially vulnerable subgroup given the dramatic social, cognitive, biological, and psychological changes that characterize this period (Giedd, 2012). Third, adolescents in the current generation are unique in that they are "born digital";[3] that is, most do not remember a time without access to the Internet and mobile devices (Palfrey & Gasser, 2008). Adolescents are now faced with the challenge of mastering key developmental tasks—including building healthy relationships, gaining autonomy, forming their identity, and transitioning to young adulthood—while fully immersed in the digital age. Thus, updated theories and data are required to understand how adolescents' high engagement with the virtual world may be influencing their development.

We begin our review with two of the most commonly voiced fears by parents—that is, concerns about whom adolescents are interacting with online (Fear 1) and cyberbullying (Fear 2). We then discuss what is currently known about fears that mobile technologies may be interfering with adolescents' offline socialization experiences and friendships (Fear 3), creating a "digital divide" between parents and adolescents (Fear 4), and damaging adolescents' evolving sense of self and identity (Fear 5). Finally, we review research regarding the potential effects of mobile technologies on adolescents' cognitive performance (Fear 6) and sleep (Fear 7). For each fear, we review existing evidence, summarize what is currently known, and identify questions or approaches for future research. The evaluation of how new technologies may be influencing adolescents is hampered by the fact that research on this topic, albeit evolving rapidly, is still in its

Table 1. A Summary of Seven Common Fears, Existing Evidence, and Future Research Directions Related to New Technologies and Adolescent Development

Fear	Fear source	Current understanding	Limitations	Questions for future research
1. Parents worry about whom their adolescents are interacting with online and what type of information they are sharing.	Parental surveys Media reports	The majority of online interactions are with close, offline friends.	Results are based mainly on self-report and observational studies.	How do adolescents' offline and online social networks form and overlap over time?
		Texting content for younger adolescents is mostly positive or neutral.	Relatively few researchers have focused on the content of online exchanges (for an exception, see work by Underwood et al., 2012).	What are adolescents' motivations for sharing sexually explicit materials? Do motivations differ, or not, from offline exchanges of this type?
		A substantial percentage (up to 30%) of older adolescents report sharing sexually explicit materials.		
2. Parents fear that their children will be victims of cyberbullying or be solicited by strangers online.	Parental surveys Media reports In-depth parental interviews	Estimates of victimization related to cyberbullying typically fall between 10% and 40%.	Estimates of cyberbullying involvement vary widely depending on the definition used, age and characteristics of the study members, and the reporting time frame.	What are the immediate and long-term effects of cyberbullying?
		There is a high degree of overlap between offline and online bullying. Similarly, offline risk factors predict online solicitation by strangers.	Nearly all researchers have relied on self-reported involvement in cyberbullying.	Is cyberbullying motivated or predicted by different factors than traditional bullying?
		Victims of cyberbullying are at risk for a wide range of offline problems and report negative feelings following incidents.	Research on online solicitation has relied primarily on older studies of Internet usage and needs to be expanded to the current generation of adolescents who are more constantly connected.	What can be done to increase the reporting of cyberbullying?
		Programs in which traditional bullying has been targeted have also been shown to reduce cyberbullying and victimization.		How does cyberbullying involvement and risk vary across diverse subgroups of adolescents?
3. Adolescents' constant connectivity prevents them from being present in "real life" and interferes with offline socialization experiences and friendships.	Media reports In-depth case studies	Results from the Internet era (1990s to 2000s), when few teens were online gaming or in "chat rooms," may differ from findings today as the vast majority of adolescents are online and communicating frequently with offline friends and family members.	The majority of evidence is based on self-reported technology use and relationship quality/skills.	How do adolescents' offline risks and characteristics moderate the potential positive and negative effects of their online exchanges?
		Adolescents who report more frequent online communication also report higher offline friendship quality.	Experimental and longitudinal research designs are needed to facilitate causal inference.	What skills are required and built during online exchanges? How do these skills differ from the development of traditional relationship and social skills?
		Longitudinal studies support a "rich-get-richer" hypothesis, in which children with strong relationships engage in more online interactions and, in turn, report higher friendship quality as adolescents.	Effects should not be expected to be uniform across adolescents and are likely to vary by offline characteristics and contexts (e.g., shy adolescents who communicate online may build skills, but adolescents with other vulnerabilities, and who replace in-person interactions with time online, may exacerbate symptoms)	Most online interactions take place with existing offline friends, but how do online-only friendships form and develop? Do these friendships confer benefits, particularly among adolescents who may be isolated or otherwise vulnerable?
		Experimental research has shown that online interactions can help both adults and adolescents "bounce back" emotionally following social exclusion.		How do adolescents use online tools to recover or cope with offline stressors or events?

(Continued)

Table 1. *(Continued)*

Fear	Fear source	Current understanding	Limitations	Questions for future research
4. Mobile phones are creating a "digital divide" between parents and adolescents.	Media reports In-depth parental interviews	Additional time spent online by adolescents may displace in-person time with parents but is not associated with lower relationship quality.	Nearly all research to date has been correlational and has relied on self-reported measures of relationship quality and device usage.	Does virtual communication have unique effects (e.g., enhanced autonomy, decreased parental knowledge) controlling for offline relationship factors?
		New technologies provide increased opportunities for connections between parents and children when separated (e.g., shared custody, college transition, children of migrant workers), but the quality of the communication is likely to reflect offline relationship quality.	Very few studies include both parents' and adolescents' views on the role of new technologies in enhancing or detracting from relationships.	How does virtual parental monitoring compare with in-person monitoring strategies in predicting adolescent behavior and disclosure?
		Parents can more closely monitor their children's behavior using new technologies, but, as in traditional forms of parental monitoring, child-initiated contact and disclosure are the key predictors of parental knowledge.	Additional research with diverse populations of adolescents—including immigrant children, first-generation college students, and others—is needed.	Do adolescents feel more comfortable disclosing information about sensitive topics to their parent online than they would in person?
5. Adolescents are experimenting with alternate identities online while leaving a digital archive of data that may damage their sense of self and future lives.	Parental surveys	Adolescents are using a variety of different online forums (e.g., social media profiles, blogs, posts, videos) for self-expression.	Most researchers in this area have relied on case studies or highly selected samples of adolescents.	Is there a meaningful difference between how adolescents present themselves in online versus offline contexts? How does this representation change over time?
	Media reports	Overall, online representations of self tend to closely mirror offline activities, interests, and personalities.	Adolescents' use of online spaces is evolving quickly, making it difficult for research to remain current.	How are adolescents using online tools and interactions to advance their identity development and resolve related crises?
		Ethnographic research suggests that adolescents use online interactions to promote a sense of belonging and self-disclosure, especially around sensitive topics (e.g., sexual identity in LGBTQ youth).	Large scale and representative studies on this topic are lacking, as are more in-depth studies with potentially vulnerable subgroups of adolescents.	Does the accumulation of digital dossier across adolescence influence future educational, employment, or relationship prospects? Are there "identity costs" associated with online exploration during adolescence?

