Computers in Human Behavior 81 (2018) 265–273

Contents lists available at ScienceDirect

Computers in Human Behavior

journal homepage: www.elsevier.com/locate/comphumbeh

WIRED: The impact of media and technology use on stress (cortisol) and inflammation (interleukin IL-6) in fast paced families[☆]

Tamara D. Afifi [a, *], Nicole Zamanzadeh [a], Kathryn Harrison [a], Micelle Acevedo Callejas [b]

[a] Department of Communication at the University of California Santa Barbara, USA
[b] Department of Communication Studies at the University of Iowa, USA

ARTICLE INFO

Article history:

Keywords:
Technology use
Media use
Cortisol
Immune system
Families
Adolescence
Parents

ABSTRACT

This study examined how technology and media use affect stress (cortisol) and inflammation (interleukin IL-6) in dual earning parents and their adolescents. Sixty-two families reflected on their technology use the past week and collected saliva on two consecutive days that week. Technology use had the greatest effect on adolescents. Adolescents with greater phone use, general media exposure, and larger social networks via Facebook had a greater rise in their cortisol awakening response (CAR) and higher IL-6. Fathers' phone use and email were also associated with an increase in their CAR and IL-6. When bedtime technology use was high, greater general media use was associated with an increase in CAR for adolescents, but a decrease for fathers. Technology use did not significantly affect cortisol diurnal rhythm or mothers' biosocial markers. This study contributes empirical evidence of the physiological consequences of technology use among family members and provides potential theoretical explanations for future research.

Published by Elsevier Ltd.

In 2015, a Pew survey estimated that 68% of Americans owned a smartphone and 45% owned tablets (Anderson, 2015). Although people are increasingly dependent on these portable devices that provide mobility, the majority of media is still consumed in the home (Common Sense Media, 2013; Nathanson, 2015). Within the family, parents experience the blurring of work and personal life through the flexibility that Internet-connected mobile devices offer and often struggle to navigate these domains (Nam, 2014). Meanwhile, adolescents are exploring identity, completing schoolwork, and developing and maintaining friendships via technology (boyd, 2015). Indeed, technology has become an inevitable and important part of the fabric of most American families.

Despite the increased adoption of technology, research suggests it has mixed effects on well-being. Technology can help family members communicate efficiently, multitask, regulate moods, and facilitate social support (Carvalho, Francisco, & Relvas, 2015). For adolescents, developing in the digital age has enabled increased autonomy through easy access to peer networks, but it can also increase parental monitoring (boyd, 2015). Similarly, while technology can expedite communication and information sharing that enhances positive emotional connections (Carvalho et al., 2015), it can also contribute to surveillance and diminished face-to-face communication that can fuel stress in families (McDaniel, 2015). Heavy technology use in particular has been associated with depression, loneliness, anxiety, and narcissism (Rosen, Whaling, Rab, Carrier, & Cheever, 2013).

Although scholars have begun to understand how technology use affects individuals psychologically, much less is known about how it affects them physiologically, especially within families where multiple members are using technology simultaneously. The current study addresses this void in the literature by focusing on how technology use, and the type of technology used, affect biological stress responses (measured through cortisol) and immune systems (measured through the pro-inflammatory marker, interleukin IL-6) of dual earning parents and their adolescents (ages 13–18). An affordances approach is used to explore distinctions in both the role and the effects of technology on family members' stress. The impact of technology and media on stress in families is a pressing issue given the increasing number of dual career households with adolescents in which all members tend to live fast-paced lives (i.e., busy lifestyles replete with obligations of balancing work and family and extracurricular activities) and where everyone is "wired" most of their waking hours. We refer to

☆ The researchers would like to thank the families who participated in the study and the research assistants who helped with data collection.
* Corresponding author.
E-mail address: tafifi@comm.ucsb.edu (T.D. Afifi).

https://doi.org/10.1016/j.chb.2017.12.010
0747-5632/Published by Elsevier Ltd.

these families as fast-paced families or FPF.

1. Technology and media as tools that can affect stress

Media psychology provides a particularly useful theoretical approach to technological effects (Rutledge, 2012, pp. 43–61). Scholars who adopt a media psychology approach often model how affordances of media and technology constrain and/or enhance social perceptions, affect cognitive processing, and shape social, emotional, and psychological outcomes. Importantly, these effects also include physiological outcomes. Technology and media are used here as overarching terms that include a multitude of devices, as well as activities and new media that saturate the environment. Through the attributes of portability and connection to the Internet, technological devices afford perpetual contact and co-presence of social networks and unprecedented amounts of information (Rice & Katz, 2003). Therefore, these valuable tools can create tremendous demands and ultimately stress that can affect the physiological health of their users. In the current study, we focus on the interconnections between one's social environment (e.g., family and technology/media use) and biological stress responses (e.g., cortisol as a marker of stress and IL-6 as a marker of inflammation or immune strength) or what researchers often refer to as "biosocial markers" of stress.

Technologies, such as the mobile phone, have become essential tools for organizing and managing information, social coordination, and maintaining relationships (Rice & Hagen, 2010, pp. 2–39). This is likely particularly true for FPF who require management and coordination of everyone's busy schedules. Portable devices connected to the Internet (i.e., social media and chatting or messaging applications) can also connect people to their offline social support networks and diverse online social support networks at multiple times throughout the day. Riva, Baños, Botella, Wiederhold, and Gaggioli (2012) also note that there are positive effects of technology on affective quality, engagement/actualization, and connectedness. They found that these technologies can facilitate positive emotions, allow people to be more engaged and active in their interests via inducing flow or total involvement, and increase social presence and social capital. Yet, the multitude of new media and technology, which afford people constant access to engaging information, entertainment, and social connections, can lead to overload.

The technological advances that facilitate connection can also be stressful for adults and adolescents if they overwhelm their capacity and/or desires for information and communication. For instance, regardless of age, the pressure to be constantly available to social networks alone can result in communication overload (Stephens et al., 2017). Reinecke et al. (2016) found that across the lifespan, people reported experiencing digital stress or digitally caused strain. Their participants also engaged in communication due to fears of missing out (FOMO) on information and the social pressure to be responsive, which predicted anxiety, burnout, and depression. However, taking an affordances approach, these experiences of stress may also be linked to particular technological use that are advantageous for people's goals at their particular life-stages. Lee, Son, and Kim (2016) also found that social networking site (SNS) use can result in information, communication, and technological overload, and later SNS fatigue. In both studies, fatigue and stress existed across a range of ages, but was highest among youth (29 or below). Adults, however, often report feeling a "technostress" due to new technologies embedded in work life, including virtual offices and increased flexibility to work from home (Jarvenpaa & Lang, 2005).

Technologies can also create stress among family members by interfering with their relationships. "Technoference," which is a term for the experience relational partners have when technology interrupts conversations and other important shared experiences, has been found to produce technology-related conflicts between romantic partners and between parents and children (McDaniel, 2015). Conflicts can inhibit one's quality of life and family relationships and ultimately induce physiological stress (Kulhman, Repetti, Reynolds & Robles, 2016). McDaniel and Coyne (2014) found that the majority (70%) of romantic partners perceived computers, mobile phones and television to "sometimes" or "more often" interfere with their relationship. More frequent "technoference" has also been associated with lower overall well-being (e.g., lower reported relationship satisfaction, greater depressive symptoms, and lower life satisfaction). Although largely studied among romantic partners or parent-child dyads, Turkle (2011) remarks on the emotional disconnect among family members at the dinner table when their devices captivate them. Technology can interrupt essential face-to-face interactions and produce lower life satisfaction and technology-related conflict and stress in families if it is not used effectively.

