TECHNOLOGY BEHAVIOURS AND ATTITUDES IN YOUTH: CORRELATES WITH COGNITIVE AND REAL-WORLD BEHAVIOURS

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ABSTRACT

Technology use, which has become ubiquitous in the lives of adolescents, has both positive and negative aspects. In the judgment and decision-making literature, the Cognitive Reflection Test is a measure of the tendency to override an incorrect response and to engage in further reflection that leads to the correct response (Toplak et al., 2014a). Navigating optimal technology use often requires resisting miserly tendencies, as measured by the Cognitive Reflection Test. The purpose of the current project was to examine technology behaviours and attitudes that are either adaptive or maladaptive through the lens of judgment and decision-making and cognitive reflection in a set of two studies with community samples of adolescents. The associations between these technology behaviours and cognitive reflection, cognitive ability, and real-life outcomes of antisocial behaviours and academic achievement were examined. Study 1 (in-person sample) served as a pilot study, demonstrating that several technology behaviours were measurable in adolescents and were significantly correlated with antisocial behaviours and academic achievement. The purpose of Study 2 (online sample) involved creating several additional items of technology behaviours and attitudes, and used exploratory factor analyses (EFA) to understand the associations among these behaviours and attitudes, and examined gender differences among these behaviours and attitudes. Both cognitive reflection and cognitive ability had small to moderate positive correlations with several technology behaviour factors. Cognitive ability significantly predicted some of the maladaptive technology behaviour factors. While cognitive reflection significantly predicted the adaptive technology attitude factor related to practical managing of technology use, suggesting a potentially important relationship between these attitudes and cognitive reflection. Furthermore, several technology factors significantly

predicted antisocial behaviours and academic achievement. The results are further discussed along with implications and future directions for studying technology use by adolescents.

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General Introduction

Electronic technology, the Internet, gaming, and social media have become ubiquitous in the lives of children and adolescents in the 21st century. Some researchers use the term *electronic devices* to refer generally to the wide spectrum of devices available, such as smartphones, tablets, and laptops that involve the use of the Internet, gaming, or texting (Bento et al., 2020; Hysing et al., 2015; Perrault et al., 2019; Twenge & Martin, 2020). Other terms for these technologies include technology devices, digital devices, smart devices, technology use, electronic media, electronic media use, screen use, electronic screen use, and social media. In this study, the term *electronic devices* was used to encompass all smart devices, including cellphones, smartphones, computers, and tablets. Furthermore, the term *technology behaviours* refers to various behaviours of adolescents while using electronic devices for diverse purposes; specifically how technology interfaces with many parts of life—both positive and negative—ranging from activities done with friends, schoolmates, peers, parents, and alone. Some of these aspects of technology have been examined in the literature, such as social media use, general technology use, gaming, and multi-tasking (Cain et al., 2016; Firth et al., 2019; Frein et al., 2013; Twenge & Martin, 2020). In addition to gathering information about the breadth of technology use, the impact of this technology use was also examined. For example, how adolescent technology behaviours can affect sleep (going to bed late because of device use), school (binge watch shows instead of schoolwork), security issue procedures (privacy settings, passwords, and document backup), relationships (arguing with parents, arguing with a stranger online, using an electronic device instead of paying attention to someone), appropriateness of uses (streaming illegal content), and strategies to work with technology (setting time limits).

The contribution of this project involved examination of technology use through the lens of judgment and decision-making literature. In this literature, resistance to miserly information processing—immediate, automated, and unreflective responses to problems—has been found to predict performance on several judgment and decision-making tasks (Toplak et al., 2011, 2014a). Miserly processing has been a critical theme in this literature, bringing attention to suboptimal responses that are the result of processing tendencies that signal the individual to think that miserly responses are adequate when presented with a problem to solve. With rapid advances in the capabilities of technology devices, technology use may elicit miserly processing tendencies. For example, default settings may seem adequate and do not signal users to evaluate these settings, autofill features may signal users to trust that all of the information that has been entered is correct, and users may not even be aware of inadvertently permitting alerts based on applications that are designed to capture attention (Firth et al., 2019).

In the judgment and decision-making literature, aspects of human cognitive processing tendencies have been identified (Kahneman, 2011; Stanovich, 1999). This is a framework that can be applied to when adolescents engage in electronic device use. A lot technology today is "smart" and can perform complex tasks that are meant to assist humans, i.e., connect people online, engage in e-commerce, secure one's home, and look up information. However, it is often not obvious if this smarter technology affects human judgment and decision-making positively or negatively. For example, adolescents can record themselves live to the Internet with the push of a button, which can lead to connection with other people around the world. While technology has wonderful advantages, it is also filled with potential pitfalls and requires an ability to understand its drawbacks and learn how to beneficially navigate it. For instance, an adolescent can accidentally push the button to go live, and reveal the intimate details of their private life to the

world. This study used a particular lens to look at adolescent technology behaviours that might map onto the judgment and decision-making literature, particularly the concept of cognitive reflection or resistance to miserly processing.

Across two studies with adolescent samples, technology behaviours in which miserly tendencies may contribute to suboptimal behaviours were examined. Adaptive technology use behaviours were also included in this research. The purpose of Study 1 was to examine common "technology hygiene behaviours" and "maladaptive technology behaviours" and how they relate to each other as well as how they relate to cognitive reflection and cognitive ability and real-life outcomes. Technology hygiene behaviours were defined as behaviours involving electronic devices that are related to positive and productive uses, such as facilitating school and work-related tasks and safer interpersonal connections online. These behaviours may also reduce the likelihood of negative outcomes such as using security settings to prevent loss of work or privacy protection settings. Maladaptive technology behaviours are defined as behaviours involving electronic devices that have a negative impact on an adolescent's life, i.e., arguing with parents due to device use, or not getting enough sleep because of device use. Study 1 included adolescents tested repeatedly across two timepoints (when adolescents were 11–17, and 14–20 years of age) as well as parent reports of adolescents (when adolescents were 11–17 years of age). The purpose of Study 2 was to create a broader set of technology behaviour items by elaborating and extending the findings from Study 1 using an online adolescent sample (16–18 years of age). Across both studies, correlations between technology behaviours, cognitive reflection, cognitive abilities, self-reported academic achievement, and antisocial behaviours were examined.

Technology use and resistance to miserly information processing

There is currently a massive growth in the study of technology use literature. Electronic devices are creating an environment never seen before in human history, impacting everyone, but especially youth. Understanding technology use can be situated in concepts that have been studied in the judgment and decision-making literature. In particular, *resistance to miserly information processing* refers to the tendency to inhibit a miserly generated (quick decision based on limited considerations) incorrect response and consider alternatives that lead to a better, correct answer (Stanovich, 2020; Stanovich et al., 2016; Toplak et al., 2011, 2014a). This processing tendency has commonly been measured using the Cognitive Reflection Test (Frederick, 2005).

One example that has become well-known in the rational thinking literature, the bat and the ball problem, emerged from the Cognitive Reflection Test (Cognitive Reflection; Frederick, 2005): "A bat and a ball cost $1.10 in total. The bat costs $1 more than the ball. How much does the ball cost?" (p. 26). To answer this question, participants must compute a response. The most common answer to this question is ten cents, which is incorrect. This response is given extremely frequently, by as many as 86% of participants (Toplak et al., 2014a). Many participants are unaware that their response could be incorrect. A minority of participants think about their initial response and realise that if the ball costs 10 cents and the bat costs $1 more, the bat costs $1.10. A participant realizes 10 cents is not the correct answer, because it is then evident that adding $1.10 and 10 cents equals $1.20, which is greater than the total amount given in the problem. Calculating the correct answer of 5 cents then becomes simple but only a minority of participants in some samples get this answer (Toplak et al., 2014a). Miserly processing strongly primes participants to respond with 10 cents. Alternatively, those who respond with 5 cents were able to overcome the allure of the incorrect response and calculate the correct response.

The Cognitive Reflection Test is one way of operationalizing and measuring resistance to miserly information processing, as people easily generate responses to problems, but it may not be apparent that the easily generated response is incorrect and should be overridden by a better response (Stanovich, 2009a; Toplak et al., 2011, 2014a). The Cognitive Reflection Test is one of the most well-studied measures in the judgment and decision-making literature (Frederick, 2005; Toplak et al., 2014a). Findings from classic heuristics and biases tasks and dual process models have advanced our understanding of these response tendencies (Evans & Stanovich, 2013; Kahneman, 2011; Stanovich, 1999, 2009a). These tasks illustrate how individuals may not be aware of alternative framings to problems, when to engage in more reflective analysis, and when salient or vivid information may detract from further processing (Stanovich, 2009a), all of which have been the basis of predictions about Type 1/Type II and System 1/System 2 processing from dual process models (Evans & Stanovich, 2013). In particular, miserly generated incorrect responses are often elicited quickly and may signal a strong sense of confidence or feeling of rightness (Thompson et al., 2013).

The types of errors that have been attributed to miserly processing, such as those measured with the Cognitive Reflection Test, may map onto the skills and abilities needed for successfully navigating technology use. The distracting and now commonplace designs of technology in the 21st century environment, provide cues that might entice adolescents with more limited cognitive reflection abilities and lead them to think more heuristically. Applications like Instagram, TikTok, and Google, would appear to exploit the adolescent with limited cognitive resources and discourage them from making better decisions. For example, people often rely on asking Siri or using Google Maps to provide information automatically; this behaviour often helps a person simply get from point A to point B efficiently without using many cognitive

resources. However, while often useful, technology may also provide an answer that is actually incorrect or damaging. Sometimes relying on Google Maps can lead to getting lost. Another example of this may be when an adolescent is on Instagram, where they get a message from a friend saying they need help verifying their account. The adolescent's initial thought might be to help their friend and click on the link they receive. Yet this is a common way of being hacked. The challenge of these examples is to recognize errors made by technology, which has failed to elicit the proper response, decouple from this answer and strive to find another solution. When using Google Maps, a person may need to check whether they have entered the correct address before beginning a journey and going to the wrong destination. In the Instagram example, the adolescent needs to actually double check with their friend on the phone or use another way to confirm that they need help before clicking a link.

Electronic device use growth in adolescence

Each day, technology plays a greater role in the lives of adolescents compared to the past. Smartphones are much more common today and adolescents increasingly get them at younger ages. For example, 53% of children in the United States now own a smartphone by the age of 11, and 84% of teenagers now have their own phone (Rideout & Robb, 2019). When adolescents use the Internet, there is an ever-expanding amount of content available, including YouTube videos, streaming services such as Netflix and Disney+, social media (Facebook, Instagram, TikTok, and Snapchat), gaming, and educational programs. Adolescents' use of technology often goes together with substantial autonomy over how they use their technology devices.

Digital media use has also steadily increased among teenagers, with the average 12th grader in 2016 spending about 6 hours a day online, texting, and on social media, double the amount of time compared to the previous decade (Twenge, Martin, & Spitzberg, 2019). In

Ontario, 20% of adolescents in 2017 spent over 5 hours a day on social media, nearly double in comparison to 2013 (Boak et al., 2018). For teens, the Internet is tempting as it offers nearly an infinite amount of information and entertainment, as well as a means of communicating with friends and peers, which can be accessed almost instantaneously (Marsh & Rajaram, 2019).

While electronic devices have become common and indispensable for most adolescents, the extent of use and life domains impacted by these tools during adolescence is not yet well understood. Adolescence (roughly 10 to 19 years) is a period of tremendous biological change and growth, including cognitive and neural development (Berenbaum et al., 2015; Blakemore, 2018; Steinberg, 2014; World Health Organization, n.d.). Adolescence is also a time of vulnerability as well as increased antisocial behaviours, and development of some psychiatric disorders relating to anxiety and impulse control (Cook et al., 2015; Kessler et al., 2005; Steinberg et al., 2008). During this period, there is also an increased desire for more freedom and independence (Kroger, 2006; Silverberg & Gondoli, 1996; Steinberg, 2014) with the expectation that adolescents will do more and develop autonomy over various areas of their lives, including responsible and healthy technology use. Navigating effective technology use during this period of development characterized by considerable changes is a critical issue for developmental researchers.

Technology brings new challenges to adolescents: potential negative implications

Many researchers have argued that the Internet may be changing adolescents' cognitive development and leading to substantial negative changes (Firth et al., 2019). For example, it may be that time spent online means that less time is spent on key offline activities that adolescents would normally have done in the past (Nie & Hillygus, 2002). This is known as the displacement hypothesis (Nie & Hillygus, 2002), in which youths use online activity to replace real-life social

interactions. Technology use has been found to be negatively associated with healthier activities such as exercise, adequate sleep, and in-person social interactions (Ballard et al., 2009; Buxton et al., 2015; Dwyer et al., 2018; Fuller et al., 2017; Gapsiso & Wilson, 2015; Owens et al., 2014). This potential replacement of real-life activities by online activities may be especially problematic for younger children who may not have gotten the chance to develop skills older generations took for granted such as being able to tolerate different and difficult social situations. Indeed, loneliness for adolescents has increased since 2012, which researchers argue is associated with high smartphone use and Internet access (Twenge et al., 2021; Twenge, Spitzberg, & Campbell, 2019).

One reason researchers argue that the Internet and electronic devices replace offline activities is due to the attention directing designs of the Internet (Firth et al., 2019). Also, social-networking platforms allow for simultaneous use; people can multi-task on unrelated tasks, such as doing schoolwork while surfing the Internet, or socially interacting with many people while on different social media platforms and applications (Alexopoulou et al., 2020). In addition, electronic devices offer distractions and constant notifications that occupy our attention and lead to “checking” behaviours, which involve repeated engagement with the device (Fitz et al., 2019; Oulasvirta et al., 2012).

Although children may be quicker to learn how to use electronic devices and digital information compared to adults, they are less able to assess the credibility of online information compared to adults (Flanagin & Metzger, 2008; Metzger et al., 2013). This lack of ability to recognize reliable content may be attributed to adolescents having less emotional and cognitive maturity and experiences compared to adults (Flanagin & Metzger, 2008; Metzger et al., 2013).

Often sources of "information" can be hidden, and many people, as well as algorithms, or artificial intelligence (AI) bots, also post content anonymously (Marsh & Rajaram, 2019).

Other dangers for adolescents include cyberbullying, pornography, and cybersex (Beyens & Eggermont, 2014; Juvonen & Gross, 2008; Sefa & Adu, 2018), which may be difficult for adults to monitor. For many teens, electronic devices interfere with school activities, especially relating to failing to complete homework and poor grades due to electronic device use. Screen use in excess of seven hours has been found to be negatively associated with academic achievement (Faught et al., 2017). Research shows that children who had owned a phone at the age of nine scored lower on standardized English and math tests when they were in adolescence (Dempsey et al., 2019). Similarly, a meta-analysis found a small negative effect for mobile phone use on general academic achievement (Kates et al., 2018).

While some parenting strategies can be helpful to control electronic device use, adolescents and parents tend to have different expectations surrounding technology, including how much time should be spent on a device, what can be done on a device, and when technology interferes with other aspects of daily life (Blackwell et al., 2016). Arguing is a common behaviour that seems to frequently occur with adolescents and parents regarding Internet and smartphone use (Kim et al., 2019; Mesch, 2006a, 2006b). It is also often common to hear anecdotally that adolescents frequently disagree with their parents who try to limit the amount of time they should spend online as well as what type of content they should engage with.

Sleep issues related to use of electronic devices are common among adolescents, with studies showing that electronic devices can often affect sleep quality (Carter et al., 2016; Hysing et al., 2015; Vernon et al., 2018). It is essential that adolescents get an adequate number of hours of sleep for the development of both their bodies and brains (Galván, 2019). Activity on

electronic devices can replace sleep time and most adolescents sleep with their smartphones at arm's reach (Buxton et al., 2015; Fuller et al., 2017; Moulin & Chung, 2017; Owens et al., 2014) and have more than two electronic devices in their bedrooms at night (Gamble et al., 2014). Since technology is now commonly available in adolescents' rooms, it seems to be a factor that influences their physiological arousal, which may contribute to disturbed sleep patterns because it is thought that the light emitted by devices may affect the circadian rhythms and melatonin, a key hormone produced at night during sleep (Touitou et al., 2016). In addition, it has been found that adolescents who own smartphones sleep less than adolescents who do not (Schweizer et al., 2017).

Messaging or texting is now a common means of communication between teenagers on electronic devices. For some adolescents, texting can become compulsive and is negatively related to grades and scholastic competence (Lister-Landman et al., 2017). Texting may also lead to misinterpretation of important information related to facial and body language as well as non-verbal cues (Kelly & Miller-Ott, 2018). Texting is often done while the adolescent is multi-tasking, possibly distracted, typing too quickly, using acronyms, abbreviations, and autocorrect, as well as sometimes experiencing device malfunctioning (Kelly & Miller-Ott, 2018).

With texting and instant messaging, it is also easy for adolescents to have a sense of disinhibition online (Wright et al., 2019). Consequently, it is much easier to post a disparaging remark and many sites allow for anonymity. Cyberbullying is a common behaviour among adolescents (Juvonen & Gross, 2008), which can involve posting something humorous but embarrassing about another adolescent.

Most adolescents spend time daily using social media on electronic devices (Rideout & Robb, 2019). It has been found that too much time on social media can have deleterious effects.

For example, more frequent electronic device use was associated with increased rates of suicide and depression among adolescents, as well as other more negative indicators of mental health (Bickham et al., 2015; Twenge et al., 2018; Yang et al., 2013).

Another online activity that adolescents regularly engage in is downloading and watching videos or listening to music on electronic devices. Most teenagers spend time on video platforms such as Youtube, Netflix, or Twitch (Anderson & Jian, 2018; Raine, 2021; Rideout et al., 2021; Rideout & Robb, 2019). Often, adolescents will share videos and music on these platforms, which have come to replace conventional television sets (Raine, 2021). As mentioned earlier, excess time spent watching and downloading music and videos has become a common use of leisure time, often taking the place of offline activities like sports, reading, and arts.

