Technology is a ubiquitous part of modern life. More than 2 billion people worldwide own a smartphone (Poushter, 2016), and 77% of Americans go online on a daily basis, interacting on social-networking sites (SNSs) such as Facebook, Twitter, Instagram, or Snapchat (Smith & Anderson, 2018). When people are not on their phones, they are on their computers, sending e-mails, immersing themselves in virtual worlds such as Second Life, or completing other computer-mediated activities. When people are not using their computers, they are often watching television or playing video games. More than a quarter of U.S. adults report being online “almost constantly” (Perrin & Jiang, 2018) and 46% of smartphone owners reported that they “couldn’t live without” their smartphones (Smith, 2015).

The speed of movement toward humans’ fully networked existence has understandably given rise to a body of journalistic, scholarly, and scientific research pursuits exploring the consequences of humans’ ever-increasing reliance on and embeddedness in technology. An entire genre of popular books, for example, assesses the terrain of everyday technology use, including the way the Internet is changing people’s brains (Carr, 2011), the ways in which devices may create psychological distance in immediate social interactions (Turkle, 2011), whether excessive technology use can be considered a behavioral addiction (Alter, 2018), and, perhaps of greatest concern, whether generational differences in teenagers’ social behaviors are a causal consequence of the technological revolution (Twenge, 2017). The rapid speed of technological advances has created an urgency around questions of whether these developments are, prima facie, good or bad (see Orben & Przybylski, 2019). Of course, this is a false dichotomy;
ultimately, the scientific evidence will likely conclude that there are many ways in which technology is (or, at least, can be) both good and bad. At this point, though, one observation is clear: This is a time of critical self-examination about the ways in which technology is dramatically reshaping the landscape of social behaviors and perhaps even the nature of social interaction itself. In the next 25 years, computer-mediated, virtual social interactions are expected to have an uncanny likeness to in-person interactions (Bailenson, 2018). As the precipice of these changes approaches, a careful evaluation of the likely or anticipated effects—and how what is happening and what is to come can be better understood—is a timely and perhaps necessary task for psychological science (see Anderson & Rainie, 2018).

This article is nested under this larger study of technology and well-being. In particular, we focus on evaluating the evidence for an emerging evolutionary mismatch between the ways in which smartphones (and their affordances—access to social networks, texting, etc.) may activate or take advantage of the basic intimacy processes required for forming and maintaining high-quality close relationships. Evolutionary mismatches are defined as situations in which human adaptations that emerged to foster reproductive and inclusive fitness in ancestral environments become maladaptive in novel contexts that may differentially cue the same adaptations (or evolved psychological mechanisms; Brenner et al., 2015; Li, van Vugt, & Colarelli, 2017; Maner & Kenrick, 2010). Within this framework, the modern environment cues ancestral adaptations that essentially “misfire” and do not provide for the same type of adaptive benefits. A classic and oft-cited example of the so-called mismatch is humans’ desire for sweet-tasting food, an adaptation that signaled nutritional value in ancestral environments. The contemporary food environment of most industrialized societies is replete with sugar-enhanced foods that contribute directly to the global obesity pandemic (Brenner et al., 2015). In this case, the mismatch is quite obvious: Although adaptive in an ancestral context and vital for humans’ survival, sweet-tasting food no longer signals nutritional value, and the evolved preferences for sugar-enhanced food have become a health risk.

Li et al. (2017) recently proposed a framework in which the case for an evolutionary mismatch would be supported if (a) there is an identifiable and evolved mechanism with specific functions; (b) these functions are elicited by specific cues for the mechanism; (c) there is a discrepancy in the current and ancestral environment in the quantity, intensity, or constitution of input cues that elicit the mechanism; and (d) the consequences of the mechanism’s output reduce reproductive fitness. Further, in modern societies, mismatches occur most commonly when a new environment is imposed on an organism and/or when novel stimuli preferentially elicit the evolved mechanism (Li et al., 2017). We argue herein that smartphones and their affordances, including easy access to SNSs and near-instantaneous two-way text-based communication, create a responsiveness draw that pulls people away from their immediate interpersonal interactions and into virtual interactions. These virtual interactions can provide innumerable benefits. However, a nascent literature suggests that a potential downside is the cost to immediate, face-to-face relationships and ongoing, real-time interactions.

The basic outline of our analysis is illustrated in Figure 1. The first section of the article sets the stage for more detailed study by discussing general ways in which smartphones and their affordances are changing social interactions. The second section focuses on attachment theory as a middle-level evolutionary theory (Buss, 1995; Fletcher, Simpson, Campbell, & Overall, 2015; Simpson & Belsky, 2016) and the role of self-disclosure and responsiveness as evolutionary adaptations designed to solve the ancestral problem of cultivating cooperation and thus enhancing reproductive and inclusive fitness (see Lewis, Al-Shawaf, Conroy-Beam, Asao, & Buss, 2017). We describe how and why self-disclosure and responsiveness are elicited in social contexts—including those that are virtual and unfold online—and their critical roles as constituent behaviors in the development and maintenance of tight social bonds. We also identify the ways in which smartphones and their affordances create a context that compels self-disclosure and responsiveness. This section provides details for Figures 1a to 1c. The third section reviews literature on potential consequences of the mismatch (Figs. 1d and 1e). Here we focus narrowly on the topic of technoference, which is defined as the ways in which smartphone use may interfere with or intrude into everyday social interactions, either between couples or within families (McDaniel & Coyne, 2016; McDaniel, Galovan, Cravens, & Drouin, 2018; McDaniel & Radesky, 2018). This section also discusses the ways in which smartphone use may also disrupt the basic cognitive processes needed to maintain intimacy. The last section of the article outlines an empirical agenda for expanding research on technoference and the possible mismatch.

We acknowledge from the outset that this analysis raises far more questions than it answers. We also note that it is not the first to suggest that smartphones and social media cue ancestral adaptations. Writing from a social-neuroscience perspective, for example, Tamir and Ward (Tamir & Ward, 2015; Ward, 2013) discuss the
ways in which contemporary technological advances activate basic reward systems and "hijack preexisting cognitive tendencies" (Ward, 2013; p. 341; see also Tamir & Ward, 2015, p. 442). The present contribution rests in extending these earlier ideas into a more complete mismatch framework, with the ultimate goal of using this framework to derive empirically testable hypotheses and to develop a more complete and systematic understanding of how technology affects social relationships.

Setting the Stage: Smartphones and Relationships

Smartphones function as vastly instrumental tools for helping people meet their social, vocational, academic, health, and recreational goals (Bayer, Campbell, & Ling, 2015). Smartphones allow people to strengthen important social ties in numerous ways (Campbell, 2015), often serving as a convenient tool for staying connected with friends, coordinating plans, and sharing jokes, thereby making communication “more personalized, direct, and timely” than ever before (Ling, 2012, p. 99). Lane et al. (2010) have argued that the implementation of smartphone technology (specifically, the phenomenon of “mobile sensing”) can potentially benefit people across many different domains, including health (Consolvo et al., 2008; Luxton, McCann, Bush, Mishkind, & Reger, 2011), social networks (Miluzzo et al., 2008), and transportation (Thiagarajan et al., 2009), all in the service of improving human potential and well-being. Indeed, there are thousands of smartphone applications to help track health, fitness, sleep, exercise habits, doctor visits, general activity, diet, mood, modes of transportation, and academic progress, and smartphones provide a variety of social platforms from which people can communicate with thousands of others, if desired.

Smartphones in relationships

With the arrival of smartphones in daily life—and the concomitant rise of SNSs such as Facebook, Instagram, Snapchat, and Twitter—technology use has also emerged as an area of frequent conflict among couples and families. A Pew Research Center study (Lenhart & Duggan, 2014) of more than 2,000 U.S. couples ages 18 and older found that 25% of couples in serious relationships reported that their partners had been distracted on a mobile phone while they were spending time together, and this number rises to 42% when the age of the couples is constrained to 18 to 29 years old. In a more recent and detailed sample of 143 married or cohabiting women, 70% reported that cell phones or smartphones interfered “sometimes, often, very often, or all of the time” (McDaniel & Coyne, 2016, p. 7). As we describe below, it is not a coincidence that smartphones exert a large pull on attention. To the extent that people’s desires to self-disclose and be responsive to others (a) draw them away from their immediate (face-to-face) interactions with close others and toward their devices and (b) is perceived by a partner or close other as a loss of responsiveness, we expect that relationship conflict and negative personal consequences (e.g., lower well-being, greater loneliness) will follow.