Moreover, technology can interrupt, distract, or delay individuals' vital behaviors such as eating, exercising and sleeping, which can increase stress. One of the most robust effects of technology and media usage is on sleep duration and sleep disturbances (Cain & Gradisar, 2010). Sleep and quality of sleep are particularly important to the body's recovery from daily stress. Yet, research suggests that people's technology interfere with their very basic and important functions. Thomée, Harenstam and Hadberg (2011) discovered that high mobile phone usage was related to more sleep disturbances and depression. Lemola, Perkinson-Gloor, Brand, Dewald-Kaufmann, and Grob (2014) also discovered that adolescents who owned a smartphone had later bed times. Further, adolescents' reporting of late night usage of smartphones in bed was associated with depressive symptoms. Overall, electronic media use was negatively correlated with sleep duration and positively correlated with disturbances and depression. By tampering with sleep, technology might hinder the body's ability to recover from stress and prepare for oncoming daily stressors. Technology's ability to overload people with information and disrupt life, including sleep, provide evidence for its role as a stressor that can affect family members' biological stress responses.

2. Technology and physiological stress in families

To understand the impact of technology on physiological stress, it is first important to provide a brief overview of how the mind and body respond to stress. In the face of a stressor, challenge or threat, the body responds via the hypothalamic-pituitary-adrenal (HPA) axis's secretion of glucocorticoids (Juster, McEwen, & Lupien, 2010). After the brain assesses that something is stressful, the sympathetic-adrenal-medullary (SAM) releases adrenaline activating the HPA axis. Stimulating the production of corticotrophin releasing hormone (CRH) leads the anterior pituitary to release the adrenocorticotropic hormone (ACTH), which finally activates the adrenal cortex leading to cortisol. Cortisol (and other hormones and enzymes) energizes the body and prepares it to respond to an impending stressor (e.g., "flight or fight" responses).

Cortisol also has a consistent diurnal pattern or cycle in healthy children and adults (Saxbe & Repetti, 2010). A healthy diurnal pattern has a high initial cortisol level that peaks approximately 30 min after waking. People need a certain level of cortisol after they wake to combat the stress they face during their day (Munck, Guyre, & Holbrook, 1984). The rise in cortisol that occurs approximately 30 min after waking is called the cortisol awakening response or CAR (Adam et al., 2014). Nevertheless, too much or too little of a rise in CAR has been associated with poor physical and mental health (see Fries, Dettenborn, & Kirschbaum, 2009). The CAR is followed by a progressive reduction or steep drop in cortisol throughout the morning with a nadir in the late afternoon, reaching its lowest point at bedtime (Saxbe & Repetti, 2010). A smaller drop in cortisol throughout the day or the flatness of people's diurnal rhythms is indicative of worse health (Doane et al., 2013).

The impact of stress on the HPA axis often depends upon the nature of the stress and how the physiological stress responses are measured. In the presence of acute perceived environmental stressors, individuals often experience elevated levels of cortisol. Chronic or recurring stress can comprise daily functioning of the HPA axis (Juster et al., 2010). The HPA axis can become dysregulated due to allostatic load, making the diurnal cortisol rhythm flatter, more sensitive to stress and challenge, poorer at recovery from stressors, or non-responsive (McEwen, 1998).

Allostasis is the body's natural response to stress and is a dynamic process through which multiple biological systems respond and adapt to environmental stressors (McEwen, 1998). This adaptation is necessary and important for humans to adapt to their environment's demands. However, the body's ability to adapt effectively to stress can be compromised when it is overstimulated. Allostatic load is the cumulative “wear and tear” of chronic and/or enduring stress on biological, physiological, and psychological systems (Repetti, Robles, & Reynolds, 2011). Although we are not measuring allostatic load in the current study, the overuse of technology could contribute to acute and chronic stress and anxiety through communication overload and technoference and manifest in people's biological stress responses.

Chronic stress can weaken the body's immune system, making it more susceptible to disease. Research shows that psychological stress (from a wide range of sources, including conflict, relationship dissatisfaction, and loneliness) can dysregulate people's stress responses and inhibit their immune functioning (see Graham et al., 2009). Stress can elevate the productive of proinflammatory cytokines, one of which is IL-6. Inflammation is an essential way the body responds to infection or injury, but the over production of it is thought to be a crucial connection between stress and poor health (Jaremka, Lindgren, & Kiecolt-Glaser, 2013). Chronic inflammation is predictive of a host of diseases and disorders, including type II diabetes, obesity, cardiovascular disease, high blood pressure, and premature aging (McEwen & Wingfield, 2003).

Different types of stress, however, seem to have different effects on these responses. Environmental stress can affect the acute functioning of the HPA axis, the diurnal variability of the system, and the production of proinflammatory cytokines (e.g., Desantis et al., 2007). For the most part, too much stress tends to contribute to the over production of IL-6, which then contributes to even greater stress (Jaremka et al., 2013). Acute or more moderate stress can exacerbate the diurnal variability of cortisol and often produces a greater rise in CAR, whereas more severe and chronic stress often produces a blunting of the diurnal variability and cortisol awakening response (CAR) (Stetler & Miller, 2005). Chronically high and chronically low cortisol levels have been associated with psychological problems such as anxiety and depression, whereas moderate levels are more indicative of adaptive functioning (Gordis, Granger, Susman, & Trickett, 2006). Among anxious individuals, however, morning cortisol levels should be exceedingly high and remain somewhat higher in the evening (Doane et al., 2013). Although there is very little research connecting technology use to cortisol or IL-6, Wallenius et al. (2010) found that school age children (39 ten year olds and 33 13 year olds) who used greater amounts of technology the preceeding day (3 or more hours) had a diminished or lower CAR the next morning. As these authors speculated, too much technology use likely overwhelmed the children's physiological stress system and its ability to function properly. Long hours of technology use day after day might function as a natural stressor that builds over time.

Correspondingly, technology can be used to facilitate connection in physical proximity (Carvalho et al., 2015) or act as a tool for isolation and separation even while in physical proximity (Turkle, 2011). In particular, the general shared experience of high technology use could produce communication overload, which should be associated with higher stress among family members. But, because of the lack of research, the exact nature of how technology use affects cortisol patterns and IL-6 is unclear. Thus, we propose the following research question:

> RQ_1: In what ways does the amount of overall technology used by parents and adolescents during the week affect their CAR, IL-6, and cortisol diurnal rhythms?

In addition, the types of technology and media parents and adolescents use could produce different levels of stress. An affordances theoretical framework provides a systematic approach to exploring the characteristics of media that contribute to their social and personal uses and effects. Specifically, work-related email use on mobile devices by parents could be most disruptive by displacing parents' time and attention and most predictive of technology-related stress (McDaniel, 2015). This might represent communicative overload as an outcome of a lack of boundaries between work and home (Jaavrenpa & Lang, 2005). Furthermore, higher social media use (such as Facebook) affords higher social connectivity, visibility, accessibility, edibility, persistence (of messages), searchability and social feedback (Treem & Leonardi, 2012, pp. 143–189). Although these affordances have benefits, they can also be stressors (Fox & Moreland, 2015; Morin-Major et al., 2016). Given the affordances literature or different functions of technology, it is logical to assume that the forms of technology and media use matter in their impact on cortisol and IL-6.