Video games are another common online activity for teenagers (Rideout & Robb, 2019). However, gaming behaviour can become problematic and it has been found to be associated with serious issues, such as tiredness, sleep interference, depression, and anxiety symptoms (Männikkö et al., 2015). Similarly, adolescents are attracted to virtual worlds, a specific type of video game with large sophisticated computer-generated environments where other Internet users interact and engage while controlling very detailed characters or avatars.

While technology use in adolescents reflects many complex issues and considerations, several features of technology devices highlight the relevance of miserly processing tendencies in technology-related behaviours. Recognizing overuse and the pervasive impact of technology use on daily functioning may not be apparent to adolescents who are still developing life skills and abilities (Toplak, 2021).

Gender differences and age differences in the literature

Some gender differences in technology use have also been reported. Vujic (2017) found that male adults reported more computer hours and computer sessions a day compared to female adults, but no differences were found on computer use per month, session duration, or years of computer experience. Conversely, a study by Cocoradă et al. (2018) found female adolescents have significantly higher scores of smart phone addiction compared to male adolescents. Twenge and Martin (2020) observed in a sample of over 220,000 adolescents, that females spent more time on smartphones and computers compared to males. Similarly, in this study, adolescent females also spent more time on social media, texting, and Internet use than adolescent males, whereas adolescent males spent more time gaming and more time overall on electronic devices than adolescent females. Twenge and Farley (2021) found that while for both adolescent females and adolescent males there were associations between higher electronic device use and lower scores on measures of mental health, these associations were stronger for adolescent females than adolescent males. In addition, although loneliness is associated with high smartphone and Internet use, it has also been found to be higher in females than males (Twenge et al., 2021). Thus, given some of these gender differences reported in technology use, gender was a variable of interest in the present research.

Similarly, the age of the adolescent can be an important variable to look at. Now more than ever, it has become more common for adolescents to own an electronic device. For example, the number of American 12-year-olds who have a device increased from 41% in 2015 to 71% in 2021 (Rideout et al., 2021). Also, as American adolescents get older they are more likely to have an electronic device and use it daily for longer periods compared to younger adolescents (Rideout et al., 2021; Rideout & Robb, 2019; Twenge, Hisler, & Krizan, 2019). Therefore, the question becomes whether adaptive and maladaptive technology behaviours

become more common in older adolescents due to more frequent use and experience with devices.

Beneficial technology uses and strategies for adolescents

Most of the research literature has focused on the negative consequences or maladaptive uses of technology in adolescents (Domoff et al., 2019; Twenge, Spitzberg, & Campbell, 2019; Wartberg et al., 2016; Yang et al., 2013), and these studies tend not to focus on the positive uses of technology or technology hygiene behaviours that maintain positive and productive behaviours with electronic devices.

Compared to previous generations, today's adolescents are the first to have lived their entire lives with the Internet, online social networking, and the connected online world. These adolescents and young adults are also known as "Generation Z" and were born between the late 1990s and early 2010s. Since adolescents spend so many hours online, they are also considered "Internet-savvy" (Greenhow et al., 2009, p. 63), meaning it is assumed that they understand how to use technology much better than older generations.

Positively speaking, technology use can support cognitive, social, and physical development. For example, electronic devices and the Internet can be used to conveniently deliver school-based lessons or therapy for adolescents who may lack the ability to access these in person. Some research has found that academic performance for adolescents was positively associated with longer Internet use for studying (Kim et al., 2017). Similarly, the Internet has made available materials and content for youth that they previously might not have had the opportunity to access, including interactive websites, podcasts, and audiobooks. Furthermore, there are now paid and volunteer opportunities through the Internet offering adolescents opportunities that have never previously existed.

Another aspect of electronic devices that is considered positive is that these devices offer many ways for youths to socialize. College students use social networking sites to connect with friends and can form intimate relationships (Subrahmanyam et al., 2008). Some have argued that online opportunities allow those with social anxiety to finally make friends, and for adolescents to strengthen existing friendships (Valkenburg & Peter, 2009a, 2009b) and engage with communities all around the world. Likewise, some researchers argue that the Internet helps increase adolescents' abilities to disclose information socially, which helps with relationship quality (Valkenburg & Peter, 2009a, 2009b). Adolescents can also keep in touch with both friends and family around the world, join causes or support groups, and find common interests across cultures and countries.

Parenting strategies are often considered one way to prevent negative technology behaviours. For parents, actively discussing technology use with adolescents and knowing about the content and time spent on the Internet has been considered a way of mitigating negative technology behaviours for teenagers (Soh et al., 2018). Often, parents think that they need to play an active role in controlling technology use for children and adolescents, as well as teaching them about privacy and security (Kumar et al., 2017; Subrahmanyam & Šmahel, 2010). For example, parents can establish rules and clear limitations regarding social media use, can follow their children's friends online, as well as discuss and model appropriate online behaviours (Joshi et al., 2019). Indeed, some research has confirmed the importance of parental discussions and monitoring of younger children's technology use, which has been found to be associated with better sleep and academics, as well as decreased aggression and social media use (Gentile et al., 2014). While another study found parental mediation strategies for social media use such as restrictive use (i.e., ruling setting and limiting use), or active mediation (i.e., discussion), or

coviewing (i.e., watching a show together), have been shown to be associated with different positive outcomes (Collier et al., 2016).

Adolescents often need guidance learning how to develop habits to ensure secure computing practices that prevent negative outcomes. Using the privacy settings on social networking sites is a way suggested by social media companies to address privacy issues and oversharing (Kastrenakes, 2020). Encouraging adolescents to actively adjust the privacy settings on websites is helpful for getting them to examine and deal with potential online privacy issues, especially with social networks (Subrahmanyam & Šmahel, 2010). Similarly, teaching adolescents not to open attachments or downloads in spam emails and to use anti-virus programs are safeguards for youth (Subrahmanyam & Šmahel, 2010). Thus, positive technology-related behaviours were also examined in the current studies, termed technology hygiene behaviours.

Correlations between cognitive reflection and electronic device usage

The current research set out to determine whether both negative and positive technology-related behaviours are correlated with miserly information-processing tendencies. Some studies have examined correlations between technology use and cognitive reflection. Barr et al. (2015) reported that adult participants with lower cognitive reflection scores spent more time on their smartphones and used their smartphones more to look up information compared to those who had higher cognitive reflection scores. Individuals with moderate Internet addiction were found to have lower cognitive reflection than non-addicted adult users (Devine et al., 2022). Vujic (2017) also reported a negative relationship between smartphone use and cognitive reflection.

However, some types of technology use may be positively correlated with cognitive reflection scores. Vujic (2017) found that computer use per month was positively correlated with cognitive reflection. Toplak et al. (2017) reported that adults who scored higher on a composite

of heuristics and biases (including the Cognitive Reflection Test) tended to also have more secure computing behaviours, such as backing up work and having virus protection on their computers. The relationship between secure computing and the heuristics and biases scores were stronger among adult males than females. Furthermore, other studies have found that adult participants who had higher scores on the Cognitive Reflection Test were more particular in the social media accounts they followed, shared news from different sources and tweeted about different content compared to those with lower Cognitive Reflection Test scores (Mosleh et al., 2021). Similarly, in an adult sample, higher cognitive reflection has been found to correlate negatively with perceiving fake news as accurate (Pennycook & Rand, 2020).

Currently, little research is available on how adolescent technology hygiene behaviours and maladaptive technology behaviours are connected to resistance to miserly processing measures like the Cognitive Reflection Test. Based on the literature with adult participants, it is expected that adolescents with higher cognitive reflection scores will display fewer negative technology-related behaviours and more positive technology-related behaviours.

Correlations between electronic device usage and cognitive abilities

The Cognitive Reflection Test is a complex measure that includes many different skills and abilities (Toplak, 2021). Based on models of rational thinking, measures of cognitive ability have been used to assess the cognitive decoupling required to generate alternative responses to problems on the Cognitive Reflection Test (Stanovich, 2009a). While making a rational choice relies on cognitive reflection, it also relies on having adequate processing efficiency because overriding bad responses and simulating new ones requires the ability to process information quickly (Evans & Stanovich, 2013; Evans, 2008). Cognitive ability can be measured by tests of fluid intelligence, attention, and working memory (Stanovich, 2009a, 2009b). Since the

Cognitive Reflection Test captures both reflective and override and decoupling processing skills, it also captures substantial variance related to cognitive abilities (Toplak et al., 2011, 2014a). In order to examine whether these different aspects of miserly processing may be separable and correlate differently with technology-related behaviours, cognitive abilities needed to be examined separately to assess override and decoupling processing skills more specifically.

Some studies have examined the correlation between cognitive abilities and technology use. Barr et al. (2015) found that lower cognitive ability was associated with increased time spent on smartphones and looking up information on smartphones in adults. Those with Internet addiction have been found to perform worse on a mental rotation task compared to those who do not have an addiction (Devine et al., 2022). Similarly, Vujic (2017) found that a measure of sustained attention was negatively correlated with total computer hours a day and computer session duration. Increased multi-tasking on electronic devices correlated with poorer working memory (Cain et al., 2016) and with lower fluid intelligence (Minear et al., 2013). If technology engages miserly processing tendencies, one might expect that for more adaptive technology behaviours, it would be easier for those with more cognitive ability to override and decouple from wrong answers in maladaptive technology behaviours, and easier for them to engage in more laborious technology hygiene behaviours.

Technology and real-world outcomes in adolescence: antisocial behaviours and academic achievement

While measuring real-world outcomes in adolescent samples is complicated by the fact that youth at this period of development may not have had many opportunities to make their own decisions and choices that may lead to real-world outcomes, there are two domains where adolescents have had many opportunities: antisocial behaviours (Moffitt, 1993; Steinberg, 2004;

Steinberg, 2008) and academic achievement (Geiser & Santelices, 2007). For adolescents, time spent on social media has been found to be positively associated with antisocial behaviours, general risky behaviours, sexual risky behaviours, and substance abuse behaviours (Galica et al., 2017; Rosen, Whaling, Carrier, et al., 2013; Vannucci et al., 2020). Indeed, for adolescents, many antisocial behaviours now take place online and not in person such as cyberbullying. Social media often provides adolescents with positive images of addictive and illegal substances and opportunities for risky behaviours likely gambling (Albarracin et al., 2018; Elton-Marshall et al., 2016; Romer & Moreno, 2017). Several studies have found a negative association between time spent using technology and academic achievement for adolescents and college students (Kates et al., 2018; Kim et al., 2017; Kirschner & Karpinski, 2010). Thus, engagement in both antisocial behaviours and academic achievement were examined as correlates of technology-related behaviours in the current study.

Study 1 plan and hypotheses

Several hypotheses were put forward regarding adaptive and maladaptive technology use in an adolescent sample. Study 1 was largely exploratory, including using previously generated technology behaviour items and examining correlations among these items. In addition, the correlations of technology use with cognitive reflection, cognitive abilities, and real-world outcomes, including academic achievement and antisocial behaviours, were estimated. Age and gender were also examined as correlates of technology use. The specific hypotheses examined in Study 1 are listed in Table 1.

Table 1. Study 1 hypotheses

	Predictions
Correlations between technology-related	1a. Technology hygiene items will be positively correlated with each other.

behaviours, age, and gender:	1b. Maladaptive technology behaviour items will be positively correlated with each other. 2a. Technology hygiene behaviours will be positively correlated with age. 2b. Maladaptive technology behaviours will be positively correlated with age. 3a. Technology hygiene behaviours will be higher in males than females. 3b. Maladaptive technology behaviours will be higher in females than males.
Correlations between technology-related behaviours, cognitive reflection, and cognitive abilities:	4. Technology hygiene behaviours will be negatively correlated with the maladaptive technology behaviours. 5a. Technology hygiene behaviours will be positively correlated with cognitive reflection. 5b. Technology hygiene behaviours will be positively correlated with cognitive ability. 5c. Maladaptive technology behaviours will be negatively correlated with cognitive reflection. 5d. Maladaptive technology behaviours will be negatively correlated with cognitive ability.
Correlations between technology-related behaviours and real-world outcomes, including antisocial behaviours and academic achievement:	6a. Technology hygiene behaviours will be negatively correlated with antisocial behaviours. 6b. Maladaptive technology behaviours will be positively correlated with antisocial behaviours. 7a. Technology hygiene behaviours will be positively correlated with academic achievement. 7b. Maladaptive technology behaviours will be negatively correlated with academic achievement.

Method

Participants

Data were collected from a community sample of 156 adolescent participants and their parents from across Ontario, Canada as part of a longitudinal study; participants were from mainly European descent. Findings from this longitudinal sample have also been published in Toplak (2021), Toplak et al. (2014b), and Toplak and Flora (2021). Participants received monetary compensation for their participation. Data for this study are from two timepoints. Data were collected from both adolescents and parents when the adolescents were between 11 and 17 years (M = 13.23, SD = 1.84; 86 males and 70 females). Three years later, 135 of the same participating cohort from the first timepoint agreed to participate again when they were between 14 and 20 years (M = 15.97, SD = 1.78; 77 males and 58 females).

Parents in this sample had relatively high levels of education. Of the mothers, 30.8% had professional degrees, 53.2% had completed college or university, 1.9% had some college or university, 9.6% had completed high school, <1% had completed less than high school, and 3.8% did not report this information. Of the fathers, 26.9% had professional degrees, 42.9% had completed college or university, 9% had some college or university, 14.1% had completed high school, 1.9% had completed less than high school, and 5.1% did not report this information.

Measures

Technology hygiene behaviours. Six items developed by Toplak (2021) and Toplak et al. (2017) assessed behaviours related to positive technology use and were completed by adolescents at both timepoints and their parents (see Appendices A and B for the adolescent and parent items). Adolescents reported on their own behaviour and parents reported on adolescents'

behaviour. Each item was scored as *present* (1) or *not present* (0). A total score was derived with a possible maximum score of six. A higher total score indicated more positive or adaptive technology behaviours.

Maladaptive technology behaviours. Ten items developed by Toplak (2021) and Toplak et al. (2017) assessed behaviours related to negative technology use and were completed by adolescents at both timepoints and their parents (see Appendices C and D for the adolescent and parent items). Adolescents reported on their own behaviour and parents reported on adolescents' behaviour. Four yes/no items were scored as *present* (1) or *not present* (0), and six items asked participants to assign a number of hours, texts, or times spent per day using technology. The raw scores on each of the ten items were standardized and summed to create a composite score. A higher score indicated more maladaptive behaviours.

Cognitive reflection. The Cognitive Reflection Test was used to measure cognitive reflection and was completed by adolescents at both timepoints. The Cognitive Reflection Test items used in this study were taken from Frederick (2005), Toplak (2021), and Toplak et al. (2014a). An example question is, "Jerry received both the 15th highest and the 15th lowest mark in the class. How many students are in the class?" (Toplak et al., 2014a, p. 151). The miserly generated incorrect response is 30 students, but the correct response is 29 students (Toplak et al., 2014a). For adolescents aged 11 to 17 years, seven items were used. Three years later, 12 items were used. Items were scored *correct* (1) *or incorrect* (0) for a maximum total of 7 at the first timepoint and a maximum of 12 three years later. A higher score indicated better performance.

Cognitive ability. At both timepoints, the Vocabulary and Matrix Reasoning subtests of the Wechsler Abbreviated Scales of Intelligence (WASI; Weschler, 1999) were used as indices of verbal and nonverbal ability. Raw non-age-corrected scores were used for both timepoints, as

age is strongly correlated with cognitive ability and should not be controlled for youth (Rizeq et al., 2017). A higher score represents higher ability. Then the raw scores on each scale were standardized and summed to create a composite score.

Antisocial behaviours. Ten items were adapted from the Youth Inventory-4 of Gadow and Sprafkin (1999) pertaining to antisocial behaviours and were completed by adolescents at both timepoints and parents (see Appendices D and E for the adolescent and parent items). The raw scores on each of the ten items were standardized and summed to create a composite score. Higher scores are indicative of more antisocial behaviours.

Academic achievement. At both timepoints, adolescents and parents reported the overall average of adolescents (out of 100) in four academic domains including Science, Math, English, and Social Studies and History. An average of these domain scores was used as a measure of overall academic achievement. A higher score indicated higher academic achievement.

Procedure

Trained examiners tested participants individually at both timepoints and administered the technology measures to adolescents and parents. The two technology behaviours measures, Cognitive Reflection Test, WASI measure, antisocial measure, and academic achievement measure were administered to adolescents at both timepoints. Parents completed the two technology behaviours measures, the antisocial measure, and academic achievement measure only at the first timepoint for their adolescents (11–17 years).

Results

Descriptive statistics

Univariate descriptive statistics were examined for all variables. For correlations among the technology hygiene behaviour items, tetrachoric correlations were used because all items were dichotomous. Similarly, because maladaptive technology behaviour items were dichotomous or ordinal in nature, either tetrachoric or polychoric correlations were used. For the correlations among composite scores, product-moment correlations were used.

Mean scores, standard deviations, skewness, kurtosis, and McDonald's (1999) omega for all composite variables are displayed in Tables 2 to 4.