(Continued)

Table 1. *(Continued)*

Fear	Fear source	Current understanding	Limitations	Questions for future research
6. Constant multitasking on mobile devices is impairing adolescents' cognitive performance.	Parental surveys Media reports	The current generation of adolescents spends an unprecedented amount of time consuming media and multitasking. Experimental research with adults has demonstrated negative effects of multitasking on cognitive performance.	The majority of the research to date is with college students and needs to be extended to "Generation M" adolescents.	Are there short- or long-term neurological effects predicted by media multitasking? Are adolescents (versus children or adults) especially vulnerable to these effects?
		Media-related multitasking among college students is associated with lower grades, less time studying, and more missed classes.	Much of the work on media multitasking is correlational or quasi-experimental and often has not accounted for newer forms of media distractions (e.g., texting and driving).	Are mobile devices interfering with activities that require sustained attention, such as driving among adolescents?
		Young adults who report heavy multitasking are more easily distracted in experimental studies.		Are adolescents more likely (than children or adults) to experience interference in task completion and/or sustained attention due to media multitasking?
7. Adolescents are losing sleep because of their devices.	Parental surveys Media reports	Most U.S. adolescents use or sleep with their mobile devices at night, which is associated with poorer quality and less sleep, as well as next day reports of fatigue.	The majority of research with adolescents has been based on self-reported device usage and sleep quality.	What are the independent effects of time, content, and light emission on adolescents sleep, and what can be done to offset the negative effects?
		Mobile technologies are thought to impair adolescents' sleep by (a) displacing sleep time, (b) introducing emotionally arousing content, and (c) emitting light that interferes with melatonin activity and sleep rhythms.	Most research to date has been correlational, and although evidence is consistent across studies, experimental research is needed.	Can the link between sleep disruptions and late-night tech use be effectively studied outside of the laboratory with ambulatory sleep monitoring devices and unobtrusive device usage measures?
		Experimental research with adults shows disruption to the circadian clock, less sleep, and reduced next morning alertness after reading from an iPad versus a book.		

Note: *Parental surveys* include a representative phone-based survey of 802 parents of adolescents 12–17 years of age in the United States in 2012 gathered by the Pew Research Center (e.g., Madden, Lenhart, Cortesi, et al., 2013; Madden, Lenhart, Duggan, Cortesi, & Gasser, 2013), a survey of more than 1,000 parents of 10- to 14-year-old adolescents (boyd & Hargittai, 2013), as well as other smaller and more selective parent surveys. *In-depth parental interviews/case studies* refer to qualitative interviews with parents of 151 adolescents participating in our mobile-phone-based research study (Russell et al., in press) as well as case studies provided by other authors (e.g., boyd, 2014; Buckingham, 2008; Turkle, 2011). *Media reports* show how concerns related to adolescents and new technology (over)use were covered in major news outlets in the United States between 2011 and 2014.

infancy. Throughout the article, we emphasize the need for more rigorous study designs that will enable researchers to isolate whether documented associations are driven by the use of new technologies per se versus simply reflecting adolescents' offline preferences and characteristics. When possible, we suggest steps that parents, teachers, and policymakers can take to promote positive development among adolescents in the digital age.

Fear 1: Parents Worry About Whom Adolescents Are Interacting With Online and What Type of Information They Are Sharing With Others

Adolescents in the United States are spending an unprecedented 7.50 hr a day, on average, consuming electronic media, including about 1.50 hr spent text messaging and an additional 0.50 hr spent interacting with social media (Rideout et al., 2010). Outside of school, text messaging is the most frequent form of daily communication among adolescents (Lenhart, 2012). Many parents report being concerned about whom their adolescents are interacting with online (boyd & Hargittai, 2013). However, research has consistently shown that online versus offline networks look very similar. For example, in a 3-day diary study of 261 middle and high school students, Gross (2004) found that communication with strangers was infrequent and that most online messages were exchanged among close, offline friends. In a more recent study, Reich, Subrahmanyam, and Espinoza (2012) focused on adolescents' interactions on social networking sites and found that adolescents (n = 250) reported interacting with more than 77% of their social network friends in face-to-face settings. Reich et al. concluded that, for the most part, adolescents were using these spaces to "interact with people from their known, offline worlds" (p. 365). Finally, in one of the few studies to go beyond self-reported information, Underwood, Ehrenreich, More, Solis, and Brinkley (2015) analyzed a 4-day sampling of text messages from 171 young adolescents and reported that 70% of all text messages were classified as interactions among friends/peers, followed by romantic partners (21%) and parents (3%), with only 1% of text messages being sent to other adults.

Thus, for most adolescents, the most common daily online activities appear to be connecting with existing offline friends and managing social relationships. With that said, to date, researchers have primarily relied on self-reports of online exchanges and friendship networks. To overcome these methodological limitations, real-time, unobtrusive monitoring of mobile phone logs, data sharing, or other forms of virtual communication are needed. In addition, social network analysis models are required to capture the complexity of adolescents' online networks and their evolution over time.

Many parents and educators also worry about the content of adolescents' online exchanges. In past research, the focus has primarily been on whom adolescents are communicating with online and how frequently they are exchanging information. Some investigators have asked adolescents to voluntarily share copies of their text messages. However, few studies have conducted unfiltered content analyses of adolescents' online exchanges. As an important exception, the "Blackberry Project" was a naturalistic study in which researchers analyzed the content of thousands of text messages from 174 14-year-old adolescents over two, 2-day assessment periods (see Underwood, Rosen, More, Ehrenreich, & Gentsch, 2012; Underwood et al., 2015). In-depth coding revealed that most messages sent by young adolescents (77%) were positive or neutral in content (Underwood et al., 2015), and only a small fraction of the messages contained sexual (6.7%) or profane language (7%; Underwood et al., 2012). This study was pioneering in that it provided one of the first attempts to capture the content of online exchanges. Future studies that unobtrusively capture adolescents' often complex and sophisticated online communication patterns are needed (for a fuller discussion and important exceptions to this limitation in past research, see work by Marwick & boyd, 2010; Marwick & Ellison, 2012; Underwood et al., 2012; Williams & Merten, 2008).