H1. Technology used (i.e., mobile phone usage, email usage, general media use, or social network size on Facebook) by parents and adolescents during the week will differ in their effects on cortisol diurnal rhythms, CAR, and IL-6.

Finally, because research indicates that high technology use is related with late night usage, sleep disturbances and decreased sleep quality (Cain & Gradisar, 2010; Lemola et al., 2014), we hypothesize the following:

H2. Overall technology/media use will interact with nighttime screen/cell phone use to predict CAR, such that those with the greatest technology/media use and nighttime screen/cell phone use will have the highest CAR, and those with the lowest technology/media use and nighttime screen/cell phone use will have the lowest CAR.

3. Method

Families reflected on their technology use the past week. They also reported on their night time technology use, sleep, and collected four saliva samples throughout the day on two consecutive days in the middle of that week to test for cortisol and IL-6.

3.1. Participants

Sixty-two heterosexual couples (M age = 44.68) and one of their adolescent children (ages 13–18; M = 14.8; 31 sons and 31 daughters) participated in this study. All the couples were married

(94%) except for four, who were cohabitating. Eight (13%) of the couples were remarried. Most adolescents and parents were Caucasian (adolescent $n = 55$ or 89%; parents = 115 or 93%). The median household income of the families was $113,000. Nine of the parents had a high school degree (7%), 24 (19%) had an Associates' Degree or some college, 47 (38%) had a Bachelor's degree, and 41 (33%) had an advanced degree (MA, Ph.D., MD). The parents had an average of three children and worked an average of 44.7 h per week. The adolescents spent an average of 11 h a week in extracurricular activities and had 4.07 social media accounts. Parents reported 2.07 social media accounts.

3.2. Procedures

The families resided in the Midwest part of the U.S. They were recruited through a university-wide email listserv at a research university, advertisements sent to employees at large businesses, Craigslist, and network sampling. Once the families called the researcher, the researcher explained the study, screened members, and gained verbal consent. Both parents needed to be employed full time (min. of 40 h a week) and have two or more children still living in their home. All parents needed to be in a romantic relationship and living together and the adolescent needed to be currently residing with them. Family members were excluded if they had a health condition or were taking medications that could have altered their hormones.

Data collection for each family lasted one week. Each family member completed an initial survey on the same weekend, daily diary logs the following Monday through Friday, and an exit survey at the end of the week on the weekend. In this exit survey, participants reported about their technology and media use during the last week. All links to the online surveys and diary logs, as well as reminders, were emailed to the family members individually each day. The families choose two consecutive days in the middle of the week to collect their saliva samples.

Upon consent, families were mailed details of the study, saliva collection procedures, collection materials marked by days and times, medical forms, and cold packets. Parents and adolescents collected saliva by passively drooling into a small vial. Families were asked not to drink alcohol or visit the dentist within 48 h before their saliva collections. They were also instructed not to exercise rigorously, consume caffeine, use illegal drugs, or smoke on the days of collection. They were told not to brush their teeth, eat, or drink anything an hour before their saliva collections. Saliva samples were collected immediately upon waking in the morning before their feet touched the floor, 30 min after waking, at noon (in a private room, before lunch), and right before bedtime (resulting in 1488 saliva samples). The family was instructed to freeze their saliva samples in their home freezer immediately after collection. If they were at work or school, participants were asked to put their sample in a freezer or use the frozen packet to keep it cold.

Several procedures were established to help ensure compliance and accuracy in the data collection. Before the family began the study, a researcher either called the family using regular voice dialing or FaceTime (allowing the researcher to visually demonstrate how to collect the saliva). The instructions were also written in a letter, where the saliva collection was also visually depicted. A wake-up text reminder was also sent to each family member the morning of the saliva collections using their self-reported expected wake-up times. Immediately after collecting every saliva sample, the participants texted the researcher “collected,” providing a time stamp. Each participant was compensated $35. The data were collected during the academic year and not during a break or family vacation. Upon retrieval from the family's home, the saliva samples were immediately transferred to a freezer in the laboratory (-20° C). The samples were then shipped overnight to Salimetrics where they were frozen at -80° C until analyzed. All of the samples were assayed for salivary cortisol in duplicate by enzyme immunoassay (Granger et al., 2012). Intra- and inter-assay coefficients of variation should be less than 10 and 15%, respectively. Cortisol is reported in micrograms per deciliter (μg/dl).

3.3. Measures

3.3.1. Media and Technology Use Scale

An adapted version of the Media and Technology Use and Attitudes scale (Rosen, Whaling, Carrier, Cheever & Rokkum, 2013) was completed by the parents and adolescents at the end of the study. We asked participants about the frequency in which they engaged in each of the following activities in the last week: emailing (on all devices; 4 items; adolescent $\alpha = 0.72$, father $\alpha = 0.86$, mother $\alpha = 0.86$), phone use (including all smart phone use, calling, texting, music, pictures, internet, etc.; 14 items; adolescent $\alpha = 0.89$, father $\alpha = 0.91$, mother $\alpha = 0.93$), general media use (i.e., TV viewing, gaming, media sharing, internet searching; 13 items; adolescent $\alpha = 0.86$, father $\alpha = 0.87$, mother $\alpha = 0.75$), and social media use (e.g., “checked Facebook or other social networks,” “post status updates” “post photos” “read postings”; 9 items; adolescent $\alpha = 0.88$, father $\alpha = 0.95$, mother $\alpha = 0.95$). These subscale items were averaged and varied along the following anchors: 1 (never), 2 (once this past week), 3 (several times this past week), 4 (once a day), 5 (several times a day), 6 (once an hour), 7 (several times an hour), and 8 (always). Finally, we included the “Facebook” subscale that more specifically asked about participants' networks on Facebook. Participants were first asked if they had a Facebook account (yes = 1; no = 0). They were then asked about their social network on Facebook that ranged on a scale from 0 (none) to 8 (751 or more) (e.g., “How many total friends do you have on Facebook, including friends you may not know?” “How many Facebook friends do you know in person?” adolescent $\alpha = 0.91$, father $\alpha = 0.81$, mother $\alpha = 0.68$).

3.3.2. Night-Time Technology Use

Five items were created for this study to assess participants' reports of their typical technology use at bedtime in the initial, entry survey. Participants indicated whether or not (i.e., indicated yes = 1 or no = 0) they usually “fall asleep at night looking at a screen (or right after looking at a screen while still in bed) of some sort (e.g., TV, laptop, cell phone, iPod, etc.),” “use your cell phone as an alarm clock,” “silence your phone when you sleep (reverse coded),” “check your cell phone in the middle of the night” and “receive instant notifications on your cell phone (for email, texts, apps, etc …) in general?”

3.3.3. Hours of Sleep

Hours of sleep was a significant control variable in the models. Participants were asked in the diary logs the two days of their saliva collections how many hours of sleep they got the night before. The two evenings were averaged.

3.3.4. Physiological Measures

IL6 was measured with the wake-up saliva on day two of the collection. For cortisol, the average across each of the time points for the two collection days was calculated. CAR was measured as the “30 min after waking up score” minus the “wakeup score.” The diurnal rhythm of cortisol was assessed across the four time points (wake up, 30 min after waking up, noon, and bedtime—coded 0, 1, 2, 3).