Table 2. Adolescent (11–17 years) descriptive statistics

Variable	Mean	SD	Skewness	Kurtosis	Omega
Technology hygiene total score	4.37	1.24	-.26	-.80	.74
Maladaptive technology z-score composite	.00	4.48	.57	-.08	.57
Cognitive reflection (Cognitive Reflection Test total score)	2.44	1.90	.98	-.07	.89
Cognitive ability (WASI z-score composite)	.00	1.67	.80	1.70	n/a
Antisocial z-score composite	.00	4.93	.70	-.24	.66
Academic achievement composite	80.00	8.54	-.1.25	3.09	.77

Table 3. Parent ratings of adolescent (11–17 years) descriptive statistics

Variable	Mean	SD	Skew	Kurtosis	Omega
Technology hygiene total score	4.84	1.10	-.77	-.18	.68

Maladaptive technology z-score composite	.00	4.33	.50	-.13	.63
Antisocial z-score composite	.00	4.63	2.03	4.57	.60
Academic achievement composite	80.41	6.35	-.24	-.01	.83

Table 4. Adolescent (14–20 years) descriptive statistics

Variable	Mean	SD	Skew	Kurtosis	Omega
Technology hygiene total score	4.30	.96	-.02	-.45	.55
Maladaptive technology z-score composite	.00	4.18	.29	-.51	.55
Cognitive reflection (Cognitive Reflection Test total score)	5.03	3.36	.25	-1.30	.94
Cognitive ability (WASI z-score composite)	.00	1.65	-.63	1.57	n/a
Antisocial z-score composite	.00	4.99	.36	-.57	.67
Academic achievement composite	80.61	7.87	-.03	-.57	.77

Correlations among technology hygiene behaviours (hypotheses 1a–1b)

Correlations among adolescent (11–17 years) technology hygiene behaviours are displayed in Table 5. Most of the correlations are positive (r = .02 to .53), with the exception of two correlations that were negative (r = -.17 and -.37). Most of the positive correlations were small in size.

Table 5. Tetrachoric correlations among adolescent (11–17 years) technology hygiene behaviours

Technology hygiene behaviours items	1	2	3	4	5	6
1. Talking with parents about online content	1					
2. Not opening attachments from strangers	.16	1				
3. Back up documents	.27	.16	1			
4. Have time limits	.50	.15	.10	1		
5. Use privacy settings	.53	-.37	.27	.14	1	
6. Use virus protection	.14	-.17	.20	.02	.35	1

Correlations among parent ratings of adolescent (11–17 years) technology hygiene behaviours (Table 6) displayed correlations that were mostly positive (r = .05 to .56), except for three negative correlations (r = -.10, r = -.12, and r = -.15). Most of the positive correlations were moderate in size.

Table 6. Tetrachoric correlations among parent ratings of adolescent (11–17 years) technology hygiene behaviours

Technology hygiene behaviours items	1	2	3	4	5	6
1. Talking with parents about online content	1					
2. Not opening attachments from strangers	.56	1				
3. Back up documents	.39	.32	1			
4. Have time limits	.11	.46	.06	1		
5. Use privacy settings	.36	-.15	.38	-.12	1	
6. Use virus protection	.05	.17	.32	-.10	.18	1

Correlations among adolescent (14–20 years) technology hygiene behaviours (Table 7) ranged from r = -.25 to r = .50. Most of the positive correlations were small in size.

Table 7. Tetrachoric correlations among adolescent (14–20 years) technology hygiene behaviours

Technology hygiene behaviours items	1	2	3	4	5	6
1. Talking with parents about online content	1					
2. Not opening attachments from strangers	.08	1				
3. Back up documents	.17	-.09	1			
4. Have time limits	.23	-.06	.29	1		
5. Use privacy settings	-.08	.15	-.06	.50	1	
6. Use virus protection	-.25	.01	.27	.09	-.10	1

Correlations among maladaptive technology behaviours

Correlations among adolescent (11–17 years) maladaptive technology behaviours (Table 8) ranged from r = -.18 to .59, but most were positive and were small or moderate in size.

Table 8. Tetrachoric and polychoric correlations among adolescent (11–17 years) maladaptive technology behaviours

Maladaptive technology behaviours items	1	2	3	4	5	6	7	8	9	10
1. Failed homework due to device use	1									
2. Grades gone down due to device use	.59	1								

3. Argued with parents due to device use	.38	.39	1							
4. Not gotten enough sleep due to device use	.54	.21	.32	1						
5. Posted embarrassing messages	.35	.39	.18	.33	1					
6. Time spent on social networking sites	.41	.29	.30	.46	.21	1				
7. Number of texts	.26	-.02	.29	.38	.25	.38	1			
8. Time spent downloading music and videos	.35	.16	.08	.09	.27	.30	.22	1		
9. Time spent playing video games	.04	.11	.24	-.14	.16	-.11	.07	.13	1	
10. Time spent in virtual worlds	.06	.09	.29	-.15	.08	-.15	-.18	.10	.59	1

Correlations among parent ratings of adolescent (11–17 years) maladaptive technology behaviours (Table 9) also ranged from r = -.24 to r = .52, but most of these were positive and were small or moderate in size.

Table 9. Tetrachoric and polychoric correlations among parent ratings of adolescent (11–17 years) maladaptive technology behaviours

Maladaptive technology behaviours items	1	2	3	4	5	6	7	8	9	10
1. Failed homework due to device use	1									
2. Grades gone down due to device use	.52	1								
3. Argued with parents due to device use	.23	.09	1							

4. Not gotten enough sleep due to device use	.32	.23	.40	1						
5. Posted embarrassing messages	.29	.00	.22	.38	1					
6. Time spent on social networking sites	.18	.39	-.07	.35	.40	1				
7. Number of texts	.04	.29	.18	.33	.22	.40	1			
8. Time spent downloading music and videos	-.04	.06	.10	.23	.35	.41	.32	1		
9. Time spent playing video games	-.03	.17	.05	-.04	-.24	-.24	-.01	.06	1	
10. Time spent in virtual worlds	.11	.17	.23	.08	.03	-.08	-.13	.12	.41	1

Correlations among adolescent (14–20 years) maladaptive technology behaviours (Table 10) ranged from r = -.42 to .58, but most were positive and were small in size.

Table 10. Tetrachoric and polychoric correlations among adolescent (14–20 years) maladaptive technology behaviours

Maladaptive technology behaviours	1	2	3	4	5	6	7	8	9	10
1. Failed homework due to device use	1									
2. Grades gone down due to device use	.46	1								
3. Argued with parents due to device use	-.04	.12	1							
4. Not gotten enough sleep due to device use	.27	.47	-.31	1						
5. Posted embarrassing messages	.27	.19	.07	. 04	1					

6. Time spent on social networking sites	.33	.09	.12	.23	.14	1				
7. Number of texts	.06	.11	-.08	.09	.00	.12	1			
8. Time spent downloading music and videos	.19	.23	.06	.18	.02	.10	.15	1		
9. Time spent playing video games	.03	.05	.40	-.42	.22	-.29	-.17	.12	1	
10. Time spent in virtual worlds	.04	.24	.19	-.04	.50	-.01	-.06	.16	.58	1

Summary of correlation findings within each technology measure

Overall, the correlations among the technology hygiene behaviour items as well as the maladaptive technology behaviour items of adolescents at both timepoints (11–17 years) and (14–20 years) plus parent ratings of adolescents were generally in the expected positive direction. They tended to be small or moderate in size and there were some negative correlations. The magnitude of the correlations varied considerably among the items across adolescent and parent reports.

Correlations between technology behaviours and age (hypothesis 2a–b)

When adolescents were between 11 and 17, age was not significantly associated with technology hygiene behaviours (r = -.12), but age was significantly and moderately positively associated with maladaptive technology behaviours (r = .43, p< .05). Similarly, when adolescents were between 14 and 20 years of age, age was not significantly correlated with technology hygiene behaviours (r = -.16). However, a significant and small positive correlation

was found between age and maladaptive technology behaviours (r = .23, p< .05). These findings suggested that maladaptive technology behaviours were related to age through adolescence but not technology hygiene behaviours.

Gender differences on technology variables (hypothesis 3a–b)

There were no significant gender differences in technology hygiene or maladaptive technology behaviours based on adolescent reports.

Correlations between technology behaviours, cognitive reflection, antisocial behaviours, and academic achievement (hypotheses 4–7)

Correlations among technology behaviours, cognitive reflection, antisocial behaviours, and academic achievement for adolescents aged 11 to 17 years are in Table 11. There was no significant association between the technology hygiene behaviours and maladaptive technology behaviours (hypothesis 4), which suggests that these variables measure different technology use constructs. Neither technology hygiene nor maladaptive technology behaviours were significantly correlated with cognitive reflection or cognitive ability (hypotheses 5a–d).

Technology hygiene behaviours were not significantly correlated with antisocial behaviours, but maladaptive technology behaviours were significantly and moderately positively correlated with antisocial behaviours (r = .48, p < .05; hypotheses 6a–b). Technology hygiene behaviours were not significantly correlated with academic achievement. However, a significant and small negative correlation was found between maladaptive technology behaviours and academic achievement (r = -.23, p < .05; hypotheses 7a–b). These findings suggest that only maladaptive technology behaviours are associated with both antisocial behaviours, and with academic achievement.

Table 11. Correlations among adolescent (11–17 years) technology behaviours and other variables

	1	2	3	4	5	6
1. Technology hygiene behaviours total score	1					
2. Maladaptive technology behaviours z-score composite	-.06	1				
3. Cognitive reflection (Cognitive Reflection Test total score)	-.03	-.02	1			
4. Cognitive ability (WASI z-score composite)	.08	-.05	.58*	1		
5. Antisocial behaviours z-score composite	.08	.48*	.05	.06	1	
6. Academic achievement composite	.07	-.23*	.28*	.40*	-.17*	1

*$p < .05$

Correlations among the parent ratings of the same measures for adolescents aged 11 to 17 years) are in Table 12. The correlation between technology hygiene behaviours and maladaptive technology was not significant (hypothesis 4). Technology hygiene behaviours were not significantly correlated with antisocial behaviours, but maladaptive technology behaviours were significantly, and moderately positively correlated with antisocial behaviours ($r = .30$, $p < .05$; hypothesis 6a–b). Neither technology hygiene behaviours nor maladaptive technology behaviours were significantly correlated with academic achievement (hypothesis 7a–b). Overall, these findings suggest that only parent ratings of adolescent maladaptive behaviours are associated with antisocial behaviours.

Table 12. Correlations among parent ratings of adolescent (11–17 years) technology behaviours and other variables

	1	2	3	4
1. Technology hygiene behaviours total score	1			
2. Maladaptive technology behaviours z-score composite	-.03	1		
3. Antisocial behaviours z-score composite	-.08	.30*	1	
4. Academic achievement composite score	-.02	-.15	-.08	1

*$p < .05$.

Correlations among the same measures for adolescents aged 14 to 20 years are in Table 13. The correlation between technology hygiene behaviours and maladaptive technology behaviours was not significant (hypothesis 4). Neither technology hygiene behaviours nor maladaptive technology behaviours were significantly correlated with cognitive reflection or cognitive ability (hypothesis 5a–d).

Technology hygiene behaviours had a significant and small negative correlation with antisocial behaviours ($r = -.27$, $p < .05$). While maladaptive technology behaviours were significantly and largely positively correlated with antisocial behaviours ($r = .55$, $p < .05$; hypothesis 6a–b). Technology hygiene behaviours were not significantly correlated with academic achievement. However, a significant and small negative correlation was found between maladaptive technology behaviours and academic achievement ($r = -.29$, $p < .05$; hypothesis 7a–b). These findings suggested that both types of technology behaviours are associated with antisocial behaviours, but only maladaptive technology behaviours are associated with academic achievement.

Table 13. Correlations among adolescent (14–20 years) technology behaviours and other variables

	1	2	3	4	5	6
1. Technology hygiene behaviours total score	1					
2. Maladaptive technology z-score composite	-.13	1				
3. Cognitive reflection (Cognitive Reflection Test total score)	.13	-.10	1			
4. Cognitive ability (WASI Z-score composite)	-.02	-.09	.57*	1		
5. Antisocial behaviours z-score composite	-.27*	.55*	-.20*	-.07	1	
6. Academic achievement composite score	.16	-.29*	.53*	.48*	-.24*	1

*$p < .05$

Study 1 Discussion

The findings from Study 1 are summarized in Table 14. Correlations among technology hygiene behaviour items for both adolescent timepoints and for parents tended to be positive and small. In terms of correlations among the maladaptive technology behaviour items, most of the correlations were positive and small to moderate (hypothesis 1).

Age was not significantly correlated with technology hygiene behaviours for adolescents. However, age was significantly correlated with maladaptive technology behaviours across the two timepoints. The correlation was moderate in size at the first timepoint when adolescents were 11–17 years, but small in size at the second timepoint when adolescents were 14–20 years of age (hypothesis 2). The finding regarding technology hygiene behaviours and age is

unexpected, as it was predicted these behaviours would have increased with age along with increased use of technology among older adolescents compared to young adolescents (Rideout & Robb, 2019; Twenge, Hisler, & Krizan, 2019). This finding of increased maladaptive technology behaviours may suggest that increased technology use in general may also relate to increased maladaptive technology behaviours. For example, as of 2018, 81% of 14-year-olds have a phone, compared to 59% of 14-year-olds just four years earlier (Rideout & Robb, 2019). While in 2021, the percent of 14-year-olds with a phone grew to 91% (Rideout et al., 2021).

Gender differences related to technology hygiene behaviours and maladaptive technology behaviours were not significant (hypothesis 3). This result was unexpected given other studies on technology use among adolescents show gender differences on electronic device usage and in types of use (Cocoradă et al., 2018; Twenge & Farley, 2021; Twenge & Martin, 2020), i.e., female youths have higher risk for Internet addiction than male youth (Cocoradă et al., 2018). Furthermore, female youths have greater use of smartphone, social media, texting, and computers, whereas male youths have higher gaming use and overall device use compared to their female cohorts (Twenge & Martin, 2020).

For hypothesis 4, the correlations between technology hygiene behaviours and maladaptive technology behaviours were small and non-significant within the two timepoints for both adolescents and parents. This was an unexcepted finding, which may suggest technology hygiene behaviours and maladaptive technology behaviours represent different constructs and are not just opposites of each other. Therefore, an adolescent could engage in both types of behaviours at once. For example, it is possible that while adolescents engage in technology hygiene behaviours such as not opening up attachments from strangers, or backing up important

documents, they also engage in maladaptive technology behaviours such as staying up late and using an electronic device or making a potentially funny but embarrassing post.

For hypothesis 5a, adolescents' technology hygiene behaviours were not significantly correlated with cognitive reflection at both adolescent timepoints. This finding was different than that obtained by Toplak et al. (2017), which had four of the same technology hygiene items in this study but found that adults with better performance on heuristic and biases tasks had more secure computing habits. This result may also suggest a difference between adolescents and adults in terms of the development of cognitive reflection skills and the association with more positive technology behaviours. For example, in the Toplak et al. (2017) study, the mean score for the 11 items on the Cognitive Reflection Test, was 5.77. For adolescents ages 11–17 years at the first timepoint of the study, the mean score was 2.44 out of 7 items. While for adolescents 14–20 years at the second timepoint of the study, the mean was 5.03 out of 12 items. This may suggest that adolescents have slightly less developed cognitive reflection skills compared to adults.

For hypothesis 5b, adolescents' technology hygiene behaviours were not significantly correlated with cognitive ability. This is a novel finding as previous studies have not tended to study adaptive uses of technology and their associations with cognitive ability. Yet, this finding was unexpected, as it was predicted that an adolescent having better cognitive ability or processing efficiency would engage in more technology hygiene behaviours. One possible explanation of why adolescent technology hygiene behaviours did not correlate with cognitive ability is that the particular items measured in this study do not require override and decoupling processing skills.

For hypothesis 5c, maladaptive technology behaviours were not significantly correlated with cognitive reflection. This was a different finding compared to some of the findings in the literature (Barr et al., 2015; Devine et al., 2022; Vujic, 2017), which examined adults and with several different types of technology measures. However, even in these studies, significant relationships between CRT scores and technology measures were not found on every measure (Barr et al., 2015; Devine et al., 2022; Vujic, 2017).

For hypothesis 5d, maladaptive technology behaviours were not significantly correlated with cognitive ability. This finding was unexpected given that other research findings show that some measures of technology use correlate negatively with different measures of cognitive ability, including fluid and verbal intelligence (Minear et al., 2013; Takeuchi et al., 2018), numeracy and verbal intelligence (Barr et al., 2015), and memory (Cain et al., 2016; Frein et al., 2013). It may also be that the adolescent maladaptive technology behaviours examined do not require decoupling processing.

Regarding hypothesis 6a, technology hygiene behaviours were not significantly correlated with antisocial behaviours across both adolescent (11–17 years) and parent reports. Yet, for the timepoint three years later (14–20 years), technology hygiene behaviours were significantly and weakly negatively correlated with antisocial behaviours. This finding suggests that correlations with technology hygiene behaviours and cognitive ability are more apparent in older but not younger adolescent samples.

For hypothesis 6b, as expected, maladaptive technology behaviours were significantly correlated with antisocial behaviours, at each of the adolescents' timepoints and parent reports. These correlations were moderate-to-large in size. The large correlation was for adolescents 14–20 years. This result is consistent with the research findings that specific technology behaviours

like social media use are positively correlated with antisocial behaviours and risky behaviours (Galica et al., 2017; Rosen, Whaling, Carrier, et al., 2013; Vannucci et al., 2020).

For hypotheses 7a–b, technology hygiene behaviours were not significantly correlated with academic achievement across timepoints or parent reports. Maladaptive technology behaviours were significantly negatively correlated with academic achievement across adolescent timepoints and were small in size. This finding regarding maladaptive technology behaviours and academics is consistent with the literature, which stresses the negative effects of technology use on academic achievement (Domoff et al., 2020; Kates et al., 2018; Kim et al., 2017). However, the correlations between maladaptive technology behaviours and academic achievement were not significant for parent reports. Parents might assume that when an adolescent says they are using their computer for studying that the adolescent is actually studying; in reality, they may be using that time for recreational use. Or it may be difficult for adults to monitor adolescents' use, as adolescents can have multiple devices. For example, parents can overestimate the amount of monitoring they do and are often not fully aware of the online risks that adolescents face (Liau, et al., 2008; Symons et al., 2017).