Most text messages sent by younger adolescents appear to be positive or neutral. However, reports of digital data sharing indicate that many older adolescents are sharing sexually explicit materials online. Although estimates vary across studies, a survey of 1,034 adolescents in 10th grade (15–16 years of age) from a large, urban school in Texas found that 20% of students reported sending a nude picture, semi-nude picture, or sexual text-only message, whereas 30% of students reported receiving such as message (Fleschler Peskin et al., 2013). In another Texas-based study of 14- to 19-year-olds (n = 964), 28% of adolescents reported sending a naked picture of themselves through text or e-mail (Temple et al., 2012). Similarly, among a probability sample of 1,839 students in Los Angeles high schools, 15% reported sending a sexually explicit message or video (Rice et al., 2012). In a separate study of 606 students from a private school in the southwestern United States, 20% reported sending a sexually explicit photo of themselves (Strassberg, McKinnon, Sustaita, & Rullo, 2013). Although most of these images were sent to romantic partners, the content is easily shared beyond the intended recipient. For example, 1 in 4 U.S. adolescents have reported that they have forwarded a sexually explicit cell phone picture (Strassberg et al., 2013). In

contrast to these findings, in a survey of 1,560 youth Internet users, Mitchell, Finkelhor, Jones, and Wolak (2012) found that only 2.5% of adolescents reported appearing in or creating nude or nearly nude pictures. However, the estimates provided by this study have been criticized because of the reliance on a primarily young sample (25% of the sample was between 10 and 12 years of age) and the use of telephone-based interviews where privacy was not guaranteed (see Strassberg et al., 2013, for a fuller discussion).

To summarize, we have learned that (a) there is a significant degree of overlap between online versus offline friendships and (b) much of the content of these high-frequency exchanges among younger adolescents appears to be positive or neutral; however, (c) a significant percentage of older adolescents reported participating in "sexting." Although estimates vary depending on how sexting is defined, the ease at which photos and videos can be created and shared via new technologies is creating some new risks for adolescents in the online world. Future studies in which researchers go beyond counting how many and to whom adolescents send messages are needed. More specifically, a more intensive focus on both the content and motivations underlying online exchanges is required to understand what these types of online behaviors may signal for adolescents' offline relationships and adjustment.

Fear 2: Parents Fear That Their Children Will Be Victims of Cyberbullying or Will Be Solicited by Strangers Online

Parents have always been very concerned about the safety of their children. With the introduction of new technologies, new fears have been introduced (e.g., the idea that strangers will contact and victimize their children online), whereas other fears have been amplified (e.g., concerns that their children will be more easily harassed and victimized by their peers). Given the constant connectivity and challenges in monitoring online behaviors, it is no surprise that online safety is one of the most frequently cited concerns by parents in large-scale surveys (e.g., boyd & Hargittai, 2013). For example, among a national sample of more than 1,000 U.S. parents of children between 10 and 14 years of age, more than 90% of parents expressed some level of concern that their child would be a victim of bullying online, and close to 80% reported being "very" or "extremely" concerned that their child would meet a stranger online (boyd & Hargittai, 2013).

Parents fear cyberbullying because it is more difficult to monitor than traditional bullying, allows perpetrators to remain anonymous, and may enter their child's life at any time of day or night. *Cyberbullying* is typically defined as aggression that is intentionally and repeatedly carried out via electronic mediums, such as text messages and social networking sites (Kowalski, Giumetti, Schroeder, & Lattanner, 2014). Cyberbullying is one of the few areas in which a substantial amount of data regarding the possible effects of online interactions on adolescents' lives now exists. A review of the information assembled in a recent meta-analysis of 131 studies by Kowalski et al. (2014) illustrates the following:

1. Estimates of victimization related to cyberbullying among adolescents typically fall between 10% and 40% but vary widely depending on the definition of cyberbullying, the age and characteristics of the study members, and the reporting time frame.
2. There is a substantial degree of overlap between adolescents who bully others offline and those who engage in cyberbullying; similarly, victims of cyberbullying are often victimized offline.
3. Adolescents who experience cyberbullying are at increased risk for a wide range of mental and physical health problems.

Cyberbullying has been a growing source of concern among educators, parents, and the media over the last decade. However, in a recent analysis of large-scale longitudinal studies, Olweus (2012) concluded that cyberbullying has a much lower prevalence than traditional bullying, has not increased in the last 5–7 years, and has not produced many new bullies or victims. This examination of traditional and cyberbullying involvement among more than 440,000 U.S. students converged on the following points. First, 17.6% of students, on average, reported being verbally bullied (offline bullying) between 2007 and 2012, versus 4.5% of youths who reported cyber victimization. Second, 9.6% of youths, on average, reported bullying others offline across this time period, versus 2.8% of youths who reported cyberbullying. Olweus also presented very similar patterns of findings from a large sample of Norwegian students (n = 9,000) drawn from more than 41 schools and followed from 2006 to 2010. Findings across both samples illustrate that significantly more youths were involved in traditional versus cyberbullying across this time period. Third, no significant increases in cyberbullying involvement were observed over time despite the increasing accessibility and use of mobile phones during this period. Fourth, an extremely high degree of overlap between cyberbullying and traditional bullying was observed. That is, among reported victims of cyberbullying, close to 90% had experienced traditional forms of bullying. Similarly, among the students who reported cyberbullying others, approximately 90% also reported bullying others offline. That is,

only 1 in 10 of reported cyber victims/bullies did not report a history of victimization/bullying offline.

Although cyberbullying may have a lower prevalence than traditional bullying and may not create a large number of new victims, being a victim of cyberbullying is routinely associated with a number of negative outcomes. Most victims report negative feelings—such as embarrassment, worry, fear, depression, loneliness, or anger—after cyberbullying events (Ortega et al., 2012). The severity of both offline and online bullying events has been shown to predict future psychopathology, including suicide ideation and self-harm (Hinduja & Patchin, 2010); furthermore, findings from a recent meta-analysis indicate that cyberbullying relates more strongly to suicide ideation than traditional bullying (Van Geel, Vedder, & Tanilon, 2014). Already marginalized adolescents—such as lesbian, gay, bisexual, and transgender youths—also report significantly more frequent online attacks than heterosexual youths (Finn, 2004). More generally, cyber victims are also likely to have significant mental health and social problems (Kowalski & Limber, 2014; Ybarra, Diener-West, & Leaf, 2007; Ybarra & Mitchell, 2004). Thus, cyberbullying may not create many new victims, but it may exacerbate problems for already vulnerable adolescents.

In sum, many adolescents at risk for cyberbullying are also at risk for traditional bullying and victimization. As in traditional bullying, many adolescents report not wanting to "tattle" on their peers and report feeling that adults cannot help their situation (E. K. Englander, 2013). However, bullying within online contexts appears also to introduce new risks (e.g., potential for anonymity, a large audience, and a digital record) and may be driven by different motivations than traditional bullying. Most victims can identify their bullies as classmates or friends (Juvonen & Gross, 2008), but some cannot definitely name their attackers either because they were strangers or because of the anonymity provided by the virtual setting (Kowalski & Limber, 2007). If cyberbullies remain anonymous, then bullies may never learn the consequences of their actions, and victims may experience greater distress and feel less in control of their online activities. A more nuanced picture of the social dynamics of online bullying is required to understand how cyberbullying attacks influence social networks and whether, because of their immersion in the digital world, it may be especially difficult for adolescents to avoid unwanted harassment. Indeed, one of the reasons that adolescents report not wanting to report bullying experiences is a fear that their parents will take away their devices (E. K. Englander, 2013).