4. Results

Means and standard deviations for the variables are provided in Table 1. On average, the parents and adolescents reported moderate levels of technology and media use. Facebook networks averaged between "51–100" to "101–175" friends. Most notably, mothers reported using email and Facebook more than fathers and adolescents and had a larger friendship network on Facebook. Fifty-eight percent ($n = 36$) of adolescents, forty-eight percent ($n = 30$) of fathers, and eighty-five percent ($n = 53$) of mothers indicated they had a Facebook account. The cortisol and IL6 scores were positively skewed and were transformed with a natural log transformation.

Multilevel modeling (using SPSS MIXED) with a random intercept was used to account for the nested nature of the data and the growth curve for the diurnal rhythm of cortisol. This statistical approach allowed for a detailed analysis of the effects of variables at the level of the individual family member (father, mother, adolescent–*level 1*), nested within a family (*level 2*). For each outcome, we first tested an unconditional or intercepts only model to obtain an estimate of the intraclass correlation (ICC). If there was significant variance in the outcome variable, we then proceeded to build the models by first testing control variables and their interaction with family role. Numerous control variables were examined (e.g., caffeine intake, number of children's activities, number of hours working, mental health, income, education), but the only one that was significant was participants' averaged hours of sleep the nights before their saliva collections. Therefore, this was the only control variable included in the models. Finally, predictor variables were entered, and interactions with family role were tested.

Separate intercepts for mothers and fathers were created by inserting dummy codes for mothers and fathers into the model instead of including a traditional intercept. The adolescent was the omitted group in the dummy coding. The models were then run again, making mothers the omitted group to determine all possible combinations of results for family role. After these analyses were complete, mothers, fathers and adolescents were then combined into one variable with the intercept included in the fixed effect (and the random effect for the growth curve models). For the growth curve models, separate slopes for mothers, fathers, and children were also created by crossing them with time. The predictors were grand mean centered.

Table 1
Descriptive statistics for predictor variables and IL6 and cortisol by family member.

	Mothers		Fathers		Adolescent	
	M	SD	M	SD	M	SD
Mean Hours Slept	6.99a	0.87	6.67b	0.98	7.44ba	1.03
Email Use	5.25ab	1.64	4.35bc	1.55	3.80ac	1.33
Phone Use	4.02	1.28	3.72a	1.28	4.30a	1.20
General Media Use	2.63a	1.11	2.66b	1.05	3.31ab	1.08
Social Media	3.56a	1.54	2.41ab	1.48	3.79b	1.49
Facebook	2.54ab	0.93	2.17b	1.22	2.04a	1.38
IL6	28.11	26.00	48.78	93.34	62.61	129.08
CAR	0.16+	0.10	0.10+	0.01	0.19+	0.04
Cortisol Wake	0.29	0.12	0.29	0.15	0.29	0.12
Cortisol 30 Min after Wake	0.45+	0.22	0.39a+	0.14	0.48a	0.16
Cortisol Noon	0.11a	0.07	0.14 + a	0.07	0.12+	0.06
Cortisol Bedtime	0.08	0.10	0.07	0.10	0.07	0.07

Note: IL6 and Cortisol scores are the raw scores before being transformed. Scale anchors for email use to social media range from 1–8 [1 (never), 2 (once this past week), 3 (several times this past week), 4 (once a day), 5 (several times a day), 6 (once an hour), 7 (several times an hour, and 8 (always)]. The specific "Facebook" scale asked participants about their network on Facebook a scale from 0 (none) to 8 (751 or more) (e.g., "How many total friends do you have on Facebook, including friends you may not know?" "How many Facebook friends do you know in person?" Facebook networks averaged between "51–100" to "101–175" friends). Corresponding letters across rows indicate significant differences between family members for that variable at a minimum of $p < 0.05$. $+ = p < 0.10$.

4.1. Results for CAR

In the final model for email use and CAR, there was a significant interaction for email use and fathers when compared to mothers $B = 0.01$, 95%CI [0.001, 0.02], $t(102.47) = 2.24$, $p < 0.05$, but no significant interaction for email use and mothers when compared to adolescents $B = -0.01$, 95%CI [-0.02, 0.01], $t(61.26) = -0.67$, *ns*, or email use for fathers when compared to adolescents $B = 0.01$, 95%CI [-0.004, 0.02], $t(59.15) = 1.25$, *ns*. This indicates that after controlling for the average number of hours slept at night, fathers who reported greater email use had a greater rise in their CAR compared to mothers. The random intercept variance remained significant in the models, Var = 0.25–26, $p < 0.01$. The test for whether these family roles and email use were significantly different from each other was not significant $B = 0.007$, 95%CI [-0.007, 0.008], $t(101.28) = 0.20$, *ns*.

In the final model for phone use and CAR, there were no significant interaction for phone use and fathers when compared to mothers $B = 0.004$, 95%CI [-0.01, 0.01], $t(95.54) = 0.06$, *ns*, no significant interaction for phone use and mothers compared to adolescents $B = -0.005$, 95%CI [-0.02, 0.01], $t(60.54) = -0.61$, *ns*, and no significant interaction for phone use for fathers compared to adolescents $B = -0.01$, 95%CI [-0.02, 0.003], $t(108.39) = -1.43$, *ns*. However, there was a main effect for adolescents for phone use at $p = 0.05$, $B = 0.01$, 95%CI [-0.0003, 0.02], $t(59.94) = 1.95$, indicating that (controlling for sleep) as adolescents increased their phone use, it corresponded with a slight rise in CAR. The random intercept variance was significant, Var = 0.22-0.24, $p < 0.05$.

In the final model for general media use and CAR, there was a significant interaction for general media use for fathers when compared to adolescents $B = -0.02$, 95%CI [-0.03, 0.002], $t(110.82) = -2.31$, $p < 0.05$, a significant interaction for general media use for mothers compared to adolescents $B = -0.02$, 95%CI [-0.03, -.0001], $t(101.40) = -2.02$, $p < 0.05$, but no significant interaction for general media use for fathers compared to mothers $B = -0.001$, 95%CI [-0.02, 0.01], $t(104.85) = -0.13$, *ns*. This indicates that after controlling for the number of hours slept at night, adolescents who reported greater general media use had a greater rise in their CAR compared to mothers and fathers. There was also a main effect for adolescents for general use $B = 0.09$, 95%CI [0.002, 0.17], $t(59.49) = 2.04$, $p < 0.05$, suggesting that as adolescents increased their general media use, it corresponded with a rise in CAR. The random intercept variance was significant, Var = 0.27–29, $p < 0.001$. The test for whether these family roles were significantly different than each other was significant $B = -0.01$, 95%CI -0.02, -.003], $t(127.91) = -2.65$, $p < 0.01$.

In the final model for Facebook use and CAR, there was a significant interaction for Facebook and mothers compared to adolescents $B = -0.02$, 95%CI [-0.04, -.01], $t(84.16) = 2.70$, $p < 0.01$, but no significant interaction for Facebook for fathers compared to adolescents $B = -0.01$, 95%CI [-0.03, 0.002], $t(96.13) = -1.65$, *ns*, and no significant interaction for Facebook for fathers compared to mothers $B = 0.01$, 95%CI [-0.01, 0.03], $t(92.46) = 1.17$, *ns*. This indicates that after controlling for the number of hours slept at night, adolescents who reported greater Facebook use had a greater rise in their CAR compared to mothers. There was also a main effect for adolescents for Facebook $B = 0.01$, 95%CI [0.002, 0.02], $t(58.45) = 2.49$, $p < 0.05$, suggesting that (controlling for sleep), as adolescents increased their Facebook use, it corresponded with a rise in CAR. The random intercept variance was significant, Var = 0.27, $p < 0.01$. The test for whether these family roles were significantly different than each other was significant $B = -0.01$, 95%CI [-0.02, -.0009], $t(142.02) = -2.20$, $p < 0.05$.