Table 14. Study 1 summary of main findings

	Results
Correlations between technology-related behaviours, age, and gender:	1a. Majority of correlations between the technology behaviour hygiene items were positively correlated for adolescents (at 11–17 years and 14–20 years) and for parents (11–17 years), consistent with hypothesis 1a. 1b. Majority of correlations between the maladaptive technology behaviour items were positively correlated for adolescents (at 11–17 years and 14–20 years) and for parents (11–17 years), consistent with hypothesis 1b. 2a. Technology hygiene items were not significantly correlated with age for both adolescent timepoints (at 11–17 years and 14–20 years), which was not consistent with hypothesis 2a.

	2b. Maladaptive technology behaviours were significantly and positively correlated with age for both adolescent timepoints (at 11–17 years and 14–20 years), consistent with hypothesis 2b. 3a. No significant differences found between males and females for technology hygiene behaviours for both adolescent timepoints (at 11–17 years and 14–20 years), which was not consistent with hypothesis 3a. 3b. No significant differences found between males and females for maladaptive technology behaviours for both adolescent timepoints (at 11–17 years and 14–20 years), which was not consistent with hypothesis 3b.
Correlations between technology-related behaviours, cognitive reflection, and cognitive abilities:	4. Technology hygiene behaviours and maladaptive technology behaviours were not significantly correlated for both adolescent timepoints (at 11–17 years and 14–-20 years), as well as for parents (11–17 years), which was not consistent with hypothesis 4. 5a. Technology hygiene behaviours were not found to be significantly correlated with cognitive reflection for both adolescent timepoints (at 11–17 years and 14–20 years), which was not consistent with hypothesis 5a. 5b. Technology hygiene behaviours were not significantly correlated with cognitive ability at either adolescent timepoint (11–17 years and 14–20 years), which was not consistent with hypothesis 5b. 5c. Maladaptive technology behaviours were not significantly correlated with cognitive reflection for samples at either adolescent timepoint (11–17 years and 14–20 years), which was not consistent with hypothesis 5c. 5d. Maladaptive technology behaviours were not significantly correlated with the cognitive ability for samples at either adolescent timepoint (11–17 years and 14–20 years), which was not consistent with hypothesis 5d.
Correlations between technology-related behaviours and real-world outcomes, including antisocial behaviours and academic achievement:	6a. Technology hygiene behaviours were not significantly correlated with antisocial behaviours for adolescents (11–17 years) and for parents (11–17 years). Technology hygiene behaviours were significantly and negatively correlated with antisocial behaviours for adolescents at the second timepoint (14–20 years), which was partially consistent with hypothesis 6a. 6b. Maladaptive technology behaviours were found to be significantly and positively correlated with antisocial behaviours for adolescents (11–17 years and 14–20 years), and for parents (11–17 years), which was consistent with hypothesis 6b.

	7a. Technology hygiene behaviours were not significantly correlated with academic achievement for adolescents (11–17 years and 14–20 years) and for parents (11–17 years), which was not consistent with hypothesis 7a. 7b. Maladaptive technology behaviours were found to be significantly and negatively correlated with academic achievement for both adolescent (11–17 years and 14–20 years) timepoints. However, maladaptive technology behaviours were found not to be significantly correlated with academic achievement for parents (11–17 years). The finding was partially consistent with hypothesis 7b.

Limitations of Study 1 and future directions

The purpose of Study 1 was to explore common technology hygiene and maladaptive behaviours in adolescents and how they related to each other as well as miserly information processing tendencies and cognitive ability. Given the exploratory nature of Study 1, the purpose of Study 2 was to elaborate these behaviours, including increasing the number of items and improving questions.

Limited number of items and task reliability. Reliability statistics such as omega within each sample for technology hygiene behaviours and maladaptive behaviours were not as high as expected. This could have been because the composites may not have been unidimensional. The lack of strong consistency among items perhaps relates to the fact that questions were asked dichotomously for 10 of 16 technology behaviours items, which may not have ascertained the true nature of some of the behaviours. For example, asking an adolescent to answer “yes” or “no” about the technology hygiene behaviour of having time limits on technology does not give a complete picture of the frequency of this behaviour, which is important information in determining whether the behaviour does prevent negative outcomes. Another example is the use of privacy settings as a technology hygiene behaviour. There appears to be a substantial difference between checking that the privacy settings are on once versus

continually checking whether these settings change on different applications. In another example related to maladaptive technology behaviours, asking about arguing with parents over technology use as a "yes or no" question does not elucidate the frequency of the behaviour, which would be helpful information to explore the maladaptive nature of this behaviour more fully. Future studies should ask more about the frequency of such behaviours.

Another limitation was the number of items; although there were six items about technology hygiene behaviours and ten items about maladaptive behaviours, other crucial technology hygiene behaviours or maladaptive technology behaviours were likely left out. Thus, future studies can improve on the reliability by including a larger set of task items and by increased piloting of task items.

Electronic device use as a maladaptive technology behaviour. Another potential limitation of Study 1 that may explain the lack of stronger correlations and even some negative correlations among the maladaptive technology behaviour items, is the decision to consider the uses of electronic devices like social networks, texting, time spent downloading and playing music, time spent using video games, and time spent being in virtual worlds as maladaptive. Electronic device use alone may not be maladaptive if most adolescents spend what they consider a normative amount of time relative to their peers, whereas adults may see more of a downside to increased electronic device use. Similarly, time spent doing one technology behaviour such as gaming may take away from time spent on another behaviour, such as listening to music and downloading content, which may be why a few negative correlations appeared among some of the maladaptive behaviours. Furthermore, adolescents may not view these behaviours as maladaptive because they derive much pleasure from them and therefore do not see these behaviours as problematic. For example, it has been found that 41% of adolescents

13 to 18 years of age noted they liked using social media in 2019, while 34% of adolescents in 2021 noted they liked it (Rideout et al., 2021). This may create less incentive for some adolescents to use their detection or override and decoupling processing skills for common errors. It may be that adults are more aware of how social networking, texting, time spent downloading and playing music, and time spent using video games may be detrimental and therefore view these behaviours in a more negative light. However, this is only a possible explanation, as adolescents were not directly asked about this. Future studies should alter questions so adolescents can reflect on whether their behaviours are problematic. Similarly, Toplak et al. (2017) found that for adults, technology use alone was not significantly correlated with a heuristic and biases composite, which had four of the same items for the maladaptive technology behaviours items as this study. This finding further supports a lack of association between cognitive reflection and use alone. Future studies should not consider use to be only a metric of maladaptive technology behaviours.

Rapid change of technology. Due to the rapidly changing nature of technology, some of the items, which were administered in 2013 and 2016, may not have captured more recent trends and habits of adolescents' technology behaviours; for many adolescents, certain technology hygiene behaviours may matter much less. For example, anti-virus programs have now regularly become integrated with computer use, so adolescents may not need to incorporate this behaviour as often as in the past. If some of these behaviours became automatic, without the need to apply effort, or occurred in low frequency, it would not matter if adolescents had higher cognitive reflection to override impulses not to engage in such behaviours.

Age range. The older sample of adolescents' age (14–20 years) displayed more consistent relationships between their technology behaviours and the real-world outcomes

compared to the first timepoint of adolescents (11–17 years). Perhaps this result is partly attributable to older adolescents having more experience with real-world outcomes. Sampling older adolescents may provide a better opportunity to examine correlations with real-world outcomes and provide a more comparable sample to published studies with young adults on miserly processing.

Conclusions

Study 1 explored common adaptive and maladaptive technology behaviours in adolescents; however, these behaviours did not significantly correlate with resistance to miserly processing or cognitive ability. Nevertheless, this result may be related to the limited number of technology items and the way technology behaviours were measured, given the literature of associations between cognitive reflection, cognitive ability, and technology behaviours. But technology behaviours were related to real-life outcomes: technology hygiene behaviours were significantly negatively correlated with antisocial behaviours for adolescents at the second timepoint (14–20 years). Maladaptive technology behaviours were significantly positively correlated with antisocial behaviours in adolescent and parent reports. Similarly, maladaptive technology behaviours were correlated with academic achievement in adolescent reports. Examining the importance of technology hygiene behaviours as well as maladaptive technology behaviours is a potential avenue to study decision-making in a world where adolescents increasingly rely on technology use in their daily lives.

Study 2 Introduction

The purpose of Study 2 was to expand on Study 1. Specifically, its aim was to elaborate the technology-related items examined in Study 1, thereby addressing some of the limitations of the methods used in that earlier study. In particular, different rating scales were used to assess technology behaviours in a more continuous manner (such as using Likert-type response scales), several technology-related behaviours were redeveloped, and additional items were added. Therefore, another goal of Study 2 was to update the items to better accommodate adolescents' current technological experiences. In addition, rather than examining a wide age range of adolescents, Study 2 was designed to focus on adolescents between the ages 16 and 18, from Grades 10 through 12.

Study 2 additions

In addition to technology hygiene behaviours and maladaptive technology behaviours, technology attitudes were also added to this study. As well, impression management, conscientiousness, and impulsivity were additional variables in Study 2.

Adaptive technology attitudes. In addition to how adolescents use technology, adolescents' attitudes towards the use of technology may be another important variable in the domain of technology. An attitude is defined as "a relatively enduring and general evaluation of an object, person, group, issue, or concept on a dimension ranging from negative to positive." (American Psychological Association, n.d., para. 1). It is important to see how technology attitudes affect behaviours. For example, do adolescents demonstrate a practical and adaptive understanding of how engaging in certain types of technology behaviours can lead to bad outcomes in one's life? Some researchers have noted that many teenagers have different ideas

about the good and bad effects of technology, as many attribute mental health issues to use of social media (Headspace National Youth and Mental Health Foundation, 2018) or have different views on how social media influence their lives (Anderson & Jiang, 2018). Adolescent attitudes about technology use may correlate with miserly tendencies and real-world outcomes, such as antisocial behaviours and academic achievement.

Gender differences should also be examined with respect to adaptive technology attitudes, as little research has been done on this regarding positive attitudes, but this issue is relevant because females have higher use in particular dimensions of device use, such as social media (Twenge & Farley, 2021; Twenge & Martin, 2020), and may suggest a discrepancy between females' and males' attitudes and behaviours around technology. It could be that females use social media more frequently than males and subsequently also know social media use is worse for them in terms of their mental health, and this consequence may also be generalized to other electronic device uses and behaviours.

Impression management. Regarding social desirability, also known as impression management, there is a tendency towards satisfying others with a socially flattering impression by overemphasizing the positive and underemphasizing the negatives (Hart et al., 2015). Currently, no studies have examined social desirability in relation to adolescent technology use. However, adolescents may exaggerate the frequency of their technology hygiene behaviours, or exaggerate adaptive beliefs, or understate the frequency of their maladaptive technology behaviours, in order to come across as more socially acceptable to others. Social desirability is worth measuring in this study to determine whether it explains findings relating to technology behaviours.

Conscientiousness. Conscientiousness is a personality trait that might relate to technology behaviours and attitudes. Conscientiousness is considered a mix of characteristics relating to a person's ability to be organized and orderly, cautious, have high standards regarding goals and responsibilities, diligent work ethic, and an eagerness to abide by rules (Lee & Ashton, 2004; Roberts et al., 2009). Conscientiousness is associated with real-world outcomes like post-secondary academic performance in large-scale meta-analytic studies as well an occupational success (Barrick & Mount, 1991; O'Connor & Paunonen, 2007). Conscientiousness has been associated negatively with addictive video game and Internet use (Wang et al., 2015), whereas some research points to both positive and negative associations between conscientiousness and technology use, depending on specific uses of electronic devices (Cocoradă et al., 2018).

Impulsivity. Impulsivity is a trait that may relate to maladaptive behaviours. Some studies report participants who invest more time in mobile devices may also be inclined towards less impulse control, while other studies have found associations between impulsivity and Internet gaming addiction, social media addiction, as well as Internet addiction (Cerniglia et al., 2019; Lee et al., 2012).

Study 2 plan and hypotheses

Study 2 expanded on Study 1 by creating more items that attempted to better capture technology use and technology attitudes. First, several exploratory factor analyses (EFA) were conducted to determine whether the pattern of correlations among the technology use items could be explained in terms of a small number of hypothetical constructs. Next, based on the results of the factor analyses, individual composite scores representing the factors were calculated. Several of the same hypotheses as in Study 1 were examined in Study 2. In addition, correlations between the technology variables and impression management, conscientiousness,

and impulsivity were calculated. Regression analyses were conducted to examine how cognitive variables were associated with technology behaviour and attitude variables. Regression models were estimated to examine how technology variables predicted real-world outcomes. Table 15 summarizes the hypotheses for Study 2.

Table 15. Summary of Study 2 hypotheses

	Study 2 predictions
Correlations between technology-related behaviours and gender:	1a. Technology hygiene behaviour factors will be higher in males than females, but adaptive technology attitudes will be higher in females than males. 1b. Maladaptive technology behaviour factors will be higher in females than males.
Correlations between technology-related behaviours, cognitive reflection, and cognitive abilities:	2a. Technology hygiene behaviour factors will be correlated positively with each other. Adaptive technology attitudes factors will be correlated positively with each other. Maladaptive technology behaviours factors will be correlated significantly and positively with each other. 2b. Technology hygiene behaviour factors will be positively correlated with adaptive technology attitude factors and negatively correlated with maladaptive behaviours factors. Adaptive technology attitude factors will be negatively correlated with maladaptive behaviour factors. 3a. Technology hygiene behaviour factors and adaptive technology attitude factors will be positively correlated with cognitive reflection and a measure of cognitive ability. 3b. Maladaptive technology behaviour factors will be negatively correlated with cognitive reflection and cognitive ability. 3c. Regressions will examine whether cognitive reflection or cognitive ability predicted technology behaviour factors. It is expected that cognitive reflection and cognitive ability will predict correlated technology factors.
Correlations between technology-related behaviours and real-world outcomes, including antisocial	4a. Technology hygiene behaviour and adaptive attitude factors will be negatively correlated with antisocial behaviours. 4b. Maladaptive technology behaviour factors will be positively correlated with antisocial behaviours.

behaviours and academic achievement:	4c. Regressions will examine whether technology behaviours and attitudes predicted outcomes of antisocial behaviours. It is expected that technology behaviours and attitudes that were correlated with antisocial behaviours, will predict antisocial behaviours. 5a. Technology hygiene behaviour and adaptive technology attitude factors will be positively correlated with academic achievement. 5b. Maladaptive technology behaviour factors will be negatively correlated with academic achievement. 5c. Regressions will examine whether technology behaviours and attitudes predicted outcomes of academic achievement. It is expected that technology behaviours and attitudes that were correlated with antisocial behaviours, will predict academic achievement.

Method

Participants

Data were collected from 432 participants, who were residents of the United States or Canada recruited through Qualtrics Panels service (Qualtrics, Provo, UT) and received monetary compensation for their participation. To be eligible for this study, participants were pre-screened by Qualtrics and were required to be between ages 16 and 18, as well as between Grades 10 and 12, speak English as their first language, or have known English for at least eight years.

In this study, there were 196 males and 222 females (51.4% female), and 14 declared their gender was nonbinary or other (3.2%), with ages ranging between 16 and 18 years (M = 16.85, SD = .74). There were 91 participants (21.1%) in Grade 10, 174 participants (40.3%) in Grade 11, and 167 participants (38.7%) in Grade 12.

Originally, 477 participants were recruited for this study. Pilot data were taken from 30 participants to get a median time as well as develop a “speed check.” The median completion

time for the first 30 participants who did the study was 19 minutes and 16 seconds, while the average time of completion was 22 minutes 55 seconds. When examining patterns in the data, it was found that two out of six participants who had times of 13 minutes or less were non-compliant with the instructions (responding with the same response repeatedly). Based on this information it was decided that a cut-off of 14 minutes would be used. The participants who then had completion times less than 14 minutes were excluded from the study, and all other participants were kept as part of the final sample. Data from 45 participants were discarded because of non-compliance with the study's instructions, such as participants giving the same response for many items and across measures "straight-lining," entering inappropriate information or not completing questions, or receiving numerous responses from the same IP address that appeared to be the same participant.

Of the total sample, 0.2% identified as Aboriginal, 10% identified as Asian, 50% as White/Caucasian, 17.6% as Black or African American, 2.1% as South Asian, 17.4% as Hispanic or Latino, and 2.8% chose other ethnicities. Of the total sample, 89.4% stated that English was their first language. For the 10.6% who noted that English was not their first language, their average length of time speaking English was 11.37 years. If English was not a participant's first language, they were allowed to continue in the study only if they indicated that they had studied English for at least eight years.

Most of the parents of the adolescents had a high level of education. Of the mothers, 24.1% had professional degrees, 29.6% had completed college or university, 14.1% had some college or university, 18.1% had completed high school, 7.2% had completed some of high school, 2.8% had completed junior high, and 4.2% had completed less than 7th grade. Of the fathers, 22.2% had professional degrees, 24.5% had completed college or university, 15.3% had

some college or university, 24.8% had completed high school, 9.2% had completed junior high, and 3.9% had completed less than 7th grade.

Measures

Technology use and device use. Participants were asked questions about their total technology use per day (Appendix G), ranging from less than 30 minutes to more than eight hours. Participants were also asked to rank the top three devices they use the most each day.

Technology hygiene behaviours. Technology hygiene behaviours were measured using 14 items (Appendix H), four of which were revised from Study 1, while the items regarding virus protection, and discussing online content with parents were eliminated. Ten new items were written and four dichotomous technology hygiene behaviour items from Study 1 were adapted and turned into statements on a seven-point Likert-type scale: 1 = *Never*, 2 = *Almost Never*, 3 = *Occasionally*, 4 = *About Half the Time*, 5 = *Frequently*, 6 = *Almost Always*, 7 = *Always*. A higher total score indicated more adaptive technology behaviours.