Of course, conflict over divided attention is nothing new. It is not hard to imagine someone becoming upset with his spouse’s incessant reading of the newspaper (or vice versa) while he is trying to explain the frustrations of his workday. In many ways, smartphones and their affordances only up the ante on this dynamic. Recast, this process can be understood as the foundation for a relatively classic mismatch in which new input cues—virtual and online social contexts that elicit self-disclosures and responsiveness in social networks—are increasing in intensity and quantity (Li et al., 2017). For example, scholarship in a range of diverse fields also
suggests that smartphones are giving rise to altered patterns of social interactions, many of which require a new lexicon to describe. There are now phrases to describe behaviors that did not exist just 2 decades ago, including not only technoference but also phubbing and Pphubbing (described, respectively, as the ways in which people can snub each other with their phones and the ways in which romantic partners may snub each other with their phones; Roberts & David, 2016); the problems of absent-presence and being alone together and microsocial fragmentation (wherein people occupy the same physical space but have their attention diverted to their devices and away from real-time interpersonal exchanges; Gergen, 2002; Turkle, 2011); the horizontalization of relationships (in which networks move from being distributed vertically as smaller and interpersonally deeper to horizontally as broader but more shallow; Gergen, 2002); and anxiety around the fear of missing out on social exchanges (Przybylski, Murayama, DeHaan, & Gladwell, 2013), which may give rise to “nomophobia” (the fear of being without one’s mobile device; King et al., 2013).

In her seminal exploration of the ways in which technology is reshaping modern life, Turkle (2011) clearly illustrates the double-edged sword of what she calls being “tethered to the Internet” (p. 153). Although the affordances of mobile devices and SNSs are immediately apparent, some of the consequences, especially to relationships, are not. Turkle (2011) writes,

And yet, in the half-light of virtual community, we may feel utterly alone. As we distribute ourselves, we may abandon ourselves. Sometimes people experience no sense of having communicated after hours of connection. And they report feelings of closeness when they are paying little attention. In all of this, there is a nagging question: Does virtual intimacy degrade our experience of the other kind, and, indeed, of all encounters of any kind? (p. 12)

The Evolution of Social Bonding and Human Attachment

Developing ideas around a potential evolutionary mismatch between ancestral social relationships and the pull of modern technology first requires the identification of an evolutionary adaptation that promoted human survival (Li et al., 2017); this first step necessitates a focus on the environment of evolutionary adaptiveness (EEA) and the problems ancestral humans faced that affected their survival and reproduction (Lewis et al., 2017). We open this section with a focus on Figures 1a and 1b. Humans have a fundamental need to form close attachments with others (Baumeister & Leary, 1995), and this need has its evolutionary roots in humans’ earliest ancestors more than 250 thousand years ago. Indeed, attachment theory (Bowby, 1969/1982) is a middle-level evolutionary theory that provides a robust account of the ways in which close relationships and social bonds provide for reproductive and inclusive fitness (Simpson & Belsky, 2016).1

The EEA and emergence of affiliative behaviors

Evolutionary accounts of social bonding suggest the attachment system emerged to solve specific problems in the EEA, including providing safety for immature infants in physically harsh conditions as well as for adults living in groups (Kaplan, Hill, Lancaster, & Hurtado, 2000). According to Lewis et al. (2017), evolutionary problems that were “high frequency, high impact”—that is, adaptive problems that were both frequently encountered and highly meaningful for survival—exerted especially strong selection pressures and gave rise to important psychological adaptations to address them. It is very likely that dangerous living conditions in ancestral environments (e.g., contact with wild animals, experiencing harsh weather, competing for scarce resources with rival group members) were experienced frequently and were often life-threatening. In this context, affiliative behaviors promoting trust, cooperation, and the formation of strong social (attachment) bonds were imperative to humans’ survival and their reproductive fitness. Indeed, some authors have argued that attachment is not just vital for human infants’ survival but that a system designed to keep people socially connected was the central problem of mammalian evolution (Lieberman, 2013). Simpson and Belsky (2016) note that in the EEA “participation in the daily functioning of small, cooperative groups may in fact have been the predominant survival strategy of early humans” (Brewer & Caporael, 2006, p. 96).

This perspective is consistent with broader anthropological accounts of humans’ sociality. The anthropologist Robin Dunbar, for example, argues that it is because of the increasing complexity of social relationships—driven by the increasing size of humans’ nonkin social groups—that humans developed such large brains relative to the size of their bodies (Hill & Dunbar, 2003). From this perspective, often referred to as the *social brain hypothesis* (Dunbar, 2003), the primary reason humans’ neocortex grew so large was so that they could
live in increasingly larger social groups and be more highly social. Humans’ sociability and the social emotions needed to navigate close relationships—including tenderness, guilt, remorse, jealousy, and love itself—emerged in the context of the EEA to promote cooperation, trust, and, in select relationships, an attachment bond. We argue below that cooperation, trust, and attachment hinge on interpersonal intimacy. Viewed from this perspective, self-disclosure and responsiveness, the social behaviors contributing to intimacy, are among interpersonal building blocks of attachment relationships, and these behaviors help solidify the bonds that promote humans’ survival.

A hallmark of being human is the formation of intimate relationships with both kin and nonkin. Intimate relationships are characterized by a deep sense of emotional closeness toward another person (Aron, Aron, & Smollan, 1992) and usually are characterized by frequent, strong, and diverse contact (Kelley et al., 1983). On average, people have between three to seven people with whom they interact at high levels of intimacy, about half of whom are usually nonkin (Milardo, 1992).

In ancestral times, a person’s intimate network functioned, above all, as a security network that provided the individual with unspoken and unquestioning support to help combat the adaptive problem of harsh and dangerous living conditions. These relationships depended on face-to-face contact and frequent reaffirmation, and it is from their intensity that individuals derived security—security that one could trust that those in their intimate network would be there in times of trouble and that they would not be excluded from the group. Shared risk taking in hunting and protecting young shows not only that early humans took risks on behalf of the group (demonstrating the importance of cooperative bonds to enhance the odds of survival) but also that they were able to trust those in their intimate networks to do so equally, thereby ensuring that cooperative relationships were mutually beneficial (Plummer, 2004). A primary constraint of intimate relationship networks was their size. The number of people with whom one could interact at such an intensity—at least in ancestral times—was relatively limited. Beyond intimate networks were so-called effective networks of friends and relatives (around 20 people), and extended networks (around 100–400 people) that included acquaintances and friends of friends (Gamble, 1998). Effective network members are often those who provide emotional and material assistance in daily life—not as emotionally deep as intimate network members, but still people with whom one would spend substantial face-to-face time on a regular basis.

A good example of an effective network was described in Thrasher’s classic study of adolescent male gangs in Chicago (Thrasher, 1927). In a sample of 895 neighborhood gangs, 90% had fewer than 50 members, whereas 60% ranged in size from 6 to 20 members. Thrasher explained the typical gang size, or clique, by the necessities of maintaining face-to-face relationships. Extended networks, in contrast, are much larger, require little face-to-face contact, and vary in whether they are active or passive. In earlier times, the extended network would have encompassed entire tribes of people, including those one barely knew and distant kin (Gamble, 1998). Probably not coincidentally, the size of extended networks in ancestral times is mirrored today in the typical size of one’s online social network (Dunbar, Arnaboldi, Conti, & Passarella, 2015).

In summary, it is clear from archaeological records and cross-species comparison not only that human brains evolved to deal with the immense complexities of social relationships but also that they were especially well designed for navigating close and intimate relationships with nonkin, including potential romantic partners. Furthermore, the adaptive psychological mechanism of creating attachment bonds and cooperating with others was particularly important for increasing the chance of surviving and reproducing when facing the “high frequency, high-impact” problems in the EEA (Lewis et al., 2017, p. 358). Indeed, romantic love is believed to be an evolved and universal “commitment device” designed to facilitate pair bonding and the persistence of the bond in time (Fletcher et al., 2015). Central to our mismatch hypothesis is the observation that core intimacy processes—that is, self-disclosure and responsiveness, which play a critical role in both human cooperation and human bonding (Reis, Clark, & Holmes, 2004)—are evolved behavioral adaptations.