In the final model for social media use and CAR, there were no significant interaction for social media use and fathers when compared to mothers $B = 0.003$, 95%CI [-0.01, 0.01], $t(99.81) = 0.51$, *ns*, no significant interaction for social media use and mothers compared to adolescents $B = -0.006$, 95%CI [-0.01, 0.006], $t(108.04) = -1.00$, *ns*, and no significant interaction for social media use for fathers compared to adolescents $B = -0.003$, 95%CI [-0.01, 0.008], $t(105.89) = -0.49$, *ns*. The random intercept variance was significant, Var = 0.23–25, $p < 0.01$.

4.2. Results for IL-6

In the final model for email use and IL-6, there was no significant interaction for email use for fathers compared to mothers $B = 0.09$, 95%CI [-0.03, 0.20], $t(103.32) = 1.51$, *ns*, no significant interaction for email use for mothers compared to adolescents $B = 0.0007$, 95%CI [-0.13, 0.13], $t(88.01) = 0.01$, *ns*, or email use for fathers compared to adolescents $B = 0.10$, 95%CI [-0.05, 0.24], $t(101.16) = 1.40$, *ns*. However, there was a main effect for fathers and email use, indicating that (controlling for sleep) the more fathers used their email, the more their IL-6 increased. The random intercept variance was not significant, Var = 0.05, *ns*.

In the final model for phone use and IL-6, there was a significant interaction for phone use for fathers compared to adolescents $B = 0.18$, 95%CI [0.01, 0.34], $t(103.86) = 2.15$, $p < 0.05$, no significant interactions for phone use for mothers compared to adolescents $B = 0.03$, 95%CI [-0.12, 0.19], $t(94.70) = 0.44$, *ns*, and the interaction for phone use for fathers compared to mothers was approaching significance $B = 0.13$, 95%CI [-0.006, 0.28], $t(95.31) = 1.90$, $p = 0.06$. After controlling for sleep, adolescents who reported greater phone use had a greater increase in their IL-6 compared to fathers. Fathers who also reported greater phone use had a slightly greater increase in their IL-6 compared to mothers. The random intercept variance was not significant, Var = 0.07, *ns*. The test for whether these family roles were significantly different than each other was not significant $B = 0.05$, 95%CI [-0.04, 0.15], $t(93.74) = 1.01$, *ns*.

In the final model for general media use and IL-6, there was no significant interaction for general media use for fathers when compared to mothers $B = 0.07$, 95%CI [-0.10, 0.25], $t(103.21) = 0.86$, *ns*, no significant interaction for general media use and mothers when compared to adolescents $B = 0.04$, 95%CI [-0.13, 0.22], $t(95.81) = 0.47$, *ns*, and no significant interaction for general media use and fathers when compared to adolescents $B = 0.13$, 95%CI [-0.07, 0.32], $t(105.93) = 1.26$, *ns*. Therefore, there were no significant effects for general media use on IL-6. The random intercept variance was not significant, Var = 0.03, *ns*.

In the final model for Facebook use and IL-6, there was a significant interaction for Facebook for mothers compared to adolescents $B = -0.16$, 95%CI [-0.32, 0.006], $t(108.88) = -2.06$, $p < 0.05$, an interaction for Facebook and fathers compared to adolescents that was approaching significance $B = -0.15$, 95%CI [-0.32, 0.03], $t(91.14) = 1.68$, $p = 0.09$, but no significant interaction for Facebook for fathers compared to mothers $B = -0.03$, 95%CI [-0.22, 0.15], $t(91.77) = -0.36$, *ns*. This indicates that after controlling for the number of hours slept at night, adolescents who reported greater Facebook use had a greater increase in their IL6 compared to mothers and fathers. There was also a main effect for adolescents for Facebook $B = 0.12$, 95%CI [0.01, 0.23], $t(54.21) = 2.25$, $p < 0.05$, suggesting that (controlling for sleep) as adolescents increased their Facebook use, it corresponded with an increase in IL-6. The random intercept variance was not significant, Var = 0.09-0.13, *ns*. The test for whether these family roles were significantly different than each other was significant $B = -0.11$, 95%CI [-0.21, -.01], $t(134.98) = 2.35$, $p < 0.05$.

In the final model for social media use and IL-6, there was no significant interaction for social media use for fathers when compared to mothers $B = 0.03$, 95%CI [-0.10, 0.16], $t(96.61) = 0.40$, *ns*, no significant interaction for social media use and mothers when compared to adolescents $B = -0.04$, 95%CI [-0.17, 0.08], $t(100.39) = -0.69$, *ns*, and no significant interaction for social media use and fathers when compared to adolescents $B = 0.002$, 95%CI [-0.14, 0.14], $t(106.93) = 0.03$, *ns*. Therefore, there were no significant effects for social media use on IL-6. The random intercept variance was not significant, Var = 0.04-0.05, *ns*.

4.3. Results for CAR and nighttime technology use and general media use

The results also revealed a significant three-way interaction for general media use, night time technology use and fathers compared to adolescents $B = -0.01$, 95%CI [-0.02, -.006], $t(54.42) = -2.06$, $p < 0.05$, but no significant interaction for general media use, night time technology use and mothers compared to adolescents $B = 0.003$, 95%CI [-0.009, 0.02], $t(57.86) = 0.49$, *ns*. The three-way interaction for general media use, night time technology use and fathers compared to mothers was approaching significance $B = -0.01$, 95%CI [-0.03, 0.001], $t(105.10) = -1.83$, $p = 0.07$. The random intercept variance remained significant in the final models, Var = 0.26-0.27, $p < 0.01$. Follow-up regression analyses, controlling for sleep, were then conducted to examine the nature of the association between general media use and CAR for fathers, mothers, and adolescents. Night time use was broken up into low and high levels based upon a mean split of the data. These analyses revealed the when night time technology use was high, general media use was associated with a significant rise in CAR for adolescents, $\beta = 0.34$, $t = 2.39$, $p < 0.05$, but a significant and sharp decrease in CAR for fathers, $\beta = -0.72$, $t = -2.73$, $p < 0.05$, and no significant association for mothers, $\beta = 0.06$, $t = 0.25$, *ns*. The associations between general media use and CAR for adolescents, $\beta = -0.16$, $t = -0.56$, *ns*, fathers $\beta = -0.06$, $t = 0.42$, *ns*, and mothers $\beta = -0.02$, $t = -0.10$, *ns*, were not statistically significant when night time use was low.

4.4. Results for diurnal rhythm

The results for the unconditional growth curve model indicated that there was not sufficient variance across family members' cortisol over time. Adding in technology as predictors also showed a lack of convergence, suggesting that there was not enough difference or change in the family members' diurnal rhythms.

5. Discussion

This study examined the physiological consequences of technology use in fast-paced families. Few studies have tested how technology use is associated with people's biological stress markers (i.e., cortisol) (for exceptions, see Brom et al., 2014; Gentile, Bender, & Anderson, 2017; Heo et al., 2017; Morin-Major et al., 2016; Wallenius et al., 2010). To our knowledge, this is the first study to assess the association between technology use and inflammation. This study is also important in that it accounts for individual family members' technology use and biosocial markers as embedded within larger technology use within the family system. The results showed that technology affected family members differently, largely as a function of the types of technology used. The most evident finding was that technology had the greatest effect on adolescents' CAR and IL-6 compared to mothers and fathers. Adolescents with higher phone use, greater general media exposure, and larger social network sizes via Facebook demonstrated a greater rise in their CAR and higher rates of IL-6.