Adaptive technology attitudes. Adaptive technology attitudes were measured using 14 new items (Appendix I) developed for Study 2. Items were generated to ask about various attitudes related to technology and technology use. Three items were reverse scored. Participants were asked to rate their level of agreement with various statements on a seven-point Likert-type scale: 1 = *Strongly Disagree*, 2 = *Disagree Slightly*, 3 = *Disagree*, 4 = *Neither Agree, Nor Disagree*, 5 = *Slightly Agree*, 6 = *Agree*, and 7 = *Strongly Agree*. Higher total scores indicated more adaptive perspectives about technology use and behaviours.

Maladaptive technology behaviours. Maladaptive technology behaviours were measured using 32 items (Appendix J), some of which were revised from Study 1. Dichotomous maladaptive technology behaviour items from Study 1 were adapted and turned into statements

on a seven-point Likert-type scale: 1 = *Never*, 2 = *Almost Never*, 3 = *Occasionally*, 4 = *About Half the Time*, 5 = *Frequently*, 6 = *Almost Always*, and 7 = *Always*. The five items from Study 1 that asked about specific time spent on technology uses, as well as the item that asked about embarrassing messages, were eliminated or worded differently to reflect more maladaptive use. While the four remaining items that asked about school, arguing with parents, and sleep, all had revised wording. Twenty-seven new items relating to maladaptive technology use were generated. A higher total score indicated more maladaptive technology behaviours.

Cognitive reflection. Eleven of the 12 Cognitive Reflection Test items used in Study 1 were used in this study. The 11 item scores were summed to produce a total score. A higher score indicated higher resistance to miserly information processing.

Cognitive ability. Cognitive ability was measured with eight items from the International Cognitive Ability Resource (ICAR) Sample Test (Condon & Revelle, 2014). A typical question on the ICAR would ask what letter comes next in a pattern of five letters and would give six possible answers. The ICAR-5 uses some of the items on the 16-item ICAR Sample Test that is used in research for adolescents (Kirkegaard & Bjerrekaer, 2016). Rizeq (2019) used the ICAR-5 with an adolescent sample but found a mean close to zero. Due to possible floor effects of the ICAR problems, the accuracy rates of each problem in the Rizeq (2019) study were examined for this study. The accuracy rate of the five problems ranged from 8% to 37% (Rizeq, 2021). Eventually, three problems that had accuracy rates of 37%, 34%, and 27% were kept while the other two were removed (8% and 15%). Five other ICAR Sample Test problems that were considered easier were added to make eight total ICAR problems. The eight item scores (five verbal questions and three pattern questions) were summed to produce a total score such that a higher score indicated higher cognitive ability.

Antisocial behaviours. Nine of the antisocial behaviour items used in Study 1 were used in this study. Although Study 1 contained ten items, the item "How many times have you lied to get your way?" was removed because it was very similar to a question on the BIDR-16 (described below). The nine items included common antisocial behaviours such as: times allowed to stay out; getting into physical fights; stealing; vandalization; sent to the principal's office; skipping school; having detentions or suspensions; being late; and cheating on a test. A Likert-type scale was used instead of the yes/no response options of Study 1, where participants rated how much they agree with statements on a seven-point Likert-type scale. The nine item scores were summed to produce a total score such that a higher score indicated more antisocial behaviours.

Academic achievement. Participants reported their overall average (out of 100) in four academic domains of Science, Math, English, and Social Studies or History. Participants were also asked about their overall average. A composite of these four subjects was taken as a measure of overall academic achievement; or, if only three subjects were taken, then the average of the three courses was used. However, if only two subjects out of the four were taken, or there was incomplete information, the overall average was used instead. A higher score indicated better academic performance.

Impression management. Impression Management was measured with the eight-item impression management subscale of the Balanced Inventory of Desirable Responding Short Form (BIDR-16). An example item would be "I never cover up my mistakes" (Hart, 2021, BIDR-16 Stimuli section). While a reversed scored item would be "I have said something bad about a friend behind his/her back" (Hart, 2021, BIDR-16 Stimuli section). The original Balanced Inventory of Desirable Responding (BIDR) was developed by Paulhus (1991) and

consisted of 40 items; the BIDR-16 represents a shorter version developed by Hart et al. (2015). The internal consistency of BIDR-16 ranged from α = .66 to .74 across their studies and had good test-rest reliability (Hart et al., 2015). To keep the number of response options consistent across measures, a seven-point Likert-type scale was used. The eight item scores were summed for a total score such that a higher score indicated more impression management.

Conscientiousness. The personality trait of conscientiousness was measured with the ten-item conscientiousness subscale from the 50-item version of the International Personality Item Pool (IPIP; Goldberg, 1992; International Personality Item Pool Website, n.d.). An example item include would be "Am always prepared" (IPIP Website, n.d., Item Stimuli section). While a reversed scored item would be "Make a mess of things" (IPIP Website, n.d., Item Stimuli section). Two items were modified slightly so that the wording would be more understandable for teenagers. The first item, "Like order" (IPIP Website, n.d., Item Stimuli section) was changed to "Like to have my things in order." The second, "Shirk my duties" (IPIP Website, n.d., Item Stimuli section), was changed to "Avoid my duties." To keep the number of response options consistent across measures, a seven-point Likert-type scale was used. The ten item scores were summed to produce a total score, with higher scores indicating higher conscientiousness.

Impulsivity. Impulsivity was measured with the eight items of Barratt Impulsiveness Scale–Brief (BIS-Brief; Steinberg et al., 2013). An example item would be "I do things without thinking" (Steinberg et al., 2013, p. 218). While a reversed scored item would be "I concentrate easily" (Steinberg et al., 2013, p. 218). The BIS-Brief is a shorter scale made up of eight items taken from BIS-11 (Steinberg et al., 2013). The BIS-Brief is a unidimensional scale with good internal reliability ranging from α = 0.73 to 0.83 (Steinberg et al., 2013) as well as α = 0.81 to 0.84 in another study (Juneja et al., 2019) for young adults. For this study, a seven-point Likert-

type scale range was used. The eight item scores were summed to produce a total score such that a higher score indicated greater impulsivity.

Procedure

Participants completed Study 2 online using the Qualtrics platform. First, participants completed the informed consent and demographic forms. Before the participants started the measures, adolescents were asked "*Do you commit to providing your thoughtful and honest answers to the questions in this survey?*" Participants were then given 3 options: "I will select my best answers," "I will not provide my best answers," or "I can't promise either way." Only participants who selected "I will select my best answers" were included.

Due to the online nature of this study, attention checks were used throughout. Four attention checks were created that asked participants to respond to visual stimuli with five response options such as "select the arrow going up" among five arrows options. To be included in the final sample, participants had to answer three out of four attention checks correctly. Five progress prompts that provided an estimate of how far participants were in the study and encouraged them to keep going with emojis were also integrated.

Following the consent forms, screening questions, and demographic questions (including questions about academic achievement), participants were presented with a battery of measures and tests in various blocks. All participants were given the same order of tasks and blocks. Blocks of different survey items were intermixed with either Cognitive Reflection Test questions or ICAR questions, as well as attention checks and progress prompts. The order was: technology-use items presented first, followed by technology hygiene behaviour items, maladaptive technology behaviour items, adaptive technology attitudes items, and finally BIDR-16 items, which were all mixed with blocks of the Cognitive Reflection Test, attention checks,

and prompts. These measures were followed by IPIP items, BIS-Brief items, and antisocial behaviour items, which were all mixed with blocks of the ICAR, attention checks, and prompts.

Results

Exploratory factor analyses of technology hygiene behaviours

To address the first goal of the study, separate exploratory factor analysis (EFA) models were estimated for the technology hygiene behaviour items, maladaptive technology behaviour items, and adaptive technology attitudes items. Correlations were examined first. A scree plot, parallel analysis, the root mean square error of approximation (RMSEA), and the root mean square residual (RMR) were used to determine the optimal number of factors for each set of items.

First, 12 of the 14 technology hygiene items correlated at least .3 with at least one other item. Whereas a scree plot suggested that a model with three common factors is optimal for the technology hygiene behaviour items, the parallel analysis suggested four factors. Next, one-, two-, three- and four-factor models were estimated using unweighted least squares (ULS). The factor loadings were obtained using oblimin rotation with a weight of 0. The model fits were the following: a one-factor model (RMSEA = .12, RMR = .11); a two-factor model (RMSEA = .07, RMR = .05); a three-factor model (RMSEA = .05, RMR = .04); and a four-factor model (RMSEA = .03, RMR = .02). Ultimately, the two-factor model was considered optimal for the data because the RMEA and RMR were acceptable and the factor loading pattern was the most interpretable compared with the other models.

Results for the two-factor model are presented in Table 16, with the items re-ordered for ease of interpretation. Names of factors were meant to reflect the content of items with salient loadings on each factor. Factor 1 is defined by salient loadings from items 1, 2, 6, 8, 9, 10, 11,

12, and 14; this factor corresponds to the "security and privacy behaviours" factor given the conceptual content of these items. Factor 2 is defined by salient loadings from items 3, 4, 5, and 7, which corresponds to a "device-limiting behaviours" factor. Finally, the communality estimates, which are the proportion of that variable's variance explained by the combination of factors, for this two-factor model were inconsistent, with four items having a communality over .4 and ten items having communality below .4. The estimated inter-factor correlation was $r = .22$.

This set of items for a two-factor model was adequate to account for associations among items, leading to two subscale scores for technology hygiene. However, item 13 was not used to create scores because it loaded on both factors equally.

Table 16. Technology hygiene behaviour items factor loadings and communality

Items	Factor 1 loading security and privacy behaviours	Factor 2 loading device-limiting behaviours	H2
1. Check that an important file or document has been saved.	**.43**	.14	.24
2. Create an extra backup of important files and documents.	**.37**	.31	.28
6. Turn the sound off on my electronic devices at nighttime so that any new alerts or messages do not interrupt my sleep.	**.27**	.12	.10
8. Create different passwords for different online accounts.	**.50**	.10	.28
9. Double-check that a website is a secure site when I am paying for something online.	**.75**	.09	.28
10. Use "more secure" password protection (such as a combination of numbers, symbols, and letters) on my electronic devices.	**.61**	.06	.40

11. Use two-step verification (such as entering a password on my email, and a code on my phone) to login into important online accounts, such as banking or payment information.	**.54**	-.09	.28
12. Use the stricter than the default privacy settings on social networking sites (such as limiting who sees photos or posts on Instagram or TikTok) to protect my personal information and privacy.	**.65**	.02	.43
14. Avoid clicking on links in texts or emails from someone whose number or name I don't recognize.	**.44**	-.17	.19
3. Set time limits on using electronic devices and generally keep to the limit.	.01	**.65**	.43
4. Focus on school or work tasks without thinking about doing other things on my electronic devices.	.17	**.36**	.19
5. Use strategies like putting my electronic devices away at least half an hour before I go to sleep.	-.06	**.82**	.65
7. Use strategies like putting my electronic devices in another room or another place to disconnect so that I can focus on studying or work.	.05	**.60**	.37
13. Take time to read the terms and conditions of a website when I sign up for online services (such as social networking platforms).	.30	.30	.22

Exploratory factor analyses for adaptive technology attitudes

First, 13 of the 14 items pertaining to adaptive technology attitudes correlated at least .3 with at least one other item. Both scree plot and parallel analysis suggested three common factors. Next, one-, two-, three-, and four-factor models were estimated using ULS; the factor loadings were obtained using oblimin rotation with a weight of 0. The model fits were the following: a one-factor model (RMSEA = .10, RMR = .09); a two-factor model (RMSEA = .07, RMR = .05); a three-factor model (RMSEA = .05, RMR = .03), and a four-factor model (RMSEA = .04, RMR = .02). Ultimately, the two-factor model was considered optimal for the

data because the RMSEA and RMR were acceptable and the factor loading pattern was the most interpretable compared with the other models.

The factor loadings are in Table 17; the items are re-ordered for ease of interpretation. Factor 1 is defined by salient loadings from items 1, 5, 6, 7, 8, 11, and 13; this factor corresponds to "technology-etiquette attitudes." Factor 2 is defined by salient loadings from items 2, 4, 9, 10, 12, and 14, which corresponds to the "device-time/access attitudes" factor. Finally, the communality estimates for this two-factor model were inconsistent, with five items having a communality over .4 and nine items having a communality below .4. The estimated inter-factor correlation is $r = .42$.

This two-factor model led to creating two subscale scores. However, item 3 was not used to create scores because it had a strong negative loading on one factor.

Table 17. Adaptive technology attitude items factor loadings and communality

Items	**Factor 1 loading technology-etiquette attitudes**	**Factor 2 loading device-time/access attitudes**	**H2**
1. It is important to take breaks from my electronic devices.	**.50**	.32	.49
5. I see no problem with entering my credit card/payment information on websites with which I am not familiar. (Reverse Scored)	**.42**	-.16	.15
6. When I am tired and choose to communicate through my electronic device with others, it is easy to make silly mistakes in my messages.	**.39**	.12	.21
7. When I am sending personal information, I am careful to ensure that the recipient is the right person.	**.65**	.00	.42
8. Backing up important files and documents on my electronic devices often saves me time in the long run.	**.56**	-.05	.29

11. It is important to have stricter than the default security settings on my electronic devices to help protect my personal information.	**.72**	.00	.51
13. Posting things on the Internet can have negative consequences.	**.58**	.09	.38
2. I do better in classes where electronic devices are not allowed.	-.03	**.57**	.31
4. If I am doing something fun on my electronic device at the same time as homework, then I probably won't get my homework done.	.07	**.43**	.22
9. If I did not have access to electronic devices at bedtime, I would probably get a better sleep.	.04	**.62**	.41
10. I pay better attention to people who I am with when I don't use my electronic device at the same time.	.29	**.41**	.36
12. I don't see the benefit of limiting my electronic device use. (Reverse Scored)	-.19	**.51**	.22
14. It is important not to spend too much time on electronic devices.	.32	**.49**	.47
3. I see no problem with multi-tasking (performing two or more tasks at the same time) on my electronic device as I do homework. (Reverse Scored)	-.41	.32	.16

Exploratory factor analyses for maladaptive technology behaviours

First, 31 of the 32 maladaptive technology behaviour items correlated at least .3 with at least one other item. The scree plot suggested two common factors while the parallel analysis suggested that a model with six common factors is optimal. Next, one-, two-, three-, four-, five-, and six-factor models were estimated using ULS and the factor loadings were obtained using oblimin rotation with a weight of 0. The model fits were the following: for the one-factor model (RMSEA = .09, RMR = .08); the two-factor model (RMSEA = .08, RMR = .06); the three-factor

model (RMSEA = .07, RMR = .05); the four-factor model (RMSEA = .06, RMR = .04); the five-factor model (RMSEA =.06, RMR = .04); and the six-factor model (RMSEA = .05, RMR = .03). Ultimately, the four-factor model was considered optimal for the data because the fit was acceptable and the factor loading pattern was interpretable.

Results for the four-factor model are presented in Table 18; the items are re-ordered for ease of interpretation. Factor 1 is defined by salient loadings from items 8, 16, 17, 18, 19, 20, 22, and 23; this factor corresponds to "device-absorption behaviours." Factor 2 is defined by salient loadings from items 7, 9, 10, 11, 13, 14, 15, 27, and 30, which correspond to "careless device behaviours that can lead to regret." Factor 3 is defined by salient loadings from items 1, 2, 3, 4, 5, and 6, which can be conceptualized as "problematic school and home behaviours." Factor 4 is defined by salient loadings from items 21, 24, 25, 26, 28, 29 and 32, and can be conceptualized as "immediate device-gratification behaviours." Items 12 and 31 cross-loaded on multiple factors. Finally, the communality estimates for this four-factor model were inconsistent, with 13 items having a communality over .4 and 19 items having a communality below .4.

This four-factor model led to four subscale scores. However, items 12 and 31 were not used because of their cross loadings.