Core intimacy processes: self-disclosure and responsiveness

Although most of what is known about ancestral social relationships relies on archaeological data, what is known about the nature of intimacy is based on voluminous research with modern-day humans. A core building block of intimacy is self-disclosure. Approximately 30% to 40% of everyday speech is used to convey information to others about one’s private experiences or personal relationships (Dunbar, Marriott, & Duncan, 1997; Emler, 1990, 1994; Landis & Burtt, 1924). Evolutionary theorists argue that such high rates of self-disclosure reflect people’s adaptive motivation to share beliefs and knowledge about the world with others (Csibra & Gergely, 2011; Tomasello, 1999). Opportunities to self-disclose are experienced as a powerful form of subjective reward in the same way as with primary rewards such as food and sex. For example, Tamir and Mitchell (2012) showed that
self-disclosure was strongly associated with increased activation in brain regions that form the mesolimbic dopamine system, including the nucleus accumbens and ventral tegmental area. Moreover, they showed that people are even willing to forgo money to disclose information about themselves.

Disclosing one’s inner thoughts and feelings to another person leads to liking and caring, ultimately fostering the deepening of a relationship (Altman & Taylor, 1973; Chelune, Robison, & Kommor, 1984; Collins & Miller, 1994; Jourard, 1971). Moreover, self-disclosure is a key signal of trust in social relationships (MacDonald, Kessel, & Fuller, 1972), and the association between self-disclosure and trust becomes stronger as relationships become deeper (Larzelere & Huston, 1980). In the EEA, self-disclosure would have conferred adaptive benefits by facilitating social bonds and alliances within one’s group (Collins & Miller, 1994; Dunbar, 2003; Greene, Derlega, & Mathews, 2006), improving outcomes in decision making (i.e., “two heads are better than one”; Bahrami et al., 2010), and promoting self-knowledge as a result of feedback received from others (Derlega, Metts, Petronio, & Margulis, 1993).

Receiving feedback from others is especially critical in the development of intimacy. Although self-disclosure is a key ingredient of intimacy, it is an insufficient one. Theorists argue that in order for self-disclosure to lead to close social bonds, it must be followed by responsive behaviors by the listener that convey understanding, validation, and warmth to the speaker (Reis & Shaver, 1988). When the speaker in turn perceives the listener to be responsive—termed perceived partner responsiveness (PPR)—feelings of closeness develop. There is extensive evidence for this interpersonal process model of intimacy, showing that self-disclosure is associated with intimacy via responsiveness (for a review, see Reis et al., 2004). Maternal responsiveness directly fosters feelings of security in infants (Ainsworth, Blehar, Waters, & Wall, 1978), a process later mirrored in adult romantic relationships (Hazan & Shaver, 1987). Putting a point on this observation, Lieberman (2013) argues that “the price for our species’ survival is that connecting to a caregiver is a lifelong need to be liked and loved” (p. 48). A specific manifestation of this need is responsiveness. In adulthood, responsiveness is strongly associated with trust, commitment, and feelings of closeness in dyadic relationships (Reis et al., 2004) and with increased perception of cooperative intentions in small groups (Gefen & Ridings, 2002). From a normative, species-typical perspective, human attachments promote reproductive and inclusive fitness, and self-disclosure and responsiveness are among the key behaviors that shape these bonds. Said differently, humans appear evolutionarily prepared to build closeness with others via the twin processes of self-disclosure and responsiveness, and this preparedness can be traced to the adaptive problems faced by early humans in the EEA.

**Intimacy, health, and well-being**

To substantiate our mismatch framework, we argued above that self-disclosure and responsiveness are behavioral adaptations that emerged in the EEA to promote social bonds and thus provide for inclusive and reproductive fitness. In this section, we review literature on the health benefits of social bonds and, especially, intimate relationships. Note that this research, in itself, is not intended to support the case for the evolved importance of intimacy, although it does at least peripherally in the sense that a survival advantage is clearly relevant to reproductive and inclusive fitness (see Fletcher et al., 2015); rather, we review work on the importance of close relationships for health and well-being as relevant background for understanding what is at stake in cases of technofference. In other words, we do not believe that technofference disrupts health directly, but we do believe that it can disrupt relationships in a variety of ways that, in turn, are relevant to a variety of health outcomes.

Relationship quality is associated with a range of important health outcomes. In adulthood, having strong and high-quality social ties is essential for happiness (Diener & Seligman, 2002), and relationship quality is associated with a range of health outcomes, including the risk for early mortality (Holt-Lunstad, Smith, Baker, Harris, & Stephenson, 2015; Holt-Lunstad, Smith, & Layton, 2010). The effects of social relationships on longevity are equal to or exceed those of other, hallowed healthy behaviors such as physical activity and good nutrition, and improving social relationships is increasingly becoming a public-health priority in the United States and around the world (Holt-Lunstad, Robles, & Sbarra, 2017). Beyond the sheer presence or absence of social ties being associated with health, the quality of close relationships matters as well (Robles, Slatcher, Trombello, & McGinn, 2014; Slatcher & Selcuk, 2017). Researchers are now beginning to identify the key aspects of high-quality relationships associated with health and well-being that might be modifiable targets for intervention. The core intimacy processes of self-disclosure and responsiveness are promising targets.

A large body of experimental evidence has shown that disclosing one’s thoughts and feelings through expressive writing results in improvements in physical health (Frattaroli, 2006) and improved functioning of the hypothalamic–pituitary–adrenal (HPA) axis (Smyth, Hockemeyer, & Tulloch, 2008; van Middendorp, Geenen, Sorbi, van Doornen, & Bijlsma, 2009), which produces
the stress hormone cortisol. Recent evidence indicates that disclosures in everyday life in the context of close relationships are beneficial for health-related processes as well. For example, self-disclosure between spouses is associated with a buffering of the physiological effects of work stress on daily cortisol production (Slatcher, Robles, Repetti, & Fellows, 2010) as well as improved sleep quality (Kane, Slatcher, Reynolds, Repetti, & Robles, 2014). Researchers are increasingly homing in on partner responsiveness as a key social driver of health and well-being. Responsive interactions foster intimacy in couples (Debrot, Cook, Perez, & Horn, 2012) as well as improved interactions between leaders and subordinates (Kluger & Zaidel, 2013) and between physicians and patients (Reis et al., 2008). Responsiveness is also linked to greater personal well-being, including greater emotional well-being among cancer patients (Otto, Laurenceau, Siegel, & Belcher, 2015), improved ability to integrate negative life experiences into the self-concept (Weeks & Pasupathi, 2011), and greater hedonic and eudaimonic well-being in both the United States and Japan, but especially the United States (Tasfiliz et al., 2018). Because responsiveness shares common elements with several important relationship constructs—facilitating core validation of the self and fostering feelings of warmth, acceptance, belonging, and trust—it has been deemed an organizing principle in the study of relationships (Reis, 2012), including in the study of relationships and health (Slatcher & Schoebi, 2017).

In infancy, responsiveness from attachment figures facilitates the biological “tuning and pruning” of stress systems and, in turn, long-term health benefits via improved stress regulation (Meaney, 2010). Studies of parenting support this idea, with greater maternal responsiveness associated with better functioning of the HPA axis (Gunnar & Quevedo, 2007) and lower levels of inflammation (Tobin et al., 2015). A recent investigation tested whether fine tuning of the HPA axis by responsive close others might extend into adulthood. In a large sample of married and cohabitating adults, greater PPR predicted steeper (“healthier”) diurnal cortisol slopes 10 years later (Slatcher, Selcuk, & Ong, 2015) and was associated with better sleep (Selcuk, Stanton, Slatcher, & Ong, 2017), even after controlling for relevant demographics, personality traits, and other important relationship factors.

Partner responsiveness is also linked to improved regulation of physical pain. For example, responsive interactions with partners are associated with an increased release of endogenous opioids, which reduce pain and promote felt security and commitment (Machin & Dunbar, 2011). Indeed, holding hands with a romantic partner makes physical pain more bearable (Eisenberger et al., 2011) and fosters recovery from recalling emotionally painful experiences (Selcuk, Zayas, Günaydin, Hazan, & Kross, 2012). Responsive relationships may also help to relieve chronic physical pain, a hypothesis supported by the finding that greater partner responsiveness predicts reduced pain 3 months after knee-replacement surgery (Khan et al., 2009).