Even though adolescents' technology use was most connected to their biosocial stress markers, fathers were also affected. Fathers who reported greater phone use had a slightly greater increase in their IL-6 compared to mothers. Fathers who reported greater email use had a stronger rise in their CAR compared to mothers. In addition, the more that fathers used their email, the more they experienced an increase in their IL-6. Finally, when night time technology use was high, general media use was associated with a significant rise in CAR for adolescents, but a significant *decrease* in CAR for fathers. Technology use did not significantly affect cortisol diurnal rhythm nor did have any significant effect on mother's biosocial stress markers.

5.1. Interpreting the physiological consequences of technology use

Overwhelmingly, technology use affected adolescents' CAR more than their parents. Interestingly, this technology use did not influence any of the family members' diurnal rhythms, but it influenced their CAR. Technology use alone was likely not powerful enough to significantly alter the slope of family members' cortisol throughout the day, but it did affect their amount of cortisol production in the morning. Adolescents' phone, general media use, and Facebook social network size resulted in a greater rise in CAR for adolescents than their parents. The only other significant predictor of a greater change in CAR for parents was for fathers, whose email use was also associated with higher CAR than mother's email use.

Our results also revealed that when fathers used more general media throughout the day and more technology at bedtime, it diminished their CAR. But, the same pattern was predictive of a rise in CAR for adolescents. This finding might indicate that using technology right before bed and throughout the day could be making fathers experience symptoms that emulate depression, such as extreme fatigu**e.** Adolescents, on the other hand, who engage in the same patterns may be feeling an increase in anxiety or stress. A rise in CAR is expected and healthy to combat daily stressors (Fries et al., 2009). Too high or too low of a CAR, however, is often predictive of poorer physical and mental health such as anxiety and depressive symptoms (Fries et al., 2009). Although the findings on CAR are still debated, acute or more moderate stress and anxiety is often predictive of a greater rise in CAR (Stetler & Miller, 2005), which could be one explanation for rise in CAR for the adolescents in our sample, whereas more severe and chronic stress can lead to a blunting of the CAR (Stetler & Miller, 2005), which might be indicative of fathers' drop in cortisol after waking. These findings suggest that the physiological impacts of technology on families depends on who is using it, how it is used, and why it is used.

Unlike adults, adolescents have reported using an array of different types of social media, including Facebook. Adolescents use Facebook to keep up with social networks (Frison & Eggermont, 2016) and maintain a mediated social identity (Oeldorf-Hirsch, Birnholtz, & Hancock, 2017). Defining their role in society and developing an identity are central goals at their age (boyd, 2015). But, this can produce social stress. Social stress is a pervasive and common type of stress for adolescents, which can have far reaching physiological effects (Finnel & Wood, 2016). Because of the continual access to others' personal information, adolescents might become overwhelmed with managing the array of emotions from others' lives, monitoring their place in their social network and experiencing social comparisons.

Our results suggest that the consequences of being "wired" not only influence CAR, but also extend to inflammation. Although no results were found for email and general media use for adolescents or parents, adolescents who reported greater phone use and Facebook use experienced greater IL-6. Pro-inflammatory cytokines, such as IL-6, have been associated with poorer physical and mental health in families (Graham et al., 2009). Overproduction of IL-6 has been correlated with cardiovascular disease, cancer, psychiatric disorders, and post-traumatic stress disorders (Carpenter et al., 2010; Cohen, Doyle, & Skoner, 1999). Given that this is only a one week study with families, however, additional research is necessary that can track adolescents' technology use and its association with biosocial markers over the life course.

5.2. Affordances as a theoretical explanation

Even though we did not examine why family members used certain technology or media, the research on media affordances (Fox & Moreland, 2015; Rice et al., 2017; Treem & Leonardi, 2012, pp. 143–189) could shed light on our findings. Fathers were more affected physiologically by increased email use than mothers. Father's email use may be bringing work into the home and thus introducing stress. However, adolescents' physiology and technology use tells a different story. Even though adolescents were born with these technologies, overall media consumption generally appears to be more physiologically stressful for adolescents than their parents. Furthermore, not all media use had this effect. Unlike parents, adolescents were unaffected by email. One speculation for this is that email is not as important in adolescents' lives, especially for maintaining their friendships, compared to other forms of technology. Moreover, Facebook social network size, rather than social media use in general, had an effect on CAR and IL-6 for adolescents. These findings seem to indicate that it is the reason for technology use above and beyond technology use itself, which has an effect on physiological stress.

These findings contribute to developing theoretical models of technology effects, such as the affordances framework. For instance, the mobility of devices (i.e., portability) may extend fathers' capacity to engage in work related media such as email, but this affordance of availability and accessibility might diminish work-home boundaries and facilitate communication overload (Jarvenpaa & Lang, 2005; Reinecke et al., 2016; Schrock, 2015). This perspective could be applied to the other family members. Mothers' CAR and IL6 were not significantly affected by technology use, which could indicate that they are better adapted to the volume of communication that technology have facilitated than fathers and adolescents. This requires further investigation. Yet, the role of portability might also explain the greater physiological effects experienced by adolescents compared to parents, especially as it relates to social network sizes via Facebook (Morin-Major et al., 2016; Schrock, 2015). Adolescents' social networks might increase the number of relationships they have beyond a size that is perhaps maintainable. This supports other findings that demonstrate that people sometimes experience fatigue and stress because of SNS (Fox & Moreland, 2015; Lee et al., 2016).

Adolescents who are in the process of exploring and developing their social environment and identity might also be affected by the content afforded by technology, such as the increased capacity for selective self-presentation (Rice et al., 2017). Selective self-presentation may combine with other affordances, such as increased access and visibility in one's social network, to facilitate social comparison. Content can be selectively chosen to enhance self-presentation, creating perceptions that one's peers are happier, more social, and more attractive. Through social comparisons, adolescents can experience sensations of loneliness (Best, Manktelow, & Taylor, 2014), dissatisfaction (Tiggemann & Slater, 2013) and anxiety such as FOMO (Rosen et al., 2013a). The communication within social networks could facilitate adolescents' social stress by creating unachievable norms that precipitate adolescent's feelings of inadequacy.

Similarly, the content of social network messages could produce stress by facilitating emotional contagion (Fox & Moreland, 2015). Hancock, Gee, Ciaccio, and Lin (2008) found that the emotional content of the messages shared by people's social networks influence the mood of messages that people share. This might be especially true of adolescents who are exploring social networks, experiencing hormonal changes, and facing the challenges of school and peers as they prepare for college and enter their first romantic relationships (boyd, 2015). Peer networks' message content could increase exposure to negative affect and increase adolescents' stress.