Table 18. Maladaptive technology behaviour items factor loadings and communality

Items	**Factor 1 loading device-absorption behaviours**	**Factor 2 loading careless device behaviours that can lead to regret**	**Factor 3 loading problematic school and home behaviours**	**Factor 4 loading immediate device-gratification behaviours**	**H2**
8. Lose sleep time or go to bed too late because of electronic devices.	**.49**	.00	.22	-.03	.37

16. Think about using my electronic devices when I am doing something else.	**.56**	.12	.02	-.04	.36
17. Check my electronic devices for a new alert or message even when I haven't received a notification.	**.68**	-.12	.04	.08	.44
18. Check my electronic device while I'm supposed to be paying attention to something else.	**.79**	-.04	.03	.03	.64
19. Get bothered when I hear or see a new alert or message and cannot get to my electronic device.	**.54**	.28	-.10	.08	.46
20. Use autofill on forms without first checking the content of the form. (Autofill is when previously stored information is automatically entered onto a webpage.)	**.29**	.05	.09	.13	.18
22. Binge-watch TV shows, or movies, instead of doing schoolwork or some important tasks.	**.39**	-.05	.29	.11	.38
23. Decide to reduce my time on electronic devices and not follow through.	**.42**	.07	.12	-.01	.26
7. Argue with my parent(s) because of staying up too late using electronic devices.	.20	**.42**	.32	-.16	.43
9. Receive a text or message or email, respond instantly and then regret it.	.29	**.37**	.04	-.01	.30
10. Accidentally text or message sensitive or personal	.04	**.70**	.00	-.01	.50

information to the wrong person.					
11. Get into arguments with a stranger online and later regret it.	.02	**.63**	.00	.09	.46
13. Use my electronic device and not pay attention to traffic while driving a car or riding a bike.	-.18	**.59**	.11	-.02	.47
14. Use my electronic device and not pay attention to other pedestrians and traffic while walking on a busy street.	-.05	**.49**	.03	.20	.36
15. Accidentally go over my data limit.	.03	**.40**	.01	.15	.26
27. Use predictable passwords (such as “password” or “123456789”).	.00	**.32**	-.01	.26	.25
30. Spend money on “in-game purchases” in virtual worlds (like Minecraft or Fortnite) or video games that I later regret.	.16	**.31**	.00	.21	.28
1. Fail to complete homework because I am using electronic devices.	.00	-.11	**.79**	.02	.59
2. Get lower grades because I am using electronic devices.	-.10	.13	**.76**	.04	.61
3. Cheat on schoolwork by using electronic devices.	.06	-.02	**.43**	.25	.33
4. Open new Internet tabs/windows not related to school while doing schoolwork.	.29	-.12	**.39**	.16	.37

5. Fail to do my chores or important tasks because of my use of electronic devices.	.24	.09	**.56**	-.05	.53
6. Argue with my parent(s) because of using electronic devices too much.	.09	.33	**.42**	-.03	.43
21. Get distracted by sexually provocative images/videos from electronic devices.	.21	.25	-.09	**.34**	.34
24. Download or stream digital content when I am not certain it is legal.	.04	-.03	.01	**.66**	.45
25. Enter false information about myself, such as my age, to get access to content online.	-.04	.09	.00	**.60**	.39
26. Visit websites even though I have been notified that they are not secure or may contain malware.	.00	.06	.04	**.66**	.49
28. Use the same password for my different online accounts.	.10	-.08	.08	**.36**	.17
29. Play video games for such a long time that I miss something important I have to do.	.23	.08	.09	**.37**	.35
32. Sign up for free stuff or coupons online without considering that the information may be collected and used for other purposes.	.27	.21	.19	**.33**	.33
12. Use my electronic device instead of paying attention to someone that I am with.	.36	.35	.04	-.02	.34

31. Buy or make purchases online and later regret it.	.22	.19	.09	.25	.30

Descriptive statistics

Means, standard deviations, skewness, kurtosis, and McDonald's omega for all measures are in Table 19.

Table 19. Study 2 descriptive statistics of measures

Variable	Mean	SD	Skewness	Kurtosis	Omega
Technology hygiene behaviours					
Security and privacy behaviours	40.82	9.51	-.15	-.34	.77
Device-limiting behaviours	11.75	4.74	.73	.01	.72
Adaptive technology attitudes					
Technology-etiquette attitudes	36.61	6.90	-.76	.25	.77
Device-time/access attitudes	27.12	6.34	-.01	-.39	.71
Maladaptive technology behaviours					
Device-absorption behaviours	27.96	8.67	.12	-.24	.81
Careless device behaviours that can lead to regret	18.98	7.62	1.20	1.12	.81
Problematic school and home behaviours	18.01	6.87	.72	.68	.81
Immediate device-gratification behaviours	18.91	7.26	.44	-.30	.77
Cognitive correlates					
Cognitive reflection (Cognitive Reflection Test total score)	2.88	3.25	1.00	-.28	.95
Cognitive ability (ICAR total score)	3.79	2.29	.15	-.90	.83
Real-world correlates					
Antisocial behaviours	17.40	8.87	1.42	1.32	.90

Academic achievement	84.96	11.54	-1.37	1.87	.92
Other variables					
Impression management (BIDR-16)	32.17	7.24	.03	.41	.64
Conscientiousness (IPIP)	43.76	8.98	.31	.52	.76
Impulsivity (BIS-Brief)	29.47	7.24	.04	.49	.78

Note. For academic achievement some participants indicated a failing mark or simply placed an "F" mark instead of an actual number; all failing marks were rounded to 49 to avoid too large a range for items. Omega for academic achievement was taken from only 411 participants since not every participant indicated they took all four subjects.

Frequency of total time on devices

Regarding the most frequently used device, most participants listed the smartphone/mobile device (75%) as the device most frequently used, followed by computer (17.9%), gaming device (4.6%), tablet (2.1%), E-reader (.2%), and television (.2%). Regarding the second most frequently used device, 51.4% of participants listed the computer as the device second most frequently used, followed by smartphone/mobile device (16.8%), gaming device (12.5%), smart television/television (8.1%), tablet (7.4%), no response (1.6%), smartwatch (.7%), portable music player (.5%), headphones (.5%), radio (.2%), and E-reader (.2%). Regarding the third most frequently used device, 26.8% of participants listed the smart television/television as the device third most frequently used, followed by computer laptop/desktop (23.4%), gaming device (17.4%), tablet (14.4%), smartphone/mobile device (4.6%), no response (4.4%), smartwatch (3.9%), miscellaneous items (1.8%), e-reader (1.6%), virtual reality headset (.7%), smart speakers (.7%), and radio (.2%).

Regarding total time spent on a device in one day, 30.1% of adolescents listed spending more than 8 hours online; 13.9% spent 7 to 8 hours online; 10.9% spent 6 to 7 hours online; 13.4% spent 5 to 6 hours online; 13.2% spent between 5 to 4 hours online; 8.6% spent between 4

to 3 hours; 5.1% spent between 3 to 2 hours; 3.2% spent between 2 to 1 hours; and 1.6% spent between an hour or less on devices. Most adolescents listed spending 6 or more hours on electronic devices (54.9%), 26.6% spent between 4 to 6 hours online, and 18.5% spent 4 or less hours online each day.

Gender differences in technology factors (hypotheses 1a-b)

Neither of the two-technology hygiene subscales had a significant gender difference. Regarding adaptive technology attitudes, females (M = 37.47, SD = 6.20) had significantly higher technology-etiquette attitudes than males (M = 35.61, SD = 7 .37), $t(416) = -2.78$, $p<.05$. Similarly, for device-time/access attitudes, females (M = 28.15, SD = 6.00) had significantly higher scores than males (M = 26.48, SD = 6.45), $t(416) = -2.92$, $p<.05$.

The only maladaptive technology behaviour subscale that had a significant gender difference was immediate device-gratification behaviour, which was higher for males (M = 20.24, SD = 7.64), than females (M = 17.96, SD = 6.78), $t(416) = 3.22$, $p<.05$.

Correlations among technology factor scores (hypotheses 2a–b)

Correlations among the technology subscales are in Table 20. For hypothesis 2a, the technology hygiene behaviour subscale of security and privacy behaviours was found to have a significant and small positive correlation with device-limiting behaviours (r = .28, p < .05). The adaptive technology attitudes subscale of technology-etiquette attitudes was significantly and moderately positively correlated with device-time/access attitudes (r = .46, p < .05). For the maladaptive technology behaviour subscales of device-absorption behaviours, careless device behaviours that can lead to regret, problematic school and home behaviours, and immediate device-gratification behaviours, significant and moderate to large positive associations were found (r ranged from .47 to .60, p < .05).

For hypothesis 2b, the correlations between technology hygiene behaviour subscales and adaptive technology attitude subscales were also examined. Security and privacy behaviours were significantly and positively correlated with technology-etiquette attitudes ($r = .44$, $p < .05$) and device-time/access attitudes ($r = .21$, $p < .05$). Device-limiting behaviours were not significantly correlated with either technology-etiquette attitudes or device-time/access attitudes.

Correlations between technology hygiene behaviours and maladaptive technology behaviour factors were also examined. Security and privacy behaviours were not significantly correlated with device-absorption behaviours but were significantly negatively correlated with careless device behaviours that can lead to regret ($r = -.19$, $p < .05$), problematic school and home behaviours ($r = -.17$, $p < .05$), and immediate device-gratification behaviours ($r = -.30$, $p < .05$). Statistical and small negative correlations were found between device-limiting behaviours and device-absorption behaviours ($r = -.23$, $p < .05$), and problematic school and home behaviours ($r = -.15$, $p < .05$). Device-limiting behaviours were significantly positively correlated with careless device behaviours that can lead to regret ($r = .13$, $p < .05$). However, device-limiting behaviours were not significantly correlated with immediate device-gratification behaviours. These correlations suggest security and privacy behaviours are negatively related to most maladaptive technology behaviour subscales, but device-limiting behaviours had different associations with the maladaptive technology behaviour subscales.

Correlations between adaptive technology attitudes and maladaptive technology behaviour factors were also examined. Technology-etiquette attitudes were not significantly correlated with device-absorption behaviours. Technology-etiquette attitudes were significantly and moderately negatively correlated with careless device behaviours that can lead to regret ($r = -.35$, $p < .05$), and statistically and weakly negatively correlated with problematic school and

home behaviours (r = -.12, p < .05), and immediate device-gratification behaviours (r = -.28, p < .05). However, device-time/access attitudes had a significant and positively small correlation with device-absorption behaviours (r = .20, p < .05). Device-time/access attitudes were not significantly correlated with careless device behaviours that can lead to regret, problematic school and home behaviours, and immediate device-gratification behaviours. These findings suggested that technology-etiquette attitudes were related negatively to most maladaptive technology behaviour subscales, but device-time/access attitudes had no significant associations with most maladaptive technology behaviour subscales.

Table 20. Correlations among technology subscales

	1	2	3	4	5	6	7	8
Technology hygiene behaviours								
1. Security and privacy behaviours	1							
2. Device-limiting behaviours	.28*	1						
Adaptive technology attitudes								
3. Technology-etiquette attitudes	.44*	-.08	1					
4. Device-time/access attitudes	.21*	.07	.46*	1				
Maladaptive technology behaviours								
5. Device-absorption behaviours	-.07	-.23*	.09	.20*	1			

6. Careless device behaviours that can lead to regret	-.19*	.13*	-.35*	-.03	.49*	1		
7. Problematic school and home behaviours	-.17*	-.15*	-.12*	.09	.57*	.51*	1	
8. Immediate device-gratification behaviours	-.30*	-.08	-.28*	-.05	.51*	.60*	.47*	1

*p<.05.

Correlations for technology subscales and other variables (hypotheses 3a–b, 4a–b, 5a–b)

Correlations among technology subscales and non-technology measures are in Table 21 and Table 22. For hypothesis 3a, security and privacy behaviours were not correlated significantly with cognitive reflection but were significantly positively correlated with cognitive ability (r =.12, p< .05). Device-limiting behaviour was significantly and weakly negatively correlated with cognitive reflection (r = -.12, p< .05) and with cognitive ability (r = -.14, p< .05).

Regarding adaptive technology attitudes subscales and the cognitive variables, technology-etiquette attitudes were significantly and positively correlated with both cognitive reflection (r =.25, p< .05) and cognitive ability (r =.30, p< .05). Device-time/access attitudes were not significantly correlated with cognitive reflection but were significantly and weakly positively correlated with cognitive ability (r =.12, p< .05).

For hypothesis 4a, security and privacy behaviours were significantly and moderately negatively correlated with antisocial behaviours (r = -.30, p< .05), but not device-limiting behaviours. Technology-etiquette attitudes were significantly and moderately negatively correlated with antisocial behaviours (r = -.49, p< .05). Similarly, a significant and small

negative correlation was found between device-time/access attitudes and antisocial behaviours (r = -.18, p< .05).

For hypothesis 5a, security and privacy behaviours were significantly and weakly positively correlated with academic achievement (r = .15, p< .05), but device-limiting behaviours were not. Regarding adaptive technology attitudes subscales and academic achievement, both technology-etiquette attitudes and device-time/access attitudes had significant and small positive correlations with academic achievement (r = .24, p< .05 and r = .21, p< .05).

Security and privacy behaviours had significant and small correlations with impression management (r = .20, p< .05), conscientiousness (r =. 29, p< .05), and impulsivity (r = -.26, p< .05). Device-limiting behaviours were significantly and weakly correlated with impression management (r = .20, p< .05), conscientiousness (r = .29, p< .05), and impulsivity (BIS) (r = -.18, p< .05).

Technology-etiquette attitudes were not significantly correlated with impression-management scores. Technology-etiquette attitudes were significantly correlated with conscientiousness (r = .20, p< .05) and impulsivity (r = -.17, p< .05). Device-time/access attitudes had significant and small correlations with impression management (r = -.11, p< .05), conscientiousness (r = .10, p< .05), and impulsivity scores (r = -.12, p< .05).

Table 21. Correlations between technology hygiene behaviour factors with cognitive variables, outcome variables, and other variables

Variable	Security and privacy behaviours	Device-limiting behaviours
Cognitive Variables		
Cognitive reflection (Cognitive Reflection Test total score)	.05	-.12*
Cognitive ability (ICAR total score)	.12*	-.14*

Outcome Variables		
Antisocial behaviours total score	-.30*	.04
Academic achievement composite	.15*	.09
Other Variables		
Impression management (BIDR-16 total score)	20*	.20*
Conscientiousness (IPIP total score)	.29*	.29*
Impulsivity (BIS-Brief total score)	-.26*	-.18*

*$p < .05$.

Table 22. Correlations between adaptive technology attitude factors with cognitive variables, outcome variables, and other variables

	Technology-etiquette attitudes	Device-time/access attitudes
Cognitive Variables		
Cognitive reflection (Cognitive Reflection Test total score)	.25*	.06
Cognitive ability (ICAR total score)	.30*	.12*
Outcome Variables		
Antisocial behaviours total score	-.49*	-.18*
Academic achievement Composite	.24*	.21*
Other Variables		
Impression management (BIDR-16 total score)	-.05	-.11*
Conscientiousness (IPIP total score)	.20*	.10*

Impulsivity (BIS-Brief total score)	-.17*	-.12*

*$p < .05$.

Correlations of maladaptive technology behaviour factors with the cognitive variables, outcome variables, and other variables are in Table 23.

For hypothesis 3b, device-absorption behaviours were not significantly correlated with either cognitive reflection or cognitive ability. Careless device behaviours that can lead to regret were significantly and weakly negatively correlated with cognitive reflection (r = -.15, p< .05), and cognitive ability (r = -.21, p< .05). Problematic school and home behaviours were not significantly correlated with cognitive reflection. However, problematic school and home behaviours were significantly and weakly negatively correlated with cognitive ability (r = -.15, p< .05). Immediate device-gratification behaviours were not significantly correlated with cognitive reflection or cognitive ability.

For hypothesis 4b, higher device-absorption behaviours, careless device behaviours that can lead to regret, problematic school and home behaviours, and immediate device-gratification behaviours were all significantly and positively correlated with antisocial behaviours ranging from small to moderate associations (r range .21 to .51 p< .05).

For hypothesis 5b, device-absorption was not significantly correlated with academic achievement. However, careless device behaviours that can lead to regret, problematic school and home behaviours, and immediate device-gratification behaviours were significantly negatively correlated with academic achievement, and all were small in size (r range -.12 to -.23, p< .05).

Device-absorption behaviours, careless device behaviours that can lead to regret, problematic school and home behaviours, and immediate device-gratification were all significantly correlated with impression management and were small to moderately negative in size (*r* range -.19 to -.34, $p < .05$). Similarly, device-absorption behaviours, careless device behaviours that can lead to regret, problematic school and home behaviours, and immediate device-gratification were all significantly negatively correlated with conscientiousness and were from small to moderate in size (*r* range -.25 to -.41, $p < .05$). Lastly, the four maladaptive technology behaviour factors were all significantly positively correlated with impulsivity and were all moderately positive in size (*r* range .31 to .40, $p < .05$).

Table 23. Correlations between maladaptive technology behaviour factors with cognitive variables, outcome variables, and other variables

	Device-absorption behaviours	Careless device behaviours that can lead to regret	Problematic school and home behaviours	Immediate device-gratification behaviours
Cognitive Variables				
Cognitive reflection (Cognitive Reflection Test total score)	.01	-.15*	.09	-.02
Cognitive ability (ICAR total score)	.03	-.21*	-.15*	-.05
Outcome Variables				
Antisocial behaviours total score	.21*	.51*	.34*	.44*

Academic achievement composite	.01	-.12*	-.23*	-.17*
Other Variables				
Impression management (BIDR-16 total score)	-.34*	-.19*	-.27*	-.27*
Conscientiousness (IPIP total score)	-.31*	-.25*	-.41*	-.35*
Impulsivity (BIS-Brief total score)	.36*	.31*	.40*	.36*

*$p < .05$

Correlations among non-technology variables are in Table 24.

Table 24. Correlations among non-technology variables

	1	**1**	**3**	**4**	**5**	**6**	**7**
1. Cognitive reflection (Cognitive Reflection Test total score)	1						
2. Cognitive ability (ICAR total score)	.62*	1					
3. Antisocial behaviours total score	-.19*	-.29*	1				
4. Academic achievement composite	.31*	.31*	-.19*	1			
5. Impression management (BIDR-16 total score)	-.04	-.04	-.15*	-.01	1		
6. Conscientiousness (IPIP total score)	-.04	-.03	-.26*	.19*	-29*	1	
7. Impulsivity (BIS-Brief total score)	-.04	-.03	.35*	-.21*	-.35*	-.66*	1

*$p < .05$

Hierarchical regression analyses regarding cognitive variables and technology variables (hypothesis 3c)

In order to further investigate hypotheses 3a–b, six separate hierarchical regression analyses were performed to predict the following six technology subscales: 1) privacy and security behaviours, 2) device-limiting behaviours, 3) technology-etiquette attitudes, 4) device-time/access attitudes, 5) careless device behaviours that can lead to regret, and 6) problematic school and home behaviours. For four hierarchical regression analyses predicting technology hygiene behaviour factors and maladaptive technology behaviour factors, cognitive reflection was entered in stage one and cognitive ability was entered in the second stage. Cognitive reflection includes both detection and override and decoupling processing skills and if cognitive reflection was found to be a significant predictor, it would suggest either the detection skills and override and decoupling processing skills would be important for predicting the technology behaviours. However, if only cognitive ability was a significant predictor, it would suggest the override and decoupling processing skills part may be a more important predictor as opposed to the detection part. Thus, this was done purposefully to parse predicting components. Since males and females significantly differed in these two factors, for two hierarchical regression analyses predicting technology-etiquette attitudes as well as device-time/access device, gender was entered in the first stage to understand if it predicted these two adaptive technology attitudes before parsing apart the cognitive variables. Cognitive reflection was entered in stage two, then cognitive ability was entered in the third stage of the model.