Given the high degree of overlap between offline and online bullying, the case has been made that cyberbullying should be viewed and treated in the context of traditional bullying (for a discussion, see Olweus, 2012). Empirically based guidelines for the creation of intervention programs targeting both traditional bullying and cyberbullying are available (Olweus, 1994, 2012), and promising programs now exist. For example, results from a randomized trial of an antibullying program delivered across 78 schools in Finland showed decreases in multiple forms of victimization, including cyberbullying (Salmivalli, Karna, & Poskiparta, 2011; Williford et al., 2012). It is also possible that new technologies can be used to assist victims targeted by both offline and online bullying. Adolescents may be encouraged to share their stories, seek support for mental health problems, and visit antibullying websites (e.g., Burns, Durkin, & Nicholas, 2009). Unfortunately, although many adolescents report cyberbullying incidents in anonymous research surveys, most youths still do not report either traditional or cyberbullying to their parents or teachers (Blumenfeld & Cooper, 2010; Juvonen & Gross, 2008). New strategies are required to create safe environments for victim disclosure.

In this section, we have focused primarily on online victimization among peers, as most communications in which new technologies are used occur among similar-age peers who know each other offline. However, one of the most commonly voiced fears among parents is that their child will be solicited by a stranger online (boyd & Hargittai, 2013). A relatively large body of research exists regarding Internet solicitation risk and demonstrates that, for most adolescents, the risk of being solicited or victimized by a stranger in the virtual world is relatively low. Internet-initiated crimes have accounted for approximately 7% of all child sex crimes (Wolak, Finkelhor, Mitchell, & Ybarra, 2008), and estimates based on a national sample of 10- to 17-year-olds (n = 1,500) have indicated that approximately 1%–3% of 10- to 12-year-olds and 5%–6% of 13- to 17-year-olds had experienced attempts to make offline contact or reported experiencing distressing sexual solicitation (Mitchell, Jones, Finkelhor, & Wolak, 2013). In addition, the targeting of potential victims online does not appear to be random (Wolak et al., 2008). Adolescents with offline risks, such as substance use or delinquency, are more likely to be sexually solicited online (Ybarra et al., 2007). Notably, simply posting information about oneself does not appear to increase risk (Lenhart & Madden, 2007; Madden, Lenhart, Cortesi, et al., 2013). Rather, it is the *interactive component* of exchanges with unknown individuals, combined with offline risk factors, that is most predictive of solicitation and harassment (for a review, see Wolak et al., 2008). There has been very little research on how the introduction of mobile devices (vs. prior Internet use at a stationary terminal in the child's home or school) may be influencing adolescents' risk for online solicitation. It is possible that the interactive components of new

technologies (e.g., easy access to cameras, geo-location features, and greater sharing of information), combined with a greater number of adolescents online, especially younger adolescents, may elevate risk. In sum, additional research is required to understand whether risks for online solicitation have changed with the introduction of mobile technologies.

Fear 3: Adolescents' Constant Connectivity Prevents Them From Being Present in "Real Life" and Interferes With Offline Socialization Experiences and Friendships

In her most recent book *Alone Together: Why We Expect More From Technology and Less From Each Other*, Turkle (2011) analyzed a set of case studies and argued that new technologies are interfering with everyone's (but especially young people's) ability to effectively communicate and achieve closeness in relationships. From this perspective, groups of adolescents seen interacting with their phones (rather than each other) are characterized as spending time "alone together" and missing out on important socialization experiences. Early research on the Internet in the 1990s tended to support the idea that online interactions with strangers were occurring at the expense of existing relationships (for a review, see Valkenburg & Peter, 2009). However, in these early studies, researchers captured online exchanges that were bounded by the state of the Internet at that time; that is, with less than 10% of adolescents online daily, more than half of adolescents never accessing the Internet (Mesch, 2001), and with chat rooms typically used for interactions among strangers, the virtual context looked much different at that time than it does today (Valkenburg & Peter, 2009).

Today, most adolescents are online, and most online exchanges occur among peers who also identify as friends offline (see summary of research in Fear 1). For the most part, research over the last decade has found that adolescents who report more frequent online communication also report higher quality friendships. For example, using a survey of more than 1,200 Dutch preadolescents and adolescents, Valkenburg and Peter (2007a) found positive associations among the time adolescents spent online, frequency of chats with friends, quality of friendships, and well-being. In general, online communication was primarily used to contact existing friends, and more online chats with friends predicted higher friendship quality and well-being in "real" life. In addition, adolescents who reported chatting more versus less often with friends online also spent more time with friends in person. Similarly, adolescents (n = 2,000) in a large study in Bermuda who reported more frequent online communications with friends also reported higher perceived friendship quality (Davis (2013). Consistent with these findings, a major theme that has emerged from in-depth interviews with smaller samples of adolescents is that online communication among friends promotes self-disclosure and feelings of belonging (Davis, 2012). Theoretically, Valkenburg and Peter (2009) have argued that the greater ease of online self-disclosure (communication about personal topics not easily disclosed in person) accounts for the positive associations observed between online communication and social connectedness within contemporary studies.

Because most researchers to date have relied on self-reported information and cross-sectional data, it is difficult to determine whether the use of online tools is strengthening existing relationships or, alternatively, whether adolescents with strong relationships are simply more likely to engage in frequent online interactions. In one of the few studies in which this question was addressed, multi-informant data from the Child Development Supplement from the Panel Study of Income Dynamics (n = 1,312) showed that children with stronger relationships early in life (prior to 12 years of age) were more likely to use online communication frequently in adolescence (evidence of social selection) and, in turn, to report having more close and cohesive friendships (evidence of social causation; Lee, 2009). This set of findings is cited as supporting the "rich-get-richer" hypothesis, originally forwarded by Kraut et al. (2002), in which those with strong existing social networks and skills are the most likely to benefit from online interactions. Perhaps the most convincing evidence regarding the potential benefits of online communication stems from one of the few experimental studies conducted to date. Following experimentally induced social exclusion, young adult and adolescent participants who were assigned to instant messaging versus solitary game play reported greater replenishment of self-esteem and perceptions of being accepted, valued, and respected (Gross, 2009). Online messaging versus solitary game place also resulted in a greater reduction of negative affect among adolescents as compared with adults. These findings suggest that online exchanges may help adolescents to "bounce back" emotionally following an experience of social rejection or isolation.