In summary, a large body of evidence indicates that the intimacy processes of self-disclosure and responsiveness foster close social relationships and, ultimately, better health and well-being. In the next section, we review findings suggesting that today’s technology—especially smartphones—capitalizes on this evolved brain architecture, drawing in its users through its ample opportunities for self-disclosure and cues to responsiveness.

**Intimacy processes in the modern world**

We have argued thus far that humans faced numerous adaptive problems in the EEA that necessitated strong affiliative bonds and cooperation to increase the odds of survival. Social behaviors that enhanced the potential for cooperation and provided for security (i.e., trust) within these relationships improved reproductive and inclusive fitness. Under these conditions, interpersonal intimacy—shaped through self-disclosure and responsiveness—provided adaptive value in building and maintaining close social bonds. Of course, the environment in which humans live today has changed dramatically from the EEA, and in this section of our analysis (corresponding to Fig. 1c), we discuss the ways in which smartphones and their affordances create a unique and entirely unprecedented context that compels disclosure and responsiveness. The case for an evolutionary mismatch requires evidence not only that modern society is different from ancestral environments but also, more precisely, that it cues psychological mechanisms in excess or in ways that preferentially elicit the mechanism toward maladaptive consequences. Li et al. (2017) refers to these mismatches as those that are “forced” or “hijacked” (p. 39), respectively (see also Tamir & Ward, 2015).

As we noted earlier, it is hard to overestimate how much communication has changed since the first iPhone was released in 2007. As of late 2016, more than 77% of all Americans owned a smartphone, including 92% of 18- to 29-year-olds (Pew Research Center, 2018). Not only do most Americans now own smartphones, but they use them a lot—on average 5 hr a day. Much of that time is spent on social media, such as Facebook, Twitter, Snapchat, and Instagram. Worldwide, people spent an average of 135 min per day on social media in 2017, up from 126 min in 2016 (Statista, 2018a). In
the United States, 60% of social-media time is spent via smartphone applications (Statista, 2018b). Thus, more and more, people are turning to social media to “talk” to friends and acquaintances, often via their smartphones. Further, online social communication may be serving as a substitute for face-to-face interactions. Online time is negatively correlated with time spent going to parties, attending cultural events, and socializing with people in a variety of offline contexts (Wallsten, 2013). As Tamir and Ward (2015) put it, “As social animals in a digital world, we seem to obsessively log on, tune in, and exchange face-to-face interaction for social content delivered through a screen” (p. 432).

**Social network activities are built on self-disclosure and responsiveness**

One purpose of social media is to share facts and one’s thoughts and feelings (or photos or links to articles) to a large number of people and, in turn, for those in one’s online social network to respond. In other words, the success of social media is built on the processes of self-disclosure and responsiveness. Some authors have gone as far as suggesting that SNSs have hijacked the human need to self-disclose (Tamar & Ward, 2015). Whereas in-person social interactions are usually limited in the size of their audience for sharing things about the self, online sharing can happen with an audience that is limitless in size. Throughout evolutionary history, the process of self-disclosure unfolded between two or at most a few people, but people can now tell hundreds, thousands, and even millions of people about their experiences at the click of a button. And this is what most people are doing online—more than 80% of social-media activity involves simply announcing or broadcasting one’s immediate experiences (Naaman, Boase, & Lai, 2010).

If ample opportunities to self-disclose provided the spark for people’s interest in social media, responsiveness provided the fuel. On February 9, 2009, Facebook introduced the “like” button (Morgans, 2017). This rendered the need for Facebook users to comment on status updates, photo uploads, or other posts obsolete; instead, users can indicate they like something simply by clicking on a thumbs-up emoji. Other social-media platforms (e.g., Instagram, Twitter, YouTube) followed suit with their own versions of this feature (in the case of Instagram and Twitter, a tiny heart) to let users respond positively to people’s posts. Thus, one can both share one’s social experiences with an infinite number of people and receive responses from (or be ignored by) an infinite number of people.

By having the ability to share and receive responses from so many people at once on social media, are people achieving deep social connections with others, or are such social connections partly illusory? That question has not yet been fully answered, but data from several studies have suggested that SNS activity may, under certain circumstances, increase the risk of mental-health problems (Guernsey, 2014; Morrison & Gore, 2010; Selfhout, Branje, Delsing, ter Bogt, & Meeus, 2009), detract from face-to-face relationships (Leung & Lee, 2005), reduce investment in meaningful activities (Leung & Lee, 2005), and negatively affect well-being in general (Kross et al., 2013; Neira, Corey, & Barber, 2014; Sagioglou & Greitemeyer, 2014; Selfhout et al., 2009; Van den Eijnden, Meerkert, Vermulst, Spijkerman, & Engels, 2008). Only a few studies have suggested that social media has an overall positive impact on social connectedness and well-being (Kim & Lee, 2011; Nabi, Prestin, & So, 2013; Valenzuela, Park, & Kee, 2009).

Almost all of the research in this area has been cross-sectional, but a study of 5,208 Americans across three waves of data (2013, 2014, and 2015) from the nationally representative Gallup Panel Social Network Study examined how online (on Facebook) and offline (i.e., in person) social interactions were independently associated with several subjective measures of well-being (Shakya & Christakis, 2017). Data from this study indicated that the use of Facebook (the most widely used and studied SNS) was negatively associated with well-being, both cross-sectionally and longitudinally. In their prospective analysis, the authors found that greater Facebook use at Time t (e.g., more likes clicked on articles, friends’ Facebook pages, and status updates) was associated with decreases in self-reported mental health and well-being at Time t + 1, controlling for self-reported mental health at Time t. Further, the effect sizes of the negative associations of Facebook use were comparable to or greater than those for the positive associations of offline interactions in the same sample of Gallup participants.

Although it is beyond the scope of this article to fully examine whether SNS activity reliably or definitively decreases psychological well-being in its many forms, the nascent evidence base suggests that it can—under certain conditions at least—and the central question becomes understanding why and when this is the case. Nowland, Necka, and Cacioppo (2017) recently argued that social technologies increase loneliness when they are used to withdraw or escape from the “social pain” of in-person social interactions. We agree with this analysis and suggest that it can be extended: Missing out on social opportunities is not the same as being drawn away from in-person interactions and into the virtual world. Smartphones and their affordances create a context that compels both self-disclosure and responsiveness, and the sheer ubiquity and ease of access.
associated with the devices allows people to connect to the entirety of their social network at any given moment; the devices also allow the network to compel our responding at any given moment as well.

From this perspective, it is reasonable to argue that in close relationships, an evolutionary mismatch occurs when smartphones and their affordances permit the outer layers of an extended social network (Gamble, 1998) to activate basic intimacy processes. For example, consider a family of two parents and two kids having dinner together. An aunt from a distant state starts posting pictures on Facebook of a summer trip with all the cousins. In the middle of a conversation about the school day, the family pauses to begin responding to the aunt via their smartphones. On the one hand, this might be quite positive for the family, with the opportunity to see their cousins and appreciate the fun trip of relatives. On the other hand, the draw to respond in near real time diverts attention from and potentially fragments a conversation about the school day or the slings and arrows of parents’ work (see Gergen, 2002). This attention-grabbing dynamic unfolds many times a day across many social contexts, in which the twin desires to disclose information about the self and to be responsive to others draw people out of or away from their immediate interactions and into the virtual world of their smartphones.

The mismatch framework allows us to view potential concerns about smartphones and their affordances on at least two levels. First, we can speculate, as many others have as well (see Rowland, Greenbaum, & Deeds, 2017), that networked interactions provide only a verisimilitude to in-person social exchanges. Social-media systems by design (with the exception of dyadic private messaging and small group features that are occasionally used on these systems) are geared toward fostering very public and often superficial disclosures that are simply not the sort of disclosures that foster feelings of closeness with others. It is only through deep self-disclosure, and perceived responsiveness to these disclosures, that feelings of intimacy and closeness form (Aron, Melinat, Aron, Vallone, & Bator, 1997; Reis & Shaver, 1988). Although high amounts of disclosure can happen online (e.g., through e-mail, text, direct message, or other dyadic routes), most online interaction is not of that nature but in more public forums in which true intimacy is difficult if not impossible. We theorize that social media specifically—and time spent online more generally—is not “bad” per se for forming social connections. Rather, it is simply not well-suited to forming deep and meaningful connections. When shallow self-disclosure and responsiveness online—what might be termed “social snacking” (Gardner, Pickett, & Knowles, 2005)—replaces (rather than supplements) in-person self-disclosure and responsiveness, we predict declines in feelings of social connection and, in turn, declines in health and well-being (see also Nowland et al., 2017).