5.3. Final thoughts

The findings of the current study must be set within its limitations. Because of the intensity and cost of the data collection, the sample included a small group of families from the Midwest. Our findings need to be tested with a larger sample and in more diverse parts of the United States, and the globe more broadly. Because the current sample is not randomly generated, we cannot generalize our findings within or outside the United States. Different effects of technology and media use on diurnal rhythm might be realized with a larger, randomly selected, international sample and one that is collected over a longer period of time. In addition, our sample size might have also affected our power to detect significant differences. We decided to continue to report findings that were approaching significance ($p < 0.10$) given that significance levels are arbitrarily created by researchers, are likely a reflection of sample size, and are of practical and theoretical importance. We were also unable to examine differences in technology/media use and biosocial markers for boys and girls because of our limited sample size. However, this is an important direction for future research given that research suggests that technology and media use and decision making often differ depending upon the sex and age of the adolescent (e.g., Fedorowicz, Vilvovsky, & Golibersuch, 2010). Finally, although different technology and media uses were compared in this study, the reasons for using these technologies are speculative and based on previous affordances research. Future research should evaluate distinctions among family members' needs, uses and gratifications of media and technology use and how they affect biosocial stress markers. In addition, gaming was measured with a couple of items within the general media use subscale. However, given its popularity with adolescents and adults alike, researchers might compare its influence on biosocial markers to other media and technology. Even with these limitations, the current study provides foundation information on the effect of technology use in families on cortisol and immune strength. Our results suggest that adolescents, in particular, might be most at risk for the effects of being “wired” in a fast paced world.

Funding

Funding for this study was provided by the University of Iowa.

References

Adam, E. K., Vrshek-Schallhorn, S., Kendall, A. D., Mineka, S., Zinbarg, R. E., & Craske, M. G. (2014). Prospective associations between the cortisol awakening response and first onsets of anxiety disorders over a six-year follow-up - 2013 Curt Richter award winner. *Psychoneuroendocrinology, 44*, 47–59. https://doi.org/10.1016/j.psyneuen.2014.02.014.

Anderson, M. (2015). *Technology device ownership: 2015*. Pew Research Center. http://www.pewinternet.org/2015/10/29/technology-device-ownership-2015/.

Best, P., Manktelow, R., & Taylor, B. (2014). Online communication, social media and adolescent wellbeing. *Children and Youth Services Review, 41*, 27–36.

boyd, d (2015). *It's complicated: The social lives of networked teens*. New Haven, CT: Yale University Press.

Brom, C., Buchtová, M., Šisler, V., Děchtěrenko, F., Palme, R., & Glenk, L. M. (2014). Flow, social interaction anxiety and salivary cortisol responses in serious games: A quasi-experimental study. *Computers & Education, 79*, 69–100. https://doi.org/10.1016/S0161-813X(14)00128-4.

Cain, N., & Gradisar, M. (2010). Electronic media use and sleep in school-aged children and adolescents: A review. *Sleep Medicine, 11*, 735–742. https://doi.org/10.1016/j.sleep.2010.02.006.

Carpenter, L. L., Gawugas, C. E., Tyrka, A. R., Lee, J. K., Anderson, G. M., et al. (2010). Association between plasma IL-6 response to acute stress and early-life adversity in healthy adults. *Neuropsychopharmacology, 35*, 2617–2623.

Carvalho, J., Francisco, R., & Relvas, A. P. (2015). Family functioning and information and communication technologies: How do they relate? A literature review. *Computers in Human Behavior, 45*, 99–108. https://doi.org/10.1016/j.chb.2014.11.037.

Cohen, S., Doyle, W. J., & Skoner, D. P. (1999). Psychological stress, cytokine production, and severity of upper respiratory illness. *Psychosomatic Medicine, 61*, 175–180.

Common Sense Media. (2013). *Zero to eight: Children's media use in American 2013*. New York, NY: Common Sense Media.

Desantis, A., Adam, E., Doane, L., Mineka, S., Zinbarg, R., & Craske, M. (2007). Racial/ethnic differences in cortisol diurnal rhythms in a community sample of adolescents. *Journal of Adolescent Health, 41*, 3–13.

Doane, L. D., Mineka, S., Zinbarg, R. E., Craske, M., Griffith, J. W., & Adam, E. K. (2013). Are flatter diurnal cortisol rhythms associated with major depression and anxiety disorders in late adolescence? The role of life stress and daily negative emotion. *Development and Psychopathology, 25*, 629–642. https://doi.org/10.1017/S0954579413000060.

Fedorowicz, Jane, Vilvovsky, Sonia Gantman, & Golibersuch, Andrew J. (2010). Gender differences in Teenagers' elective use of computer technology. *Communications of the Association for Information Systems, 27*. Article 3. Available at: http://aisel.aisnet.org/cais/vol27/iss1/3.

Finnell, J. E., & Wood, S. K. (2016). Neuroinflammation at the interface of depression and cardiovascular disease: Evidence from rodent models of social stress. *Neurobiology of Stress, 4*, 1–14. https://doi.org/10.1016/j.ynstr.2016.04.001.

Fox, J., & Moreland, J. J. (2015). The dark side of social networking sites: An exploration of the relational and psychological stressors associated with Facebook. *Computers in Human Behavior, 45*, 168–176. https://doi.org/10.1016/j.chb.2014.11.083.

Fries, E., Dettenborn, L., & Kirschbaum, C. (2009). The cortisol awakening response (CAR): Facts and future directions. *International journal of Psychophysiology, 72*, 67–73. https://doi.org/10.1016/j.ijpsycho.2008.03.014.

Frison, E., & Eggermont, S. (2016). Exploring the relationships between different types of Facebook use, perceived online social support and adolescents' depressed mood. *Social Science Computer Review, 34*, 153–171.

Gentile, D. A., Bender, P. K., & Anderson, C. A. (2017). Violent video game effects on salivary cortisol, arousal, and aggressive thoughts in children. *Computers in Human Behavior, 70*, 39–43. https://doi.org/10.1016/j.chb.2016.12.045.

Gordis, E. B., Granger, D. A., Susman, E. J., & Trickett, P. K. (2006). Asymmetry between salivary cortisol and α-amylase reactivity to stress: Relation to aggressive behavior in adolescents. *Psychoneuroendocrinology, 31*, 976–987. https://doi.org/10.1016/j.psyneuen.2006.05.010.

Graham, J. E., Glaser, R., Loving, T. J., Malarkey, W. B., Stowell, J. R., & Kiecolt-Glaser, J. K. (2009). Cognitive word use during marital conflict and increases in proinflammatory cytokines. *Health Psychology, 28*, 621–630. https://doi.org/10.1037/a0015208.

Granger, D., Fortunato, C., Beltzer, E., Virag, M., Bright, M., & Out, D. (2012). Focus on methodology: Salivary bioscience and research on adolescence: An integrated perspective. *Journal of Adolescence, 35*, 1081–1095. https://doi.org/10.1016/j.adolescence.2012.01.005.

Hancock, J. T., Gee, K., Ciaccio, K., & Lin, J. M. (2008). I'm sad you're sad: emotional contagion in CMC. In *Proceedings of CSCW '08: ACM Conference on computer supported cooperative work* (pp. 295–298). https://doi.org/10.1145/1460563.1460611.

Heo, J.-Y., Kim, K., Fava, M., Mischoulon, D., Papakostas, G. I., Kim, M.-J., … Jeon, H. J. (2017). Effects of smartphone use with and without blue light at night in healthy adults: A randomized, doubleS-blind, cross-over, placebo-controlled comparison. *Journal of Psychiatric Research, 87*, 61–70. https://doi.org/10.1016/j.jpsychires.2016.12.010.

Jaremka, L., Lindgren, M., & Kiecolt-Glaser, J. (2013). Synergistic relationships among stress, depression, and troubled relationships: Insights from psychoimmunology. *Depression and Anxiety, 30*, 288–296.

Jarvenpaa, S., & Lang, K. (2005). Managing the paradoxes of mobile technology. *Information Systems Management, 22*, 7–23.