There is also reason to believe that time spent online may be beneficial for skill building and enhanced well-being among those with existing vulnerabilities (Bardi & Brady, 2010; Valkenburg & Peter, 2007b). For example, shy college students report that they Instant Message to increase interpersonal contacts, improve fluency of in-person conversations, and decrease loneliness (Bardi & Brady, 2010). Additionally, the use of Facebook among

college students has been positively associated with building and maintaining multiple forms of social capital, with evidence that Facebook usage may provide the greatest benefits for at-risk students (those experiencing low-self esteem and life-satisfaction; Ellison, Steinfield, & Lampe, 2007). Additional research in which larger community- versus college-based samples are used is required to understand how adolescents with existing vulnerabilities are spending their time online. In addition, experimental studies in this area are sorely needed and, as illustrated by Gross (2009), offer the ability to disentangle the effects of online experiences per se from how certain types of individuals choose to engage with new technologies.

Online conversations may help build networks and confidence for some young people. However, they may also mark or exacerbate problems for individuals with existing mental health problems. For example, among Dutch adolescents with low friendship quality, greater technology use has been associated with inflated feelings of loneliness and isolation over time when used for entertainment rather than communication (Selfout, Branje, Delsing, ter Bogt, & Meeus, 2009). In a naturalistic observational study of U.S. adolescents, Underwood et al. (2015) reported that adolescents who sent a greater number of text messages characterized by negative content (i.e., negative talk to or about others) were more likely to suffer from informant-reported internalizing and depressive symptoms; however, there was little evidence that the frequency of texting predicted emotional problems. Findings from this study also illustrated that adolescents whose text messages contained antisocial themes were more likely to experience increases in parent-reported, teacher-reported, and self-reported antisocial behavior over time (Ehrenreich et al., 2014). These findings are important, as they go beyond simply characterizing the frequency of online exchanges and instead begin to address what the content of exchanges may signal for offline development. This study was also novel in that the researchers integrated information from multiple informants, whereas in most studies, researchers have relied on single informant and self-reported information.

To summarize, time spent online may displace in-person interactions, but there is little evidence to date that it reduces friendship quality or leads to social isolation. For the most part, adolescents appear to be using mobile technologies to communicate and stay connected to existing friends and, in turn, may be strengthening the quality of existing relationships. Although primarily correlational, young people who replace in-person exchanges with time spent online appear to intensify their social impairments, whereas those who use online exchanges to supplement existing friendships report improvements in the quality and closeness of their existing relationships. However, it is important to note that in nearly all of the studies reviewed, researchers have relied on self-report data and nonexperimental study designs, making it difficult to discern whether technology usage per se is influencing outcomes (for a key exception, see Gross, 2009). Moving forward, experimental studies delivered via mobile devices are needed to begin testing for whom and under what conditions online activities may influence key aspects of adolescents' friendships and social development.

Fear 4: Mobile Phones Are Creating a Digital Divide Between Parents and Adolescents

Many parents worry that the constant use of mobile phones by their teens is interfering with their ability to effectively communicate with their children. Although research has shown that adolescents' time spent online displaces face-to-face interactions with parents, moderate technology use does not appear to predict declining parent–child relationship quality (Williams & Merten, 2011). For example, in a U.S.-based diary study, Lee (2009) monitored the amount of time adolescents spent online versus interacting with others in person. Adolescents who reported higher versus lower levels of time online also reported spending less time with their parents. However, there were no differences in the child-reported quality of those parental relationships by time spent online (Lee, 2009). Some studies have shown that higher than average reported Internet use by adolescents is associated with lower quality parental relationships, including parental attachment and knowledge (e.g., Willoughby, 2008). However, it is not clear whether technology use per se is affecting the relationship or whether patterns of virtual parent–child communication are simply correlates of the existing offline relationship. Finally, there is some evidence that the shared use of new technologies across generations can foster stronger ties via more frequent parent–child contact. Families may engage in shared learning or play using new technologies (see, e.g., research on video game play: Coyne, Padilla-Walker, Stockdale, & Day, 2011), and interviews with a small sample of U.S. college students suggests that mobile phones may increase the frequency of adolescents' communications with parents when they are apart and, subsequently, improve the quality of parent–child relationships (Chen & Katz, 2009).

One thing that appears to matter is who is initiating contact. On the one hand, new technologies can provide adolescents with quick, easy, and remote access to their parents. Adolescents who report calling their parents for support more often report better family cohesion and parental knowledge (Weisskirch, 2009). On the other

hand, parents who call their children more frequently may not necessarily know more about their child's behaviors. In families or situations in which conflict is high, constant communication between parents and adolescents may exacerbate tensions. For example, among a sample of 196 parent–child dyads, frequency of parental calls was negatively related to adolescent-reported truthfulness (Weisskirch, 2009). Similarly, parents who reported frequently calling their child when they were upset or for the purposes of monitoring also reported less knowledge of their child's activities and poorer parent–child interactions than parents who relied on adolescent-initiated contact (Weisskirch, 2009, 2011).

One novel feature that mobile technologies offer is the potential for tech-savvy parents to unobtrusively monitor their adolescents' behaviors, including monitoring the content of their online posts or exchanges and tracking their location. Findings based on a 2012 nationally representative phone survey of 802 U.S. parents and their teens indicated that most parents, especially those of younger teens, are taking steps to monitor their children's online activities (Madden et al., 2012). That is, 50% of parents of online teens report using parental controls to block, filter, and monitor their children's activities, and 59% of the parents of teens who use social networking sites have spoken with their child about something that concerned them on their account (Madden et al., 2012). However, it is important to note that parental monitoring alone has not been found to change adolescents' behaviors within offline contexts (Kerr, Stattin, & Burk, 2010). Instead, adolescents' own efforts to disclose information, versus parents' attempts to monitor their children, have consistently emerged as the best predictor of involvement in risky behaviors. Given the lack of evidence for a causal association, it is unclear whether enhanced parental monitoring via mobile devices will lead to either increased parental knowledge or changes in adolescents' behaviors. In addition, mobile devices (vs. computers in the home) and rapid changes in the tools that adolescents are using online are making it difficult for parents to effectively monitor their adolescents' online activities and accounts.

To summarize, technology use among adolescents may take away from time spent with parents, but it does not necessarily weaken the parent–child relationship. Existing evidence suggests that if the quality of the parent–child relationship is strong offline, then new technologies may confer benefits. Again, parallels are seen between the relationships that adolescents have in their offline versus online lives. More research is needed to understand how specific forms of virtual communication could be used to strengthen existing relationships, enhance feelings of adolescent autonomy, and increase parent knowledge. For example, experimental research is required to test whether adolescents find it easier to discuss sensitive topics with their parents online versus offline. Again, nearly all of the research conducted to date has been correlational and has relied on adolescent or parent reports to describe relationship quality. Study designs that facilitate causal inference are needed to test whether variations in online communications and monitoring lead to, or simply mark, differences in parent–child relationship quality.