Second, and perhaps at a deeper level, the adaptive value of humans’ proclivities toward self-disclosure and responsiveness is at odds with the affordances of smartphones. In this case, because SNSs and real-time text messaging exchanges compel disclosure and responsiveness (Fig. 1c), broad social networks regularly activate adaptations that are critical for forming and maintaining close social ties. At any given moment, the phone compels people to engage intimacy processes with the farthest reaches of their social networks. An important potential consequence of this shift in resources is that the ability to be present, attentive, and responsive to a partner or family member in the moment is arguably diminished or, at a minimum, taxed on a regular basis; the same adaptations for building close social bonds in intimate networks are engaged in a manner that draws people away from real-time social interactions and into the virtual world. Viewed from this perspective, an obvious question emerges: Is there an existing or even emerging evidence base to suggest that smartphone use has the potential to undermine relationship quality?

The Social and Cognitive Effects of Technology Use: A Review of the Current Findings

We have argued that smartphones and SNSs create a responsiveness draw that directly competes for humans’ evolved desires to be responsive to social bids and to perceive others as responsive as well. This competition operates when smartphones usurp attentional resources that are typically allocated to in-person social interactions, undermining one’s ability to both perceive responsiveness and to be responsive in the moment. In this section, which corresponds to Figure 1d, we systematically review the empirical evidence on technology and work suggesting that smartphones and their affordances can disrupt the basic social-cognitive processes required for PPR. Specifically, we propose that smartphones and SNSs disrupt attentional resources and undermine basic cognitive processes, which in turn disrupt relationship processes and may ultimately lead to decreases in health and well-being. Figure 2 illustrates the process by which smartphones and SNSs disrupt cognitive and, in turn, relationship processes. In the sections that follow, we review literature that supports each numbered link displayed in this figure, with key findings summarized in Table 1.

Although the focus of this section is on the ways in which smartphones can yield negative consequences for relationships, we recognize that evidence for technology must be viewed in light of the many positive
features of smartphones and the ways in which they can enhance relationship connection and quality. We emphasize that smartphones themselves are neither good nor bad, but how they are used and when they are used can make them instruments for success or agents of failure. In this next section, we focus on the empirical evidence to support Paths 1 to 3 in Figure 2.

**Technology Use and Cognition**

When attention is split, people are less able to perceive unusual things in their environment (Hyman, Boss, Wise, McKenzie, & Caggiano, 2009), and it stands to reason that people are similarly less able to perceive subtleties in their environment. For example, it may be more difficult to pick up social cues when one's attention is split between one's phone and one's partner—when one is looking at the phone instead of one's partner, the partner's nonverbal cues are likely to be missed (Fig. 2, Paths 1 and 2). Evidence from studies on communication suggests that people who are using their phones during in-person interactions are less able to pick up on cues of dissatisfaction with the conversation, are less able to understand their partners, and are perceived as being uninterested in the in-person interaction. For example, one small but qualitatively rich study of 25 college students (Aagaard, 2016) suggested that engagement with phones during face-to-face interactions resulted in perceived delays of responses, mechanical verbal communication, and a lack of appropriate expressiveness (e.g., reduced eye contact, lack of facial expression, head nodding), which contributed to perceptions of interaction partners as uninterested and lacking empathy. In addition, participants reported that when they use their own smartphones during in-person interactions, they are less able to hear and focus on what their interaction partner says (Aagaard, 2016), demonstrating the smartphone's capacity to usurp attentional resources (supporting Paths 1–3 in Fig. 2; see Table 1). Although it is important to understand the associations between smartphone use and relationship processes, it is also important to consider why these associations exist, and this question points to the study of basic social-cognitive processes that can be disrupted by smartphones (i.e., perception and attention). We argue that disruptions in these processes can translate into disruptions in social interactions.

There is considerable evidence suggesting that technology use disrupts basic cognitive processes, including those that are critical to the creation and maintenance of interpersonal intimacy. Just as the mere presence of smartphones can disrupt interpersonal interactions (Misra, Cheng, Genevie, & Yuan et al., 2014; Przybylski & Weinstein, 2013; Sprecher, Hampton, Heinzel, & Felmlee, 2016), the mere presence of smartphones can disrupt basic cognitive processes (Fig. 2, Path 1). For example, Thornton, Faires, Robbins, and Rollins (2014) showed that people performed worse on the difficult part of a Trail-Making Task (TMT) in the presence (compared with the absence) of the participants' smartphones. Other work shows that receiving even a single smartphone notification (Stothart, Mitchum, & Yehnert, 2015) can disrupt one's attentional...
resources and, in turn, cognitive performance, particularly for highly demanding tasks. Stothart et al. (2015) showed that performance on the Sustained Attention to Response Task suffered when participants received a notification on their phone during the task (prompting “task-irrelevant thoughts”) compared with when they performed the task without being interrupted by a phone notification (supporting Path 1 from Fig. 2; see Table 1.

<table>
<thead>
<tr>
<th>Pathway</th>
<th>Key findings</th>
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<tbody>
<tr>
<td><strong>Path 1: Smartphone use and SNSs disrupt cognitive processes</strong></td>
<td>Phone notifications are associated with poorer performance on the Sustained Attention to Response Task (Stothart et al., 2015). The mere presence of smartphones is associated with poorer cognitive performance on the Trail Making Task (Thornton et al., 2014). Only 25% of people notice a unicycling clown while walking and using their phones (Hyman et al., 2009). The mere presence of a smartphone is associated with reduced working memory capacity (Ward et al., 2017).</td>
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<tr>
<td><strong>Path 2: Disrupted cognitive processes lead to disrupted relationship processes</strong></td>
<td>Although there is little empirical evidence for this link, to the extent that attention is necessary for relationship processes to unfold (e.g., self-disclosure, responsiveness), the studies illustrating undermined cognitive functioning support this theoretical link. In a small qualitative study, participants reported their own phone use as detrimental to their attention, negatively influencing their ability to interact with others (Aagaard, 2016).</td>
</tr>
<tr>
<td><strong>Path 3: Smartphone use and SNSs disrupt relationship processes</strong></td>
<td>The mere presence of a phone is associated with reduced relationship satisfaction, especially when the topic of conversation is meaningful (Przybylski &amp; Weinstein, 2013). Perceptions of problematic technology use are associated with criticism-defensive and demand-withdrawal communication patterns and, in turn, reduced relationship satisfaction (Spencer, Lambertsen, Hubler, &amp; Burr, 2017). Partner ‘phubbing’ (phone snubbing) is associated with conflict over technology and, in turn, reductions in relationship satisfaction (Roberts &amp; David, 2016). Texting frequency at time 1 significantly predicts decreases in relationship satisfaction 1 year later (there was no effect of time 1 relationship quality on texting 1 year later; Halpern &amp; Katz, 2017). The mere presence of a phone is associated with reductions of perceived empathy in a naturalistic setting (Misra et al., 2016). Technology interference is associated with increased conflict over technology and, in turn, reductions in relationship satisfaction (McDaniel &amp; Coyne, 2016). Self-reported parent technofrenic is associated with greater internalizing and externalizing behavioral problems in children (McDaniel &amp; Radesky, 2018). Husbands’ social networking and wives' online gaming are negatively associated with marital quality (technology-use incongruence is associated with increased conflict; Dew &amp; Tulane, 2015). Boss phubbing is linked to undermined employee trust and reductions in employee engagement (Roberts &amp; David, 2017). Participants' smartphone dependency was a significant predictor of relational uncertainty, whereas romantic partner’s perceptions of participants’ smartphone dependence predicted relationship satisfaction (Lapierre &amp; Lewis, 2018).</td>
</tr>
<tr>
<td><strong>Path 4: Smartphone use and SNSs lead to reduced well-being</strong></td>
<td>Partner phubbing is directly linked to increases in depression, even when reductions in relationship satisfaction are accounted for (Wang, Xie, Wang, Wang, &amp; Lei, 2017). Facebook use is linked to more negative offline social relationships and decreased psychological well-being (but Facebook use is positively associated with well-being through more satisfying online relationships; Hu et al., 2017). Facebook use is linked to decreased satisfaction with life and reduced subjective well-being over a 2-week-experience sampling study (Kross et al., 2013). Time spent with friends in person is valued less when individuals use smartphones (Rotondi, Stanca, &amp; Tomasuolo, 2017). Smartphone use is linked to reductions in life satisfaction (Rotondi et al., 2017).</td>
</tr>
<tr>
<td><strong>Path 5: Disruption of relationship processes leads to reduced well-being</strong></td>
<td>Partner phubbing is associated with reductions in relationship satisfaction, which in turn is associated with increases in depression among married Chinese couples (Wang et al., 2017). Conflict over technology use is significantly related to depression among women (McDaniel &amp; Coyne, 2016). Phubbing is linked to reduced relationship satisfaction, which in turn is linked to undermined life satisfaction and increased depression (Roberts &amp; David, 2016).</td>
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Note: Each path number refers to a specific path illustrated in Figure 2. SNS = social networking site.
Table 1). This effect emerged despite participants’ inability to engage with their phone in either instance (Stothart et al., 2015).