For security and privacy behaviours, Model 1 did not significantly predict scores on the security and privacy behaviours (F [1,430] = 1.28, p = .26, R^2 =.003). Model 2 also did not significantly predict security and privacy behaviours (F [2,429] = 2.99, p = .05, R^2 = .014).

However, only cognitive ability added significantly to the prediction. Results are summarized in Table 25.

Table 25. Summary of hierarchical regression analysis for predicting security and privacy behaviours

Predictor	*B*	*SE B*	*β*	*T*	*P*
Model 1					
1. Cognitive reflection (Cognitive Reflection Test total score)	.16	.14	.05	1.13	.26
R^2 = .003					
ΔR^2 = .003					
Model 2					
1. Cognitive reflection (Cognitive Reflection Test total score)	-.08	.18	-.03	-.47	.64
2. Cognitive ability (ICAR total score)	.55	.26	.13	2.17	.03*
R^2 = .014					
ΔR^2 = .011					

*$p < .05$

Regarding device-limiting behaviours, Model 1 did significantly predict scores on the device-limiting behaviours (F [1,430] = 6.62, p = .01, R^2 = .015), and cognitive reflection was a significant predictor. Model 2 significantly predicted device-limiting behaviours (F [2,429] = 4.94, p = .01, R^2 = .022), but neither cognitive reflection nor cognitive ability were significant predictors of device-limiting behaviours. Results are summarized in Table 26.

Table 26. Summary of hierarchical regression analysis for device-limiting behaviours

Predictor	*B*	*SE B*	*B*	*T*	*P*
Model 1					
1. Cognitive reflection (Cognitive Reflection Test total score)	-.18	.07	-.12	2.57	.01*

R^2 = .015 ΔR^2 = .015					
Model 2					
1. Cognitive reflection (Cognitive Reflection Test total score)	-.08	.09	-.06	-.89	.37
2. Cognitive ability (ICAR total score)	-.23	.13	-.11	-1.79	.07
R^2 = .022 ΔR^2 = .007					

*$p < .05$

For technology-etiquette attitudes, Model 1 significantly predicted scores on the technology-etiquette attitudes (F [1,416] = 7.86, p<.01, R^2 = .02). In this model, gender was a significant predictor. Model 2 significantly predicted technology-etiquette attitudes (F [2,415] = 19.83, p<.001, R^2 = .09). Gender and cognitive reflection were significant and positive predictors of technology-etiquette attitudes. Model 3 also significantly predicted technology-etiquette attitudes (F [3,414] = 18.07, p<.001, R^2 = .12); gender, cognitive reflection, and cognitive ability all added significantly to the prediction. Results are summarized in Table 27.

Table 27. Summary of hierarchical regression analysis for technology-etiquette attitudes

Predictor	*B*	*SE B*	*B*	*T*	*P*
Model 1					
1. Gender	1.86	.66	.14	2.80	<.01*
R^2 = .02 ΔR^2 = .02					
Model 2					
1. Gender	2.10	.64	.15	3.26	<.01*
2. Cognitive reflection (Cognitive Reflection Test total score)	.55	.10	.26	5.59	<.001*
R^2 = .09					

$\Delta R^2 = .07$

Model 3					
1. Gender	1.82	.64	.13	2.85	.01*
2. Cognitive reflection (Cognitive Reflection Test total score)	.27	.13	.13	2.11	.03*
3. Cognitive Ability (ICAR total score)	.64	.18	.22	3.66	<.001*

$R^2 = .12$
$\Delta R^2 = .03$

* $p < .05$.

For device-time/access attitudes, Model 1 significantly predicted scores on the device-time/access attitudes (F [1,416] = 8.50, $p < .01$, $R^2 = .02$); gender was a significant predictor of device-time/access attitudes. Model 2 significantly predicted device-time/access attitudes (F [2,415] = 6.07, $p < .01$, $R^2 = .03$). Gender was a significant predictor, but cognitive reflection did not add significantly to the prediction. Model 3 also significantly predicted device-time/access attitudes (F [3,414] = 5.20, $p < .01$, $R^2 = .04$), however, in the third model, only gender was a significant predictor. Results are summarized in Table 28.

Table 28. Summary of hierarchical regression analysis for device-time/access attitudes

Predictor	*B*	*SE B*	*B*	*T*	*P*
Model 1					
1. Gender	1.78	.61	.14	2.92	<.01*
$R^2 = .02$					
$\Delta R^2 = .02$					
Model 2					
1. Gender	1.85	.61	.15	3.04	<.01*

2. Cognitive reflection (Cognitive Reflection Test total score)	.18	.09	.09	1.89	.06
R^2 = .03 ΔR^2= .01					
Model 3					
1. Gender	1.72	.61	.14	2.81	<.01*
2. Cognitive reflection (Cognitive Reflection Test total score)	.04	.12	.02	.34	.74
3. Cognitive ability (ICAR total score)	.31	.17	.11	1.86	.07
R^2 = .04 ΔR^2 = .01					

* $p < .05$.

For careless device behaviours that can lead to regret, the first model significantly predicted scores on careless device behaviours that can lead to regret (F [1,430] = 10.45, $p <$ .001, R^2 = .02). In this model, cognitive reflection was a significant predictor of careless device behaviours that can lead to regret. Model 2 significantly predicted careless device behaviours that can lead to regret (F [2,429] = 9.66, p<.001, R^2 = .04). Cognitive reflection was not a significant predictor, but cognitive ability was significant. Results are summarized in Table 29.

Table 29. Summary of hierarchical regression analysis for careless device behaviours that can lead to regret

Predictor	*B*	*SE B*	*B*	*T*	*P*
Model 1					
1. Cognitive reflection (Cognitive Reflection Test total score)	-.36	.11	-.15	-3.23	<.01*
R^2 = .02 ΔR^2 = .02					
Model 2					

1. Cognitive reflection (Cognitive Reflection Test total score)	-.10	.14	-.04	-.70	.48
2. Cognitive ability (ICAR total score)	-.59	.20	-.18	-2.95	<.01*
R^2 = .04					
ΔR^2 = .02					

* $p < .05$.

For problematic school and home behaviours, the first model did not significantly predict scores on the problematic school and home outcomes (F [1,430] = 3.64, p= .06, R^2 = .008), and cognitive reflection was not a significant predictor. Model 2 significantly predicted problematic school and home outcome behaviours (F [2,429] = 4.59, p = .01, R^2 = .021). Cognitive reflection was not a significant predictor, but cognitive ability added significantly to the prediction. Results are summarized in Table 30.

Table 30. Summary of hierarchical regression analysis for problematic school and home behaviours

Predictor	*B*	*SE B*	*β*	*T*	*P*
Model 1					
1. Cognitive reflection (Cognitive Reflection Test total score)	-.19	.10	-.09	-1.91	.06
R^2 = .008					
ΔR^2 = .008					
Model 2					
1. Cognitive reflection (Cognitive Reflection Test total score)	.00	.13	.00	.03	.98
2. Cognitive ability (ICAR total score)	-.43	.18	-.14	-2.35	.02*
R^2 = .021					
ΔR^2 = .013					

*$p < .05$.

Simultaneous regression analysis for real-world outcome variables (hypotheses 4c and 5c)

A simultaneous multiple regression model was estimated to predict the antisocial behaviour composite from gender (because several technology factors had significant gender differences) and the technology subscales that were significantly correlated with antisocial behaviours including: security and privacy behaviours, technology-etiquette attitudes, device-time/access attitudes, device-absorption behaviours, careless device behaviours that can lead to regret, problematic school and home behaviours, and immediate device-gratification behaviours. The model's multiple R^2 was significant (F [8,409] = 34.47, p<.001, adjusted R^2 = .39). The significant predictors of antisocial behaviours included technology-etiquette attitudes, careless device behaviours that can lead to regret, problematic school and home behaviours, and immediate device-gratification behaviours. Results are summarized in Table 31.

Table 31. Summary of simultaneous regression analysis for antisocial behaviours

Predictor	*B*	*SE B*	*B*	*T*	*P*
Model					
1. Gender	.40	.71	.22	.56	.57
2. Security and privacy behaviours	-.05	.04	-.05	-1.25	.21
3. Technology-etiquette attitudes	-.44	.07	-.33	-6.48	<.001*
4. Device-time/access attitudes	-.01	.06	-.01	-.14	.89
5. Device-absorption behaviours	-.03	.06	-.03	-.60	.55
6. Careless device behaviours that can lead to regret	28	.06	.24	4.40	<.001*
7. Problematic school and home behaviours	.15	.07	.11	2.29	.02*
8. Immediate device-gratification behaviours	.18	.07	.15	2.79	.01*

R^2 = .40
Adjusted R^2 = .39

* p < .05.

A simultaneous multiple regression model was estimated to predict the academic achievement composite from gender and the technology subscales that significantly correlated with academic achievement, including security and privacy behaviours, technology-etiquette attitudes, device-time/access attitudes, careless device behaviours that can lead to regret, problematic school and home behaviours, and immediate device-gratification behaviours. The model's multiple R^2 was significant (F [7,410] = 11.50, p<.001, adjusted R^2 = .15). The significant predictors of academic achievement included gender, technology-etiquette attitudes, device-time/access attitudes, and problematic school and home behaviours. Results are summarized in Table 32.

Table 32. Summary of simultaneous regression analysis for academic achievement

Predictor	*B*	*SE B*	*B*	*T*	*P*
Model					
1. Gender	3.91	1.08	.17	3.63	<.001*
2. Security and privacy behaviours	.04	.06	.03	.62	.53
3. Technology-etiquette attitudes	.25	.10	.15	2.51	.01*
4. Device-time/access attitudes	.29	.10	.16	2.98	<.01*
5. Careless device behaviours that can lead to regret	.17	.10	.11	1.76	.08
6. Problematic school and home behaviours	-.41	.09	-.24	-4.45	<.001*
7. Immediate device-gratification behaviours	-.05	.10	-.03	-.53	.59
R^2 = .16					
Adjusted R^2 = .15					

* p < .05.

Study 2 Discussion

Study 2 involved developing the different domains of technology hygiene behaviours, maladaptive technology behaviours, and adaptive technology attitudes in an online sample of adolescents. Exploratory factor analyses were conducted for the technology hygiene behaviours, maladaptive technology behaviours, and adaptive technology attitudes, and the resulting subscales had improved reliability compared to Study 1. The associations between technology subscales with cognitive reflection, cognitive ability, antisocial behaviours, and academic achievement were then examined. The main findings are presented in Table 33.

For hypotheses 1a–b, there were no significant gender differences on technology hygiene behaviour subscales, security and privacy behaviours and device-limiting behaviours. For the adaptive technology attitude subscales, significant gender differences were found for both technology-etiquette attitudes and device-time/access attitudes, which were significantly higher in females than males. This gender difference on technology-etiquette attitudes and device-time/access attitudes, may relate to the broader literature of how females have been found to engage in more time on smartphones, social media, texting, the Internet, and computers than males (Twenge & Martin, 2020).

Three of the maladaptive technology behaviour subscales were not significantly correlated with gender. However, males had significantly higher immediate device-gratification than females. Overall, these were somewhat surprising results, given that the literature has found significant gender differences in technology use (Cocoradă et al., 2018; Twenge & Martin, 2020; Twenge & Farley, 2021; Vujic, 2017). Yet, the finding that males had significantly higher immediate device-gratification than females may be related to the literature on gaming behaviours, which has found that males spend more time gaming than females (Rideout et al.,

2021; Twenge & Martin, 2020). Many video games are attractive because they provide immediate gratification when playing them.

For hypothesis 2a, the two technology hygiene behaviour factors were significantly and weakly correlated with each other, the four maladaptive technology behaviours factors were significantly and moderately to strongly correlated with each other, and the two adaptive technology attitudes were significantly and moderately correlated with each other. Thus, the findings were as predicted.

For hypothesis 2b, some technology hygiene behaviour subscales were significantly correlated with adaptive technology attitudes (security and privacy behaviours were positively and moderately correlated with technology-etiquette attitudes and were weakly positively correlated with device-time/access attitudes). Both technology hygiene behaviour subscales were negatively correlated with some maladaptive behaviours (security and privacy behaviours were correlated significantly and negatively with three maladaptive technology factors either small to moderate in size, and device-limiting behaviours were correlated significantly and weakly negatively with two maladaptive technology factors). Technology-etiquette attitudes were negatively correlated with three maladaptive technology factors and ranged from small to moderate in size. While device-time/access attitudes were not correlated with three maladaptive technology factors and significantly and weakly positively correlated with one maladaptive technology factor. Therefore, hypothesis 2b was only partially supported and suggests that a youth who has certain adaptive behaviours or attitudes might still not engage in certain maladaptive technology behaviours but may be at risk for engaging in other maladaptive technology behaviours, and highlights that these behaviours and attitudes depend on the specific subscales.

For hypothesis 3a, security and privacy behaviours were significantly and weakly positively correlated with cognitive ability but not cognitive reflection. Unexpectedly, device-limiting behaviours were significantly and weakly negatively correlated with cognitive reflection and cognitive ability. It was found that technology-etiquette attitudes had a significant and small positive correlation with cognitive reflection and moderate positive correlation with cognitive ability. Device-time/access attitudes were not significantly correlated with cognitive reflection but were weakly and positively correlated with cognitive ability. Therefore, hypothesis 3a was partially supported.

For hypothesis 3b, only one of the maladaptive technology subscales, careless device behaviours that can lead to regret, was significantly and weakly correlated with cognitive reflection. Additionally, only two of the factors, careless device behaviours that can lead to regret and problematic school and home behaviours, were significantly and weakly correlated with cognitive ability. Thus, hypothesis 3b was only partially supported. The findings were partially in line with other research findings and show that some measures of technology use are correlated negatively with cognitive ability or negatively with cognitive reflection (Barr et al., 2015; Cain et al., 2016; Devine et al., 2022; Frein et al., 2013; Minear et al., 2013; Takeuchi et al., 2018; Vujic, 2017).

For hypothesis 3c, cognitive ability was the only significant predictor of security and privacy behaviours, however, the regression model was not significant. While cognitive reflection, cognitive ability, and gender were all significant predictors of technology-etiquette attitudes. Cognitive ability was a significant predictor of both careless device behaviours that can lead to regret and problematic school and home behaviours. Therefore, this hypothesis was only partially supported and suggests that cognitive reflection and cognitive ability may be

importantly related to some but not most technology subscales. This also may suggest that both the detection and override and decoupling processing skills are important for technology-etiquette attitudes, while override and decoupling processing skills are important for careless device behaviours that can lead to regret, and problematic school and home behaviours.

For hypothesis 4a, only the security and privacy behaviours subscale was significantly and moderately negatively correlated with antisocial behaviours, but the device-limiting behaviours subscale was not. Both technology-etiquette attitudes and device-time/access attitudes were significantly and negatively correlated with antisocial behaviours and ranged from small to moderate in size. Thus, the hypothesis was only partially supported.

For hypothesis 4b, all four maladaptive technology behaviour subscales were positively correlated with antisocial behaviours and ranged from small to large in size. This result was consistent with literature that found social media is negatively associated with antisocial behaviours and risky behaviours (Galica et al., 2017; Rosen, Whaling, Carrier, et al., 2013; Vannucci et al., 2020). Therefore, the hypothesis was supported.

For hypothesis 4c, technology-etiquette attitudes and careless device behaviours that can lead to regret, problematic school and home behaviours, and immediate device-gratification behaviours were all significant predictors of antisocial behaviours. Therefore, some, but not all of the significant technology subscales did predict antisocial behaviours, which partially supported this hypothesis.

For hypothesis 5a, security and privacy behaviours were significantly correlated with academic achievement and were small in size, but device-limiting behaviours were not. Yet both technology etiquette-attitudes and device-time/access attitudes were significantly correlated with

academic achievement and were small in size. This was a hypothesis that was partially supported.

For hypothesis 5b, three of the four maladaptive technology behaviour subscales (careless device behaviours that can lead to regret, problematic school and home behaviours, and immediate device-gratification behaviours) were significantly correlated with academic achievement and were small in size. Much of the literature on this association has shown similar findings of the negative relationship between electronic device use and worse academic achievement (Domoff et al., 2020; Kates et al., 2018; Kim et al., 2017; Kirschner & Karpinski, 2010). This was a hypothesis that was mostly supported.

For hypothesis 5c, problematic school and home behaviours, technology etiquette-attitudes, device-time/access attitudes, and gender were significant predictors of academic achievement. Therefore, this hypothesis was partially supported. It also suggests the importance of not only certain technology behaviours as important for academic achievement, but adaptive technology attitudes may also have an impact.