Fear 5: Adolescents Are Experimenting With Alternative Identities Online While Leaving a Digital Archive of Data That May Damage Their Sense of Self and Future Lives

Adolescence has long been viewed as a time of self-exploration and discovery of one's place in the social world (Erikson, 1968; Steinberg & Morris, 2001). Identity formation represents a key developmental task of adolescence involving the resolution of fundamental psychological conflicts or crises. During this process, adolescents become increasingly self-aware of their abilities, limitations, and defining qualities while addressing critical questions about their values and roles in the social world. A successful progression through this stage-based process is characterized by the adolescent arriving at a cohesive, integrated sense of him- or herself in the transition to adulthood (Erikson, 1968; Marcia, 1966). Over the years, the idea that adolescence is a critical period for self-reflection and locating oneself in the social world has held with a slight shift in more recent scholarship to focusing on the development of self-conceptions and self-worth among younger adolescents (Masten et al., 1995) and on ethnic identity development within diverse populations (Phinney, 1989). In short, adolescence is generally viewed as an optimal time for self-exploration and identity consolidation—processes that depend on interactions with peers and caregivers as well as internal self-reflection and consolidation.

Mobile technologies offer a number of opportunities for adolescents to experiment with alternative identities and roles in the virtual world. In particular, there is now a growing body of research showing how adolescents are using digital media for self-expression and experimentation, including the creation of online forums, posts, videos, and the creation of social media profiles (Buckingham, 2008; Calvert, Jordan, & Cocking, 2002; Davis & James, 2013; H. Gardner & Davis, 2013; Subrahmanyam & Smahel, 2011; Turkle, 1995; Williams & Merten, 2008). For example, in his edited volume, Buckingham (2008) has brought together a diverse collection of case studies that illustrate how youths are

engaging with digital tools and networks in ways that encourage adolescents' growing autonomy and need for self-expression—allowing them to generate a "constant presence" and "write themselves into being" (p. 10). Buckingham has also illustrates how technology may be regarded as

> a force of liberation for young people—a means for them to reach past the constraining influence of their elders, and to create new, autonomous forms of communication and community. Far from corrupting the young, technology is seen to be creating a generation that is more open, more democratic, more creative, and more innovative than their parents' generation. (p. 13)

Narrative accounts also suggest that online spaces may offer safe places for some young people to explore sensitive topics about their sexuality and identity (Harper, Bruce, Serrano, & Jamil, 2009). These types of observations have helped to spark an ongoing debate about how the digital age may be influencing identity development among young people.

Consistent with research on adolescent friendships, adolescents' online behaviors and presentations of self tend to closely mirror their offline activities, interests, and personalities. For example, in a daily diary study of virtual messaging in the United States, 1 in 10 adolescents reported frequently using the Internet to pretend to be somebody else, whereas the majority of adolescents reported using the Internet for communication with offline friends on everyday topics (Gross, 2004). In a more recent study of more than 2,000 adolescents in Bermuda, online peer communications have been shown to indirectly influence adolescents' self-concept via their positive influence on friendship quality (Davis, 2013). Similarly, thematic analyses of in-depth interviews with adolescents have indicated that online peer-to-peer communications are often used to promote adolescents' sense of belonging and self-disclosure (Davis, 2012)—two key processes that support successful identity development during adolescence.

Access to the online world may also spark new interests and allow some adolescents to try out new identities in a relatively safe place. In an older survey study of Internet communication, close to 50% of Dutch adolescents (n = 600) reported pushing the boundaries of their identities to reinforce social skills and relationships or, most commonly, for self-exploration (Valkenburg, Schouten, & Peter, 2005). For example, adolescents in this study, especially girls and younger adolescents, pretended to be older or more attractive to see how others online might react to them differently. There are also virtual spaces, such as Second Life, where completely new environments allow for the creation of avatars that can model different social situations and personalities, potentially allowing adolescents to take on new identities and roles (Turkle, 2011). Unfortunately, very little information exists on how most adolescents use these types of virtual spaces. Thus, it is not known whether adolescents are taking advantage of these virtual settings to try out new identities or roles versus simply recreating images that resemble their offline selves.

Small scale case studies have suggested some intriguing possibilities regarding the ways in which adolescents are "repurposing" technology to fulfill their desires or to achieve their goals (e.g., encoding online messages to communicate privately with close peers, monitoring and sharing information online to position themselves in social groups) as well as using online spaces to "take control over their lives, and find ways to be part of public life" (boyd, 2014, p. 212). However, one concern that has been voiced is that online presentations of self are closing adolescents off from face-to-face exploration while encouraging online self-promotion and the need to script a "flawless narrative" about their lives (Turkle, 2011). Indeed, previous interview-based research and content analyses of online posts suggest that adolescents struggle to reconcile wanting to present their lives honestly with wanting to impress others (Bortree, 2005). To date, much of this work has focused on Internet use in general versus mobile technology usage in particular and has drawn from small, selective, or convenience samples.

Another area of expressed concern is that adolescents are leaving digital trails of information that may carry longer term reputational and identity costs. The accumulation of digital data (e.g., adolescents' online communications, photos, and videos) archived online over time has been termed a *digital dossier* (Palfrey & Gasser, 2008). Very little is known about how digital dossiers may influence adolescents' evolving or future sense of self. Symbolic interactionist theorists suggest that negative labels applied to adolescents by others (e.g., "druggie" and "delinquent") may become internalized by the adolescents and ultimately lead to behaviors that are congruent with the label (e.g., Matsueda, 1992). Whereas prior generations of adolescents had the benefit of fading memories around potentially salient incidents (e.g., bullying incident, using drugs or alcohol at a party), online videos and photos may cause adolescents to relive emotionally charged experiences. As the first generation of adolescents who were born digital move through early adulthood, we will need to test how the online archiving of their experiences influences their evolving sense of self and whether there are reputational or "identity costs" associated with these digital archives in young adulthood (e.g., effects on college admissions, employment, and future romantic partners).

To summarize, social scientists are just beginning to understand the ways in which online interactions are influencing how adolescents explore, form, and modify their sense of self over time and, to a lesser extent, how mobile devices are contributing to these effects. Most research has shown echoes of a recurrent theme—that there is considerable overlap in how individuals present themselves to others both online and offline. However, there are important exceptions to this finding, including—for example—the ability of lesbian, gay, bisexual, and transgender youths to more fully explore and develop their identities in safe and shared spaces. Notably, research in this area has been generated from a very diverse set of perspectives, sources, and methodologies. Ethnographic research and narrative reviews have been invaluable in showcasing the diversity of effects that mobile technologies may have on adolescents' still developing sense of self. These studies have also provided powerful illustrations of the challenges that adolescents face when trying to integrate their online and offline personas (for a more detailed discussion, see Buckingham, 2008). However, large-scale longitudinal studies as well as experimentally based studies are now needed (a) to test whether there is anything unique about mobile technologies per se that is influencing identity exploration and formation across adolescence and (b) to evaluate whether online experiences uniquely contribute to adjustment in the transition to adulthood.