In their review of technology habits and cognitive functioning, Wilmer, Sherman, and Chein (2017) argue that smartphones disrupt cognition in two primary ways: endogenously (when thoughts naturally “drift” to the smartphone because of boredom with the environment or dissatisfaction with a primary task) and exogenously (when one is on the phone for one disruptive task but the disruption continues when additional, unrelated applications prompt further smartphone engagement). Thus, because of their double-pronged disruptive nature, smartphones may uniquely undermine cognitive function. Likewise, Levy, Rafaeli, and Ariel (2016) found that when participants were interrupted by a multimedia text message (a text message that displayed graphics as well as text) while playing a competitive online game (the primary task), they performed worse than participants who were interrupted by a multimedia message via the computer; unsurprisingly, uninterrupted participants performed the online game best. This suggests that although multimedia-message interruptions are generally detrimental to cognitive performance, multimedia messages that are received via one’s smartphone are especially disruptive (Levy et al., 2016), presumably because of the potential for other applications on the smartphone to prolong the disruption.

The current section detailed how technology use can disrupt cognitive processes, focusing on the first path proposed in Figure 2. Although there is little empirical evidence for the second path proposed in Figure 2, we argue that to the extent that attention is necessary for relationship processes to unfold (e.g., self-disclosure, responsiveness), the studies illustrating impaired cognitive functioning support this second theoretical link. In the next section, we turn our attention to how technology use affects relationships directly (Path 3), how technology use can affect one’s well-being (Path 4), and, finally, how the link between technology use and well-being may be at least partially explained by disruptions in close-relationship processes (Path 5).

Technology and Social Relationships

Over the past 5 years, research on technology and interpersonal relationships has steadily increased, and much of this work focuses on the potential negative influences that smartphones and technology can exert on interpersonal relationships (McDaniel & Coyne, 2016; Przybylski & Weinstein, 2013; Roberts & David, 2016; Vanden Abeele, Anheunis, & Schouten, 2016). Research in this area can be divided into three broad categories: mere-presence studies, which focus on the effect of the mere presence of smartphones or similar mobile technologies on cognition and relationship functioning (Fig. 2, Paths 1–5); technoference studies, which focus on how snubbing partners with phones or engaging with mobile technology while in the presence of partners can undermine relationship functioning (Fig. 2, Paths 3 and 5); and social-networking studies, which focus on both the positive and negative aspects of using SNSs for relationship functioning and well-being (Fig. 2, Paths 4 and 5). The mere-presence, technoference, and social-networking studies collectively provide support for the general consequences of technoference (Figure 1e) and numbered paths presented in Figure 2, and the specific studies that support these linkages are highlighted in the review below and summarized in Table 1.

Mere-presence studies

The responsiveness draw of smartphones and mobile technology is so profound that their mere presence has been shown to disrupt relationship processes. For example, Przybylski and Weinstein (2013) showed that the presence (compared with the absence) of a smartphone led to reductions in relationship satisfaction for people who were interacting for the first time, especially when they were speaking about a topic of importance. Specifically, participants who were instructed to discuss the most important events that occurred in the past year (i.e., the condition that called for a great deal of self-disclosure) reported significantly reduced relationship quality, trust, and perceived empathy in the mere presence (vs. absence) of a partner's smartphone compared with participants who were instructed to casually discuss plastic holiday trees (supporting Path 3 from Fig. 2; see Table 1). This suggests that something about simply having a mobile device present is aversive, and its potential to disrupt an in-person interaction is sufficient to negatively affect one’s interaction experience, particularly when the phone represents a threat to an important topic of conversation.

Furthermore, these findings suggest that one’s availability to others (via the smartphone) represents a competition for the attentional resources of an interaction partner (supporting Paths 1–3 in Fig. 2; see Table 1), which is especially detrimental to relationship processes when one is self-disclosing meaningful information (e.g., the most meaningful events in the past year). Misra et al. (2016) conducted a conceptual replication of Study 2 from Przybylski and Weinstein (2013) in a naturalistic setting with dyads in coffee shops; dyads were observed unobtrusively while discussing either (a) holiday trees (control condition) or (b) the most meaningful events that occurred during the past year (meaningful-topic condition). Misra et al. (2016)
replicated the findings of Przybylski and Weinstein (2013), showing that the absence (vs. presence) of mobile phones significantly and positively predicted reports of connectedness after the dyads’ 10-min conversation (however, unlike Przybylski & Weinstein, they did not find that the conversation topic moderated feelings of connectedness).

More recently, Sprecher et al. (2016) found that unacquainted dyads interacting via Skype did not differ in their ratings of affect or conversation quality when one interaction partner unobtrusively used a smartphone (out of view of the interaction partner) versus when neither interaction partner used a smartphone. They found that those who unobtrusively used a smartphone during the Skype interaction were significantly less engaged in the interaction, yet this decreased engagement was not detrimental to self-reported conversation quality by the actor or the partner, suggesting perhaps that the presence of the smartphone must be perceived by an interaction partner before it exerts any negative effect on in-person interactions. These findings also suggest that participants may not have perceived any competition for an interaction partner’s attentional resources (or, perhaps, that competition for attentional resources is more normative in the context of an online interaction). It should be noted that participants may have attributed seemingly occasional lapses of attention to the slight delays that can occur when using Skype as an interaction medium; thus, the expectation of slight communication difficulties via Skype may have contributed to interaction partners being more “forgiving” of occasional conversation disengagement. Two of the mere-presence studies were conducted with unacquainted individuals, and there is reason to believe that smartphones may be particularly detrimental to relationships that have already been formed (e.g., romantic couples).

**Technoference studies: phubbing, conflict, and satisfaction**

Other studies have extended the mere-presence work by examining the explicit use of technology and smartphones in the presence of partners. For instance, in a longitudinal online study with committed romantic couples, Halpern and Katz (2017) showed that greater self-reported frequency of texting was associated with a reduction in relationship quality 1 year later; furthermore, relationship satisfaction at Time 1 did not predict texting at Time 2, supporting the idea that smartphone use leads to greater relationship dissatisfaction rather than the other way around (Fig. 2, Path 3; see Table 1). Roberts and David (2016) also showed that being phubbed was associated with increased relationship conflict and, in turn, decreased relationship satisfaction, particularly among those with an anxious attachment style. Although cross-sectional in nature, this study provides preliminary evidence that using a smartphone in a partner’s presence can disrupt relationship functioning by introducing conflict; furthermore, this increased conflict may reflect the competition that takes place for the attentional resources of one’s partner (supporting Paths 1–3 from Fig. 2; see Table 1). Several recent studies suggest that the negative effects of phubbing are not restricted to friendships or romantic partners. Roberts and David (2017) showed that when bosses phub their employees, the employees’ feelings of trust are undermined, and McDaniel and Radesky (2018) showed that parents’ self-reported problematic media use predicted both internalizing and externalizing problematic behavior in their children. These findings further support the idea that people feel a near-universal need to respond to others online in the modern digital age, across multiple contexts. Furthermore, across these contexts, people find phubbing and technoference to be aversive, representing a near-constant competition for an interaction partner’s attentional resources.