Juster, R. P., McEwen, B. S., & Lupien, S. J. (2010). Allostatic load biomarkers of chronic stress and impact on health and cognition. *Neuroscience and Biobehavioral Reviews, 35*, 2–16. https://doi.org/10.1016/j.neubiorev.2009.10.002.

Kuhlman, K. R., Repetti, R. L., Reynolds, B. M., & Robles, T. F. (2016). Change in parent-child conflict and the HPA-axis: Where should we be looking and for how long? *Psychoneuroendocrinology, 68*, 74–81. https://doi.org/10.1016/j.psyneuen.2016.02.029.

Lee, A. R., Son, S. M., & Kim, K. K. (2016). Information and communication technology overload and social networking service fatigue: A stress perspective. *Computers in Human Behavior, 55*, 51–61. https://doi.org/10.1016/j.chb.2015.08.011.

Lemola, S., Perkinson-Gloor, N., Brand, S., Dewald-Kaufmann, J. F., & Grob, A. (2014).

Adolescents: Electronic media use at night, sleep disturbance, and depressive symptoms in the smartphone age. *Journal of Youth and Adolescence, 44*, 405–418. https://doi.org/10.1007/s10964-014-0176-x.

McDaniel, B. T. (2015). "Technoference": Everyday intrusions and interruptions of technology in couple and family relationships. In C. J. Bruess (Ed.), *Family communication in the age of digital and social media*. New York: Peter Lang Publishing.

McDaniel, B. T., & Coyne, S. M. (2014). "Technoference": The interference of technology in couple relationships and implications for women's personal and relational well-being. *Psychology of Popular Media Culture, 5*. https://doi.org/10.1037/ppm0000065. Advance online publication.

McEwen, B. S. (1998). Protective and damaging effects of stress media- tors. *New England Journal of Medicine, 338*, 171–179.

McEwen, B. S., & Wingfield, J. C. (2003). The concept of allostasis in biology and biomedicine. *Hormones and behavior, 43*, 2–15.

Morin-Major, J. K., Marin, M. F., Durand, N., Wan, N., Juster, R. P., & Lupien, S. J. (2016). Facebook behaviors associated with diurnal cortisol in adolescents: Is befriending stressful? *Psychoneuroendocrinology, 63*, 238–246. https://doi.org/10.1016/j.psyneuen.2015.10.005.

Munck, A., Guyre, P. M., & Holbrook, N. J. (1984). Physiological functions of glucocorticoids in stress and their relations to pharmacological actions. *Endocrine Review, 5*, 25–44. https://doi.org/10.1210/edrv-5-1-25.

Nam, T. (2014). Technology use and work-life balance. *Applied Research in Quality of Life, 9*, 1017–1040. https://doi.org/10.1007/s11482-013-9283-1. article.

Nathanson, A. I. (2015). Media and the family: Reflections and future directions. *Journal of Children and Media, 9*, 133–139. https://doi.org/10.1080/17482798.2015.997145.

Oeldorf-Hirsch, A., Birnholt, J., & Hancock, J. (2017). Your post is embarrassing me: Face threats, identity, and the audience on Facebook. *Computers in Human Behavior, 73*, 92–99. https://doi.org/10.1016/j.chb.2017.03.030.

Reinecke, L., Aufenanger, S., Beutel, M. E., Dreier, M., Quiring, O., Stark, B., … Dreier, M. (2016). Digital stress over the life span: The effects of communication load and internet multitasking on perceived stress and psychological health impairments in a German probability sample. *Media Psychology, 0*, 1–26. https://doi.org/10.1080/15213269.2015.1121832.

Repetti, R. L., Robles, T. F., & Reynolds, B. (2011). Allostatic processes in the family. *Development and Psychopathology, 23*, 921–938. https://doi.org/10.1017/S095457941100040X.

Rice, R. E., Evans, S. K., Pearce, K. E., Sivunen, A., Vitak, J., & Treem, J. W. (2017). Organizational media affordances: Operationalization and associations with media use. *Journal of Communication, 67*, 106–130.

Rice, R. E., & Hagen, I. (2010). Young adults' perpetual contact, social connectivity, and social control through the internet and mobile phones. In C. Salmon (Ed.), *Communication yearbook, 34*. London: Routledge.

Rice, R. E., & Katz, J. E. (2003). Comparing internet and mobile phone usage: Digital divides of usage, adoption, and dropouts. *Telecommunications Policy, 27*, 597–623.

Riva, G., Baños, R. M., Botella, C., Wiederhold, B. K., & Gaggioli, A. (2012). Positive Technology: Using interactive technologies to promote positive functioning. *Cyberpsychology, Behavior, and Social Networking, 15*, 69–77. https://doi.org/10.1089/cyber.2011.0139.

Rosen, L. D., Whaling, K., Carrier, L. M., Cheever, N. A., & Rokkum, J. (2013a). The media and technology usage and attitudes Scale: An empirical investigation. *Computers in Human Behavior, 29*, 2501–2511. https://doi.org/10.1016/j.chb.2013.06.006.

Rosen, L. D., Whaling, K., Rab, S., Carrier, L. M., & Cheever, N. A. (2013b). Is Facebook creating "iDisorders"? The link between clinical symptoms of psychiatric disorders and technology use, attitudes and anxiety. *Computers in Human Behavior, 29*, 1243–1254. https://doi.org/10.1016/j.chb.2012.11.012.

Rutledge, P. B. (2012). Arguing for media psychology as a distinct field. In K. E. Dill (Ed.), *The Oxford handbook of media psychology*. Oxford, UK: Oxford University Press.

Saxbe, D., & Repetti, R. L. (2010). For better or worse? Coregulation of couples' cortisol levels and mood states. *Journal of Personality and Social Psychology, 98*, 92–103.

Schrock, A. R. (2015). Communicative affordances of mobile media: Portability, availability, locatability and multimediality. *International Journal of Communication, 9*, 1229–1246. https://doi.org/10.1177/0094306111425016k.

Stephens, K. K., Mandhana, D. M., Kim, J. J., Li, X., Glowacki, E. M., & Cruz, I. (2017). Reconceptualizing communication overload and building a theoretical foundation. *Communication Theory, 3*, 269–289. https://doi.org/10.1111/comt.12116.

Stetler, C., & Miller, G. (2005). Blunted cortisol response to awakening in mild to moderate depression: Regulatory influences of sleep patterns and social contacts. *Journal of Abnormal Psychology, 114*, 697–705.

Thomée, S., Härenstam, A., & Hagberg, M. (2011). Mobile phone use and stress, sleep disturbances, and symptoms of depression among young adults - a prospective cohort study. *BMC Public Health, 11*, 1–11. https://doi.org/10.1186/1471-2458-11-66.

Tiggemann, M., & Slater, A. (2013). NetGirls: The Internet, Facebook, and body image concern in adolescent girls. *International Journal of Eating Disorders, 46*, 630–633.

Treem, J. W., & Leonardi, P. M. (2012). Social media use in organizations: Exploring the affordances of visibility, editability, persistence, and association. In *Communication Yearbook* (Vol. 36)New York, NY: Routledge.

Turkle, S. (2011). *Alone together: Why we expect more from technology and less from each other*. New York, NY: Basic Books.

Wallenius, M., Hirvonen, A., Lindholm, H., Rimpela, A., Nygard, C., Saarni, L., et al. (2010). Salivary cortisol in relation to the use of information and communication technology (ICT) in school-aged children. *Psychology, 1*, 88–95. https://doi.org/10.4236/psych.2010.12012.