Fear 6: Constant Multitasking on Mobile Devices Is Impairing Adolescents' Cognitive Performance

The media has dubbed 21st-century children and adolescents "Generation M" because of the unprecedented amount of time they spend consuming media and multitasking (Rideout et al., 2010). Among adults, experimental studies have consistently shown that multitasking, task switching, or distractions can lead to detrimental effects on immediate cognitive performance (e.g., Altmann, Trafton, & Hambrick, 2014; Rogers & Monsell, 1995). That is, multitasking increases error rates and tends to increase the amount of time that it takes to complete a given task. Adolescents report using new technologies to multitask—for example, talking to a friend while completing their homework online (Gross, 2004)—and both adolescents and college students admit to frequently operating multiple types of new technologies at the same time (Jacobsen & Forste, 2011; Moreno et al., 2012). For example, when adolescents are supposed to be doing homework, students are typically multitasking (Shumow, Schmidt, & Kackar, 2008), and one third of adolescents report media multitasking with some online activity most of the time (Rideout et al., 2010).

Research with college students suggests that multitasking associated with new technologies could have negative effects. For example, college students classified as "heavy users" of new technologies tend to exhibit more academic impairments—such as lower course grades (F. Englander, Terregrossa, & Wang, 2010), less time spent studying (Kirschner & Karpinski, 2010), and a greater number of missed classes (Kubey, Lavin, & Barrows, 2001)—compared with adolescents with average or low usage of new technologies. In addition, students who report frequent multitasking with Instant Messaging while doing schoolwork also report that they believe that these behaviors have a detrimental effect on their work and contribute to lower academic achievement (Junco & Cotten, 2011). However, the causal direction (if any) is unclear, as it is possible that those who tend to use new technologies more frequently for recreation or nonacademic purposes are simply more likely to experience difficulties across domains. Research with adults also suggests that those who engage in high levels of multitasking are often the most easily distracted. In a quasi-experimental study, participants who self-reported more versus less daily multitasking were more distracted by experimental external interference and had lower scores on tests of task switching (Ophir, Nass, & Wagner, 2009). Heavy multitaskers perceive their ability to multitask to be high, but their actual ability is lower than that of light multitaskers (Sanbonmatsu, Strayer, Medeiros-Ward, & Watson, 2013).

Unfortunately, very little is known about how Generation M adolescents are performing in the face of unprecedented changes in the amount of time spent consuming and interacting with new technologies. Experimental paradigms need to be extended to adolescence and reconfigured to account for the unique features of adolescents' development and their use of mobile devices. There is also almost no research on the hypothesized neurological effects of multitasking on individuals using new technologies across adolescence (Giedd, 2012). It may be that the plasticity of the adolescent brain is allowing adolescents to optimize their performance to their new digital worlds, or, conversely, digital overload may be leading to impairments in cognitive abilities and performance. Finally, it will be important to understand how mobile devices may be interfering with tasks that require sustained attention in daily life, such as distracted driving, as more than 1 in 3 driving adolescents report that they have texted while driving (Madden & Lenhart, 2009). Experimental paradigms currently exist for evaluating how adolescents' cognitive performance and decision making are influenced by the presence of peers (e.g., M. Gardner & Steinberg, 2005), and it will be informative to extend these paradigms to evaluate whether the presence of a virtual peer can have similar effects.

Fear 7: Adolescents Are Losing Sleep Because of Their Devices

Adolescents require between 8.5 and 10 hr of sleep per night; yet, most adolescents (58%) are sleeping 7 hr or less per night (Emsellem et al., 2014). Poor sleep habits can lead to physical and mental health problems and are associated with reduced cognitive performance (for a review, see Dahl & Lewin, 2002). Puberty itself has been linked to delayed phase preference, meaning adolescents' brains become naturally wired to stay up and sleep later than children (Carskadon, Vieira, & Acebo, 1993). Research has shown that adolescents are sleeping less than both children and previous generations of adolescents (Iglowstein, Jenni, Molinari, & Largo, 2003). Sleep is one area in which there is now compelling evidence that adolescents' use of mobile technologies is having adverse effects on sleep duration and quality (for a recent review, see Hale & Guan, 2015). There are at least three possible pathways through which new technologies may impair adolescents' sleep: (a) media and device time displaces sleep time, (b) emotionally arousing media or online interactions make it more difficult for adolescents to fall and stay asleep, and (c) bright light from monitors or electromagnetic radiation from mobile phones disturbs melatonin activity and sleep rhythms.

Nearly all (97%) of U.S. adolescents have some type of electronic media (e.g., music player, TV, video games, phone, computer, or Internet) in their bedrooms (Carskadon, Mindell, & Drake, 2006). Adolescents with four or more devices in their bedrooms report greater sleep-related difficulties (e.g., feeling tired) and sleep less on weeknights and weekends than adolescents with three or fewer devices (Carskadon et al., 2006). Late night computer or mobile phone use is related to later bedtimes, less total sleep, greater tiredness, and lower sleep quality (Calamaro, Mason, & Ratcliffe, 2009; Van den Bulck, 2004). Over half of adolescents access the Internet, and more than one third text or talk on their phones after 9 p.m. (Calamaro et al., 2009). In addition, 4 in 5 adolescents in the United States now report sleeping with their phone on or near their bed. Adolescents who use their phone for texting are 42% more likely than adolescent mobile-phone owners who do not text to sleep with their phone by their bedside, and many report leaving their phones under their pillows so that they can respond to texts during the night (Lenhart et al., 2010). Among a large sample of 1,656 young adolescents in Belgium, 62% reported using their mobile phone after lights out (Van den Bulck, 2007). Adolescents who used their mobile phones right after lights out were twice as likely to report being very tired compared with those who did not text after dark. Furthermore, adolescents who used their phones throughout the night were close to four times more likely to report being very tired the next day compared with adolescents who did not respond (or allow) late night phone messages. Thus, media time appears to be displacing sleep time for a significant number of adolescents.