In an extension of the work on phubbing, Chotpitayasunondh and Douglas (2016) showed that self-reported “smartphone addiction” (operationalized as a score of 31 or higher for men and 33 or higher for women on the short version of the smartphone-addiction scale) was associated with increased phubbing, which in turn was associated with perceiving phubbing as more normative. In addition, people who reported phubbing others were also more likely to report being phubbed themselves, suggesting that phubbing is bidirectional in nature, facilitating its perception as a normative behavior (Chotpitayasunondh & Douglas, 2016). These findings may reflect the idea that many people experience the responsiveness draw that their smartphones create, and although phubbing negatively influences relationship satisfaction, people cannot help but engage with their mobile devices while in the presence of others. Other research suggests that relationship satisfaction appears to be highly dependent on perceptions of partners’ smartphone dependence—that is, the more people believe their partners are dependent and fixated on their phones, the lower their self-reported relationship satisfaction—and this effect was independent of participants’ self-reported phone dependence (Lapierre & Lewis, 2018; see also Lapierre, 2019).

**Social networking, relationship satisfaction, and well-being**

One area of research that predates the widespread adoption of the smartphone is work that investigated
the effects of SNSs on well-being. Although SNSs were initially intended to serve as tools for expanding one's supportive network, providing a convenient way of keeping in touch with others, it is important to bear in mind that SNSs began at a time when one was required to be in front of a desktop or laptop computer to use them (i.e., not while one's primary activity was interacting with present others). However, as smartphone applications became more advanced and widely used, engaging with SNSs frequently (and while in the presence of others) became possible—and, at least sometimes, problematic. For instance, in a 2-week-experience sampling study in which participants were texted 5 times per day, Kross et al. (2013) found that greater use of Facebook between text messages (with an average time between daily text messages of 168 min) led to decreases in affective well-being; furthermore, even after controlling for baseline levels of life satisfaction, greater Facebook use during the 2-week study period was associated with greater decreases in life satisfaction over time (supporting Path 4 from Fig. 2; see Table 1).

Kross et al. (2013) also tested the possibility that when people felt worse, they engaged in Facebook use more frequently; however, there was no evidence for this alternative explanation. Likewise, Hu, Kim, Siwek, and Wilder (2017) found that greater Facebook use was indirectly linked to decreases in life satisfaction via decreased offline social relationship satisfaction, supporting Paths 2, 4, and 5 from Figure 2; however, greater Facebook use positively predicted enhanced well-being via online social-relationship satisfaction. It is crucial to note that to the extent that Facebook advances one's need to foster quality social relationships (e.g., by providing a means to self-disclose and perceive responsiveness), its use can positively affect well-being; however, to the extent that Facebook use detracts from offline relationships (or relationships that are primarily fostered in person), its use can negatively affect psychological well-being.

Despite the negative consequences of technoference and people's negative emotional reactions to it, people engage in it frequently. A recent poll of 3,042 adult cell-phone users (Smith, 2015) showed that 89% reported using their smartphones at the last social gathering they attended, yet 82% also reported that smartphone use frequently or occasionally detracts from conversations at social gatherings. Only 25% reported that their own smartphone use takes away their attention from others during a social gathering (Smith, 2015). This finding is consistent with the idea that people believe their own divided attention does not negatively affect their ability to perform on their primary task of interest (e.g., driving a car, having a conversation, studying).

In summary, the literature reviewed here examined how technology can disrupt basic cognitive functioning as well as how it can interfere with relationship processes and, in turn, well-being. We proposed a model for how this process unfolds (see Fig. 2) and provided evidence for each theoretical link between smartphone use/SNSs and disruptions in cognitive and relationship functioning. The findings outlined above are summarized in Table 1, which displays the evidence that supports each path from Figure 2. These findings collectively support the idea that people are drawn to use their smartphones even in the presence of others and that this behavior disrupts cognitive functioning (i.e., reduces attentional resources) and is associated with disruptions in relationships processes and diminished well-being.

**Deeper Into Technoference: A Research Agenda**

Following the model proposed by Li et al. (2017) and as outlined in Figure 1, the primary goal of this article is to make the case for a potential evolutionary mismatch between the ways in which smartphones (and their affordances—access to social networks, texting, etc.) activate the basic intimacy processes required for forming and maintaining high-quality close relationships. As noted above, evolutionary mismatches are defined as situations in which human adaptations that emerged to foster survival in ancestral environments become maladaptive in novel contexts that may differentially cue the same evolved psychological mechanisms (Brenner et al., 2015; Li et al., 2017; Maner & Kenrick, 2010). Within this framework, the modern environment cues ancestral adaptations that essentially misfire and may not provide for the same type of adaptive benefits. We have provided credible evidence that humans' adaptive desires to self-disclose and respond to others, which serve to promote and maintain social bonding, may be at odds with the technological advances that put the entirety of humans' social networks at their fingertips. This final section of the article outlines a series of initial research questions that, when addressed, will deepen and refine the understanding of these processes and the accuracy of the mismatch framework we outlined above. We have organized this agenda into a series of short questions, all of which can be answered in a variety of different ways.

**Is an evolutionary framing necessary for making the case that cell-phone use can interfere with in-person interactions?**

Another goal of this article is to provide an overarching framework for asking and answering questions about why smartphones have the potential to disrupt relationship
functioning. Strictly speaking, a mismatch framework is not needed to observe evidence of technoference, and with only a few exceptions, the technoference literature does not rely on an evolutionary framework. We have argued, however, that the field needs theoretical framing to understand the behaviors that may drive technoference, and we believe the evolutionary framing is useful for understanding why smartphones and their affordances exert such a strong pull on people’s attention. A large part of this analysis is to go beyond the cognitive-interference literature to examine not only why these devices are so ubiquitous but also why they capture people’s attention so completely. We view this evolutionary framework as very useful in working toward answering these questions.

**How can we develop testable evolutionary hypotheses regarding self-disclosure and responsiveness?**

A key element for establishing the evolutionary-mismatch outline rests in identifying behavioral adaptations that operated to confer fitness advantages in the EEA (Buss, 1995) and then deriving specific hypotheses from middle-level evolutionary theories about how these adaptations operate (Lewis et al., 2017). We reviewed research indicating that attachment theory is also a middle-level evolutionary theory (see Simpson & Belsky, 2016), and this perspective has proven highly useful in generating testable hypotheses about how people—from the cradle to the grave—think and behave in and around close relationships (e.g., Brumbaugh & Fraley, 2006). Attachment theory also has a normative component, which refers to the bond itself—the question of what it means to be attached to another person (see Hazan, Gur-Yaish, & Campa, 2004). As an evolved “commitment device,” for example, romantic love can be understood as an emergent (emotional) property of an attachment bond (Fletcher et al., 2015), but much remains to be learned about the specific behaviors that facilitate social bonding—from close friendships, to pair bonds, to attachment relationships.

To the extent that self-disclosure and responsiveness are critical to the creation and maintenance of intimate social bonds, what specific evolutionary hypotheses can be derived from an evolutionary perspective on attachment theory? In this context, we are not concerned with the role of technology and relationships per se; rather, specific hypotheses from middle-level evolutionary theories provide a basis for accepting that specific behaviors have adaptive value for the species (Lewis et al., 2017). One straightforward hypothesis is that in new friendships or new romantic relationships, partners’ willingness to disclose intimate personal information and the degree of perceived responsiveness to these disclosures should be associated with the emergence of relationship commitment, trust, and, the development of an attachment bond. We are aware of no studies that have tested the prospective nature of these predictions—for example, diary studies in newly formed relationships that examine the ways in which self-disclosure and responsiveness give rise to the specific behaviors that characterize close relationships. Likewise, we would predict that in lab-based paradigms that manipulate self-disclosure and responsiveness in groups (e.g., see Aron et al., 1997; Birnbaum & Reis, 2012; Caprariello & Reis, 2011; Welker, Baker, Padilla, Holmes, Aron, & Slater, 2014), greater cooperation would follow. These hypotheses and study ideas are derived from the important observation that the behaviors subserving intimacy had adaptive value in promoting trust, cooperation, and social bonding. Evidence to this end would advance not only the case for the specific mismatch described here but also the normative understanding of adult attachment relationships and social bonding in general.

**What evidence would support a mismatch?**

Using legal evidentiary standards of proof to support the case for an evolutionary mismatch may prove informative (Kagehiro & Stanton, 1985). Credible evidence exists for the mismatch, but much more data are needed to ultimately reach definitive conclusions and/or to make public health statements of concern. Moreover, any statements about the potential negative consequences of the mismatch must be balanced by an appreciation for the positive contributions of smartphones not only to communication and productivity but also to close relationships (e.g., enhancing long-distance relationships). These positive contributions may operate hand in hand with the mismatch, and we simply need more and better science to understand the scope of the potential problem. Central to the case for a mismatch is the idea that because smartphones and their affordances create a responsiveness draw into their virtual world, intimacy in immediate close relationships becomes diminished.

Here we suggest harmonizing current intimacy studies with data collected before the widespread adoption of smartphones and the emergence of application-based SNS involvement on smartphones. The Facebook mobile application was released in 2007, and a number of older intimacy studies (Laurenceau, Barrett, & Pietromonaco, 1998; Laurenceau, Barrett, & Rovine, 2005; Reis & Franks, 1994) could be replicated or reenvisioned for
Within this framework, questions about conflict around technology use are important as well. Does conflict follow from diminished PPR, or does it lead to diminished PPR? Without conflict around technology use, do we observe diminished PPR? Furthermore, a series of questions may be asked about the health consequences of technoference and whether divorce rates would be influenced by technoference. We believe this work should be done in large, population-level studies (e.g., through Gallup surveys and reports or embedded into representative longitudinal studies) using preregistered analyses to gain a clear sense of the scope and consequences of technoference. (For an excellent example of this type of work, see Orben & Przybylski, 2019.) At a minimum, any work in this area must assess three dimensions: conflict surrounding technology in relationships, intimacy processes, and mental- or physical-health-relevant outcomes.

Is the smartphone a unique form of distraction? Does uncertainty (about interaction partners) matter?

As reviewed above, reasonably strong evidence indicates that smartphones can disrupt basic cognitive processes that we have argued are essential for maintaining intimate relationships. We have no data, however, to help us understand whether smartphones are simply another powerful means of distraction in relationships (through which people are compelled into virtual worlds largely as a function of the adaptive desires to self-disclose and be responsive), or whether technoference arises when one person is uncertain about the nature of his or her partner's interaction on the smartphone. Of course, sometimes people know that their partners are playing a solo game, but most smartphone use is social in nature—people are texting others, revealing information about themselves, and responding to others. At this stage, we do not know enough about technoference to conclude whether it emerges as a function of how relationships become degraded in real time through diminished attention or whether the uniquely social affordances of smartphones simply create new contexts in which people perhaps feel rejected in their relationship. We need research studies that conduct specific tests of these different hypotheses.

Can people be intimate with the entirety of their social network?

We have argued that the intimacy processes of self-disclosure and responsiveness are evolutionary adaptations for forming and maintaining small and intimate social networks, which were central to humans’ survival as a species. The idea that smartphones and SNSs may activate or take advantage of these adaptations to pull
people out of their in-person relationships and thus create technoference is at the heart of the mismatch. To date, however, much of the literature on relationships and technology is framed from a slightly different perspective: Are virtual interactions as good as in-person interactions? This question assumes that in-person interactions provide for “high-fidelity” intimacy by virtue of eye contact, smell, touch, and physiological attunement, all of which emerged to service social connection over the course of evolutionary history. Our position is that deep, meaningful, and intimate relationships can be formed and maintained online, but we also hypothesize that people cannot maintain intimacy with the entirety of their social network (which is consistent with the anthropological literature on network size), and the degree to which people make attempts to do so should be directly proportional to diminished quality in immediate kin networks. In other words, to the extent that one has limited resources (e.g., time, attention, energy), we would expect that as one expends those resources on more and more people (via social networking and virtual interactions), the “amount” of intimacy that can be maintained with any one person will be reduced. However, one could also argue that “intimacy” is not a limited resource, and people may indeed be able to maintain an acceptable degree of intimacy with their entire social network. From the perspective of evaluating a potential mismatch, the question of whether virtual relationships are as good as in-person interactions is best recast as what are the potential costs (and/or gains) for attempting to maintain intimacy with the entirety of one’s social network?

**Who is most susceptible to technoference?**

Our analysis of smartphone use and diminished PPR focuses largely on mediation, with an effort to explain the specific pathways through which heavy smartphone use may undermine relationship satisfaction. However, the question of moderation is relevant as well. Is the proposed association between heavy technology use and reduced PPR weaker for emerging adults who are embedded in a social context of near-constant engagement with one’s smartphone? Does attachment style moderate the association between PPR and relationship quality, perhaps with the relationship being stronger for more anxious people who are hypervigilant to cues of potential rejection? It is possible that what we have proposed as a normative process only appears or operates when individual differences are taken into account. Determining which individual differences are most relevant is an important task for future research.

**What experimental work would most strongly support the evolutionary mismatch framework?**

From basic laboratory studies to interventions that attempt to reduce technoference, experimental work will prove highly valuable in the future. As highlighted in Table 1, few experimental studies have examined whether manipulating how people interact with their smartphone causes changes in relationship quality. Most immediately, laboratory studies are needed to outline the boundaries of technoference—for example, does partner smartphone use diminish PPR, increase conflict, impede self-regulation, or alter attentional capacity compared with distraction via a book or a magazine? Can these effects be reversed if partners are instructed in different approaches for maintaining PPR? To the extent that the mere-presence finding replicates in larger samples, what specific psychological processes explain the experimental effects? Although we have theorized that the mere presence of a smartphone represents a
competitor for a partner's attentional resources, empirical studies are required to test this theory, and understanding this process better would inform a more general understanding of the mismatch.

Smartphones are here to stay, at least until they are replaced with a superior technology. If technoference is as large a problem as the current evidence suggests, then the emergence of experimental intervention research will be a timely addition to the science in this area as well. Are there specific harm-reduction strategies that can be implemented to alter how people interact with their phones that will reduce conflict or maintain in-person responsiveness? For example, do strategies such as setting daily intentions to be more present for one's partner make any appreciable difference to partners' reports of technology use, partner responsiveness, and/or technoference? Are there scientific best practices for using phones that can improve mental health and relationship quality?

**Conclusion**

This article outlined the case for a potential evolutionary mismatch between basic intimacy processes and smartphones. We argued that self-disclosure and responsiveness, interpersonal behaviors that subserve intimacy and promote cooperation, trust, and social bonding, are behavioral adaptations that emerged over the course of evolutionary history to ensure humans' survival by promoting inclusive and reproductive fitness. This analysis examined the ancestral (social) contexts that cued intimacy processes, and we highlighted a growing body of work indicating that intimacy processes are associated with several important health advantages. We also argued that the global rise of smartphones, and especially affordances that allow for virtual social connection via texting and SNSs, creates a context that compels self-disclosure and responsiveness online. At any given moment, smartphones compel people to engage in self-disclosure and responsiveness behaviors with the farthest reaches of their social networks; most simply, the same adaptations for building social bonds in immediate kin networks are engaged in a manner that draws people away from real-time social interactions and into the virtual world. The act of engaging in the virtual world when present with close others is not free of consequences, and this article summarized a growing literature on the ways in which smartphones may interfere with in-person social connection, including the rise of technoference, defined as relational conflict after technology use.

Despite the emerging science on technoference, the evidence in this area is far from definitive, and our analysis concluded with a series of empirical research questions that we hope will spur advances and a deeper understanding of the core issues surrounding the case for a potential mismatch. As we indicated in the opening, it would be naive to conclude that smartphones and their affordances are simply good or bad; however, it would be equally naive to suggest that the rate of technological advancement has no consequences on the ways in which humans interact. The key question, then, is whether and how these changes undermine human health and well-being. The mismatch framework provides an explanation for how this might happen and offers a series of testable research questions that can advance the long-term understanding of technology, relationships, and health.

**Action Editor**

Darby Saxbe served as action editor and June Gruber served as interim editor-in-chief for this article.

**Acknowledgments**

 Portions of this article were delivered as talks at the 2017 Mind & Life Institute’s Summer Research Institute (by D. A. Sbarra) and at the 2018 European Spring Conference on Social Psychology (by R. B. Slatcher). We thank Jeffry Simpson, Chris Segrin, and A. J. Figueredo for helpful input on the ideas discussed herein.

**Declaration of Conflicting Interests**

The author(s) declared that there were no conflicts of interest with respect to the authorship or the publication of this article.

**Note**

1. Middle-level evolutionary theories are propositions about domains of functioning and give rise to specific hypotheses about evolved behavioral adaptations in those domains (see Buss, 1995). Bowlby's attachment theory (Bowlby, 1969/1982) is also a middle-level theory because it outlines a universal suite of cognitive and affective behaviors that bind humans together in service of reproductive and inclusive fitness (Simpson & Belsky, 2016).

**References**