There is also some evidence that emotionally arousing media content and the light emitted from devices interfere with the amount and quality of sleep that adolescents may be receiving. For example, adolescent study participants who were assigned to play an interactive video game before bed were more cognitively alert and took slightly longer to fall asleep than participants who passively watched a movie (Weaver, Gradisar, Dohnt, Lovato, & Douglas, 2010). In a recent laboratory-based experimental study conducted with a small sample of adults (n = 12), Chang, Aeschbach, Duffy, and Czeisler (2014) found that reading a book on a light-emitting device (iPad) in the hours before bedtime versus reading a printed book resulted in a longer amount of time falling asleep, a 50% reduction in melatonin secretion (the sleep-promoting hormone), later timing of the circadian clock (participants melatonin rhythm was more than 1.50 hr delayed), and reduced next morning alertness (Chang, Aeschbach, Duffy, & Czeisler, 2014). Experimental studies of this kind are needed outside of laboratory settings with adolescents in which device use prior to bedtime is common and the amount of exposure time and content varies widely.

In sum, research to date has consistently shown that mobile device and media usage prior to bedtime is associated with reduced sleep time and quality. Although many researchers have relied on self-reported sleep duration and quality (for a review, see Cain & Gradisar, 2010), experimental studies in which researchers manipulate pre-bedtime exposure to new technologies and capture sleep via more objective measures are now emerging (Chang et al., 2014). Future research is required to understand the effects of specific types of media consumption, such as peer messaging, on late night technology use and subsequent sleep quality. It is now possible to use high-quality ambulatory monitors of sleep duration and quality alongside tools that record the frequency and content of online activities. As adolescents' lives become increasingly wired, it will also be important to understand how the use of multiple devices and modes of communication interfere with sleep and what can be done to offset these effects.

Conclusions

In this article, we reviewed seven commonly expressed fears about the effects of ubiquitous new technologies on adolescents' safety, social development, cognitive performance, and sleep. The list of fears examined was not

exhaustive but included concerns that repeatedly emerged across national survey data, in-depth parent interviews, and recent popular press coverage. Three main sets of conclusions from this review are detailed below.

First, although there are cases in which new technologies have introduced new risks to adolescent well-being (e.g., by creating a new platforms for bullying, interfering with sleep, and creating a digital archive that may carry reputational costs), most behaviors and risks that are present in the online world appear to be mirrored offline. For example, there is a high degree of overlap in online versus offline friendship networks (e.g., Reich et al., 2012) as well as in the content of young adolescents' exchanges (see Underwood et al., 2015, for a review). Adolescents at risk of being victimized or solicited in their offline lives are also at a heightened risk for being victimized online (e.g., Kowalski et al., 2014; Olweus, 2012). Similarly, adolescents with high-quality relationships in real life are also likely to be strongly connected and to engage in positive interactions online (e.g., Valkenburg & Peter, 2007a). That is, although new technologies are offering new platforms for adolescents to interact with each other, online behaviors can often be predicted by offline behaviors and characteristics.

Second, the effects of new technologies on adolescent development are not uniform, and researchers should not expect them to be. Adolescents with strong familial and peer relationships exhibit enhanced relationship quality when virtual interactions are also present (e.g., Valkenburg & Peter, 2007b). In contrast, for adolescents who are struggling within existing relationships, high levels of technology use predicts lower well-being and relationship quality (e.g., Weisskirch, 2009). Similarly, shy or isolated adolescents may seek out online interactions to decrease loneliness or to build skills (e.g., Bardi & Brady, 2010), whereas among adolescents with low quality friendships, time spent online for noncommunicative purposes predicts more depression and social anxiety over time (Selfout et al., 2009). Similarly, posting personal information online is not associated with an elevated risk for unwanted sexual solicitation for most adolescents, but it does increase risk for those already at risk offline (Wolak et al., 2008).

Third, prior research has relied heavily, if not almost exclusively, on observational and correlational study designs. Studies that can more readily facilitate causal inference are sorely needed. There is also a need to move beyond the sole reliance on self-reported technology usage and outcomes. Unobtrusive monitoring of online activities, sleep, and physiology are now available through mobile applications and wireless sensors (for a review, see George, Russell, & Odgers, in press). In addition, text-based mining algorithms and advancements in the "Big Data" space are opening up new opportunities to dive deeper into the content and meaning of online exchanges (see, e.g., text-based microcoding methods by Underwood et al., 2012, 2015). This is a rapidly advancing and diverse field in terms of research methods as well as usage patterns among adolescents. To provide more definitive answers to many of the concerns raised by parents and educators, researchers will need enhanced methodological rigor and more innovative study designs. A foundational question for future studies will be whether new technologies are introducing new risks or opportunities or, conversely, whether offline behaviors, preferences, and relationship features are simply mirrored within online spaces.

Future Directions

Many adults have expressed concern that the use of mobile devices and the seemingly constant connectivity among adolescents are impeding their development. Despite these fears, very few uniformly negative effects of new technologies on adolescent development have been documented. With some notable exceptions, many of the effects of new technologies on adolescents' lives have been, or are expected to be, positive. There are also a number of exciting—and testable—ideas about the effects of the digital world on still developing adolescents. For example, some have suggested that high exposure to multitasking and digital media during this sensitive period could "rewire" the brain in ways that diminish concentration and hinder performance, whereas others cite the adaptability of the adolescent brain as allowing for optimization to the digital world (for a review, see Giedd, 2012). In addition, mobile health platforms offer the tools for evaluating the mechanisms through which technology may influence adolescents' development as well new ways of fielding and evaluating interventions (George et al., in press). The medical field has already implemented mobile-phone-based interventions that are effective in disease management and promoting healthy behaviors (for a review, see Cole-Lewis & Kershaw, 2010), and this could be an incredibly positive direction for psychological science (Schueller, Muñoz, & Mohr, 2013). Thus, even though our review is framed around seven fears related to new technology, our conclusions point to a number of promises of new technology for adolescent development, and we end with a call for future studies that can isolate how, for whom, and under what conditions new technologies are influencing the lives of adolescents.

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Notes

1. The Internet, social networking sites, and mobile devices are not separate media. Adolescents often access multiple types of media or use them simultaneously, such as using a mobile phone with Internet access to post a message on Facebook (Rideout et al., 2010).
2. Several additional fears were noted frequently in the popular press but were not included in this review because of insufficient empirical research on the topic, a lack of evidence that sufficient numbers of parents were also concerned about the topic, and space limitations. These additional fears included the following: concerns that adolescents were becoming addicted to technology and/or gaming, fears that the reliance on truncated messaging and digital communication may be influencing communication and writing skills, and claims that mobile phones are physically damaging children's brains.
3. The term "born digital" is used by Palfrey and Gasser (2008) in their book *Born Digital: Understanding the First Generation of Digital Natives*. "Digital natives" is a term coined by Prenksy (2001) to refer to individuals who were born after about 1980 and who have grown up immersed in a culture of computers and mobile technologies, as opposed to "digital immigrants" who have had to learn to use these devices later in life.

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