Table 33. Study 2 summary of main findings

	Results
Correlations between technology-related behaviours, including age and gender:	1a. No significant differences were found between males and females on security and privacy behaviours or device-limiting behaviours. But technology-etiquette attitudes and device-time/access attitudes were significantly higher in females compared to males. Hypothesis 1a only partially supported. 1b. No significant differences found for device-absorption behaviours, careless device behaviours that can lead to regret or problematic school and home behaviours. However, males had significantly higher immediate device-gratification behaviours than females. Hypothesis 1b was only partially supported.
Correlations between technology-related behaviours, including	2a. Both technology hygiene behaviour factors correlated significantly and positively with each other. Similarly, both adaptive technology attitude factors correlated significantly and positively

cognitive reflection and cognitive abilities:	with each other. All four maladaptive technology behaviour factors significantly and positively correlated with each other. Hypothesis 2a was supported. 2b. Only one of the technology hygiene behaviour factors was significantly and positively correlated with both adaptive technology attitude factors (security and privacy behaviours with technology-etiquette attitudes and device-time/access attitudes). The technology hygiene behaviour factors correlated significantly and negatively with only some maladaptive behaviour factors (security and privacy behaviours were correlated significantly and negatively with three maladaptive technology factors, while device-limiting behaviours were correlated significantly and negatively with two maladaptive technology factors). Only one of the adaptive technology attitudes was correlated significantly and negatively with some maladaptive behaviours (technology-etiquette attitudes were correlated significantly and negatively with three maladaptive technology factors, while device-time/access attitudes were not). Hypothesis 2b was only partially supported. 3a. Cognitive reflection was not correlated significantly and positively with either technology hygiene behaviour factors, and only correlated significantly and positively with one of the adaptive technology attitude factors (technology-etiquette attitudes). Cognitive ability correlated significantly and positively with one technology hygiene behaviour factor (security and privacy behaviours), and both adaptive technology attitude factors (technology-etiquette attitudes, device-time/access attitudes). Hypothesis 3a was only partially supported. 3b. Only one maladaptive technology behaviour factor (careless device behaviours that can lead to regret) was significantly and negatively correlated with cognitive reflection. While two maladaptive technology behaviour factors (careless device behaviours that can lead to regret, and problematic school and home behaviours) were correlated significantly and negatively with cognitive ability. Hypothesis 3b was only partially supported. 3c. In a regression predicting technology-etiquette attitudes, it was found that gender, cognitive reflection, and cognitive ability, were significant predictors. In the regressions predicting careless device behaviours that can lead to regret, and problematic school and home behaviours, only cognitive ability was a significant predictor. Hypothesis 3c was only partially supported.

Correlations between technology-related behaviours and real-world outcomes, including antisocial behaviours and academic achievement:	4a. One technology hygiene behaviour factor (security and privacy) and both adaptive attitude factors (technology-etiquette attitudes, device-time/access attitudes) were significantly and negatively correlated with antisocial behaviours. Hypothesis 4a was mostly supported. 4b. All four maladaptive technology behaviour factors were significantly and positively correlated with antisocial behaviours. Hypothesis 4b was supported. 4c. In a regression predicting antisocial behaviours, it was found that technology-etiquette attitudes, careless device behaviours, problematic school and home behaviours, and immediate device-gratification behaviours were significant predictors. Hypothesis 4c was only partially supported. 5a. One of the technology hygiene behaviour factors (privacy and security behaviours) and both adaptive technology attitude factors (technology-etiquette attitudes, device-time/access attitudes) were significantly and positively correlated with academic achievement. Hypothesis 5a was mostly supported. 5b. Three of the maladaptive technology behaviour factors (careless device behaviours, problematic school and home behaviours, and immediate device-gratification behaviours) were significantly and negatively correlated with academic achievement. Hypothesis 5b was mostly supported. 5c. In a regression predicting academic achievement, it was found that technology-etiquette attitudes, device-time/access attitudes, and problematic school and home behaviours, along with gender were significant predictors. Hypothesis 5c was only partially supported.

General Discussion

The purpose of these two studies was to examine technology behaviours that are either adaptive or maladaptive, as well as attitudes that are adaptive, through the lens of judgment and decision-making and cognitive reflection. This research project sought to quantify important aspects of technology use among adolescents and captured a wide range of technology

behaviours that are usually not captured in other research studies with focuses such as addiction or general electronic device use (Devine et al., 2022; Twenge et al., 2021).

Expanded number of items and reliability from Study 1 to Study 2. Study 1 used existing items from Toplak (2021) as well as Toplak et al. (2017) relating to technology hygiene behaviours and maladaptive technology behaviours and piloted them in an adolescent sample. One novel aspect of Study 1 involved the types of items used, specifically items that reflected behaviours that maintain positive and productive technology behaviours. It also involved investigating whether these positive technology behaviours correlated with other negative technology behaviours. Next, Study 2 expanded the measurement of technology behaviours. Study 2 was one of the first studies to generate items that related to adaptive technology attitudes. As well, Study 2 used exploratory factor analyses to determine how the inter-item correlations could be represented by a small number of factors representing technology use constructs. One result of Study 2 was to expand the number of items in the technology measures and to include a Likert-type response scale instead of dichotomous responses; the reliability of the resulting technology composite scores was higher in Study 2 (Omega = .71 to .81) compared to Study 1 (Omega = .55 to .74). Study 2 revealed a variety of factors reflecting the content of the items.

In the end, two factors of technology hygiene behaviours were uncovered that captured two important domains: behaviours relating to privacy and security and behaviours relating to limiting electronic device use. Two factors were also uncovered for technology attitudes, one relating to general common sense or "etiquette" regarding technology use and more specific attitudes towards device time and access. Four factors were uncovered for maladaptive technology use: device-absorption, careless device behaviours that can lead to regret,

problematic school and home behaviours, and immediate device-gratification behaviours. So far, a limited number of technology domains have been identified in adolescent literature, but there are many other measures of addiction and parental attitudes toward technology, as well as general technology use (Domoff et al., 2019; Twenge et al., 2018; Wartberg et al., 2016; Yang et al., 2013).

It is clear that researchers emphasize the importance of adaptive technology skills (Huda et al., 2017), but it is very difficult to find studies regarding adaptive technology behaviours or attitudes among adolescents. Similarly, adaptive behaviours and attitudes are not well studied and therefore may also be deemed less important than negative uses. Yet these adaptive behaviours and attitudes may be clinically relevant if they allow adolescents to avoid some negative technology behaviours. Therefore, these new measures may allow other researchers to investigate specific behaviours and attitudes and allow for further discoveries.

Relations between technology measures. Study 1 found that technology hygiene behaviours were not significantly correlated with maladaptive technology behaviours, while in Study 2, results varied depending on subscales, which seemed to measure different subsets of behaviours than the composites used in Study 1. For example, in Study 2, technology hygiene behaviour subscales of security and privacy behaviours, and device-limiting behaviours were significantly correlated, however, the correlation was small between these two subscales. However, other technology subscales in Study 2 were not significantly correlated. These results show that adolescents engage in a large array of different behaviours and attitudes, and some are not correlated in ways that were predicted. Overall, these findings contribute to a better understanding of technology use because they highlight the complexities of technology behaviours and attitudes, and while use is pervasive, the behaviours can vary a lot.

In this research study, these technology-etiquette attitudes also generally correlated overall with actual technology behaviours in ways that were expected for one of the technology hygiene measures and three of the maladaptive technology measures, suggesting a relationship between what one thinks and does.

Further research is needed to better assess adolescents' subjective reports of their technology behaviour because they may be better at stating their attitudes than accurately remembering the frequency of their actual behaviours. For example, adolescents might assess, "It is important to take breaks from my electronic devices" without accurately recalling the exact number of times they did take breaks. Similarly, adolescents may understand, "Posting things on the Internet can have negative consequences" and follow that dictum in general but not remember the exact number of times they refrained from posting something. Another reason to examine adolescents' attitudes is that in some surveys, adolescents have expressed a wide variety of opinions about whether they find technology positive or negative (Anderson & Jian, 2018; Headspace National Youth and Mental Health Foundation, 2018).

Gender differences in Study 2 but not Study 1. Gender differences were another essential purpose of this research project and have been found in the literature (Cocoradă et al., 2018; Twenge & Farley, 2021; Twenge & Martin, 2020; Vujic, 2017). While there were no significant gender differences for technology behaviours in Study 1, Study 2 found significant gender differences for the maladaptive technology behaviour subscale of immediate device-gratification, with males performing worse than females.[1] This result relates to other meta-

[1] A partial correlation was run to examine the relationship between gender and immediate device-gratification behaviours while controlling for impulsivity. A significant small negative correlation was found between gender and immediate device-gratification in the direction of males engaging in more immediate device-gratification behaviours.

analytic research in judgment and decision-making literature, which found that females are better able to delay gratification in non-technology measures (Silverman, 2003).

Another novel and important contribution of Study 2 was the discovery that female adolescents scored higher on technology attitudes with respect to technology-etiquette attitudes and device-time/access compared to male adolescents. This result suggests that males and females view technology differently. This was an intriguing finding since this study found no significant gender differences in most technology behaviours other than males performing worse on immediate device-gratification behaviours, which is not consistent with the literature, as other studies have found gender differences in technology behaviours (Twenge & Farley, 2021; Twenge & Martin, 2020). Other outside factors may also influence whether there are gender differences in technology behaviours. For example, females engage in different types of social interactions compared to males which may explain mental health differences in technology use (Twenge, 2020) and which may lead to more use by females in some areas. However, given this research project findings on gender differences in attitudes, even if male adolescents and female adolescents engage in the same frequency of certain behaviours, the females may still interpret their behaviours differently than males.

Associations between technology measures and cognitive reflection. Study 1 findings indicated no significant correlations between technology hygiene behaviours and cognitive reflection or between maladaptive technology behaviours and cognitive reflection. With newly generated subscales in Study 2, cognitive reflection only significantly predicted technology-etiquette attitudes. Previous studies on cognitive reflection have found some significant results across young adult or adult samples but at times depended on the technology measure (Barr et

al., 2015; Devine et al., 2022; Vujic, 2017), which suggests a difference between adolescents in this study and adults in the past in how both engage with their devices.

As mentioned earlier, it was thought that the easy access to electronic devices and distracting designs of technology in the environment provide cues which discourage adolescents with lower cognitive reflection from using their detection and override and decoupling processing skills when engaging in certain technology hygiene behaviours or maladaptive technology behaviours. Yet the research did not find significant relationships between technology behaviours and cognitive reflection, which was hypothesized to show detection skills. It could also be that because adolescents have grown up with technology nearly all their lives, most adolescents' detection and override and decoupling processing skills are not being used when they engage in technology devices.

Conceptually, the relationship between cognitive reflection and technology-etiquette attitudes may signal an important association that has not been studied before. Technology-etiquette attitudes may tap into some aspects of cognitive reflection and may tap into detection and override and decoupling processing skills. Therefore, these attitudes may require some reflection about decisions people make on their electronic devices. For example, "It is important to have stricter than the default security settings on my electronic devices to help protect my personal information" may require a person to reflect on their decision-making and privacy habits and not just assume that default settings are adequate because sticking with default settings may allow for more preservation of cognitive resources and are simply easier.

These adaptive technology attitudes also may be relevant to the broader literature studies on higher cognitive reflection and adults' use of the Internet to search and select for certain websites and content. As mentioned earlier, research has found that adult participants who had

higher scores on cognitive reflection were pickier in the social media and trusted different news accounts compared to those with lower cognitive reflection (Mosleh et al., 2021). Additionally, another study found that adult participants with higher cognitive reflection scores fall for fake news less compared to those with lower cognitive reflection (Pennycook & Rand, 2020). Similarly, in this research project, for adolescents, cognitive reflection may affect what attitudes adolescents select towards technology and therefore influence their technology behaviours.

Associations between technology measures and cognitive ability. Study 1 findings indicated no significant correlations between technology hygiene behaviours and cognitive ability, or between maladaptive technology behaviours and cognitive ability. For Study 2, cognitive ability significantly predicted careless device behaviours that can lead to regret, problematic school and home behaviours, and technology-etiquette attitudes. These findings lend some support to the idea that cognitive ability influences how youth use technology. It is worth asking why only some maladaptive technology behaviours are associated with some skills important to miserly processing but not others including the technology hygiene behaviours. It is also interesting to question why some technology behaviours that are associated with override and decoupling processing skills were not associated with detection skills. This research may suggest some qualitative differences in certain types of technology behaviours that may use override and decoupling processing skills and the behaviours that do not.

Cognitive ability is important to examine in relation to technology use because cognitive ability is predictive of both academic and occupational success later in life, as well as longer life span (Calvin et al., 2017; Čukić et al., 2017; Deary et al., 2007; Gottfredson, 1997, 2002). It may also suggest that those with higher cognitive ability are less at risk of being careless with their devices; will not let technology get in the way of schoolwork; and have more adaptive attitudes

towards the protocols of technology use. These findings might be important for both the adolescent as well as the parent, especially if a parent allows more independence for the adolescent.

Technology and real-world outcomes. Throughout both studies, there was some support for the hypothesis that technology behaviours and attitudes were associated with real-world outcomes of antisocial behaviours and academic achievement. In Study 2, technology-etiquette attitudes and device-time/access attitudes significantly predicted academic achievement. This finding regarding attitudes makes sense given that having higher technology-etiquette attitudes would likely involve attitudes about taking fewer risks, and therefore likely would not be associated with antisocial behaviours. The findings regarding academic achievement also make sense as technology-etiquette attitudes and device-time/access attitudes may also overlap with attitudes that are important for successful studying such as, "I do better in classes where electronic devices are not allowed," which was an item captured in the device-time/access attitudes. The finding regarding academics and attitudes is consistent with a study that found that the use of the Internet for studying is associated positively with academic achievement (Kim et al., 2017).

Study 1 and Study 2 consistently found significant relationships that ranged from small to large in size, between maladaptive technology behaviours and real-world outcomes of antisocial behaviours and academic achievement. Study 2 found that three maladaptive technology behaviour scales were significant unique predictors of antisocial behaviours: careless device behaviours that can lead to regret, problematic school and home behaviours, and immediate device-gratification behaviours. The finding of antisocial behaviours and maladaptive technology use is consistent with the literature on social media and antisocial behaviours and risk-taking

behaviours (Galica et al., 2017; Rosen, Whaling, Carrier, et al., 2013; Vannucci et al., 2020). Furthermore, this finding is plausible as electronic device use easily allows for careless behaviours, interference with school, as well as immediate gratification, all of which could make an adolescent more susceptible to antisocial behaviours. In fact, many antisocial behaviours are found online, including cyberbullying, stealing, and lying. Other antisocial behaviours, for example, staying out late, might involve adolescents overusing their devices at the same time. If adolescents go online on these electronic devices they then can find positive and deceitful depictions of illegal substances as well opportunities for other risky activities like gambling (Albarracin et al., 2018; Elton-Marshall et al., 2016; Romer & Moreno, 2017).

For Study 2, only the maladaptive technology behaviour factor of problematic school and home behaviours significantly predicted academic achievement. Although not all maladaptive technology scales significantly predicted academic achievement, one scale that did significantly predict academic achievement was problematic school and home behaviours, which involved items that asked participants about interference with school, failing grades, lower grades due to device use, cheating, arguing with parents, and failing to do chores. The findings between maladaptive technology behaviours and academic achievement are consistent with the larger literature of technology use in general being negatively associated with grades (Domoff et al., 2020; Kates et al., 2018; Kim et al., 2017).

Taken together, the associations between technology measures and antisocial behaviours are important as they can impact an adolescent's life detrimentally. For example, adolescents with antisocial behaviours can have other poor life outcomes in adulthood such as being less likely to graduate high school, more likely to commit crimes, use substances, be unemployed, and have health and relationship issues (Cook et al., 2016; Wertz et al., 2018). In addition,

antisocial behaviours have been found to negatively correlate with measures of decision-making (Parker & Fischhoff, 2005).

Most people recognize the importance of academics for adolescents because academic achievement predicts future success for postsecondary education and adult income (French et al., 2015; Geiser & Santelices, 2007; Hodara & Lewis, 2017). In addition, academic achievement and academic skills have been found to be associated with better decision-making (Gómez-Veiga et al., 2018; Morsanyi et al., 2018; Weller et al., 2012).

Taken together, these results indicate that how adolescents use technology and their views towards technology may have real-life consequences in terms of antisocial behaviours and academic achievement.

Other unexpected or important findings. In addition, it is worth considering an unexpected but significant finding of this research project: the positive and weak correlation between device-limiting behaviours (a technology hygiene behaviour scale) and careless device behaviours that can lead to regret (a maladaptive technology behaviour scale). This result suggests that device-limiting behaviours may not prevent careless device behaviours that can lead to regret from happening.

Similarly, there was a significant positive correlation between device-time/access attitudes (an adaptive technology attitude scale) and device-absorption behaviours (a maladaptive technology behaviour scale). This result may be related to the fact that some adolescents have higher adaptive device-time/access attitudes after they have experienced some device-absorption behaviours. This association is analogous to how many people tend not to diet, or limit calories, or avoid certain foods, unless they have gained weight. Future research could attempt to explore the relationship between device-time/access attitudes and device-absorption behaviours,

especially how they affect each other. Attempting to limit devices with certain behaviours might be a sign of overuse with device-absorption and therefore relevant clinically. Similarly, these associations may be related to type of use; for example, this relationship may differ depending on whether one uses a device for school or for leisure-related use; however, this difference was not tested in this research project.

It was also surprising that device-limiting behaviours had small negative correlations with cognitive ability and cognitive reflection, as these were expected to be positive and larger. This finding suggests that those adolescents with high cognitive reflection or cognitive ability may not yet feel the need to use device-limiting strategies. It is also not clear how much adolescents need these strategies or that they would want to use these strategies. Another possibility is that technology settings may change too quickly even for some of the items that ask about device-limiting behaviours or strategies to remain relevant. For example, teens may not need to shut off their phones because in the future devices might automatically shut off at a certain time or allow parents to shut them off.

In Study 2, technology behaviour and attitude scales were significantly correlated with personality variables including conscientiousness and impulsivity and ranged from small to moderate in size. It is logical for conscientiousness to be positively correlated with technology hygiene behaviour factors and adaptive technology attitudes because hard work and persistence may be required to regularly engage in these types of behaviours and attitudes. Whereas it is also probable that conscientiousness would be negatively correlated with maladaptive technology behaviour factors since hard work and persistence are not required to engage in these types of behaviours. It is also understandable that impulsivity would be negatively correlated with both technology hygiene and adaptive technology attitudes, as these behaviours and attitudes require

an ability to inhibit impulsive thought and action. It is not surprising that the more impulsive adolescents tended to engage in more maladaptive behaviours. Impulsivity may be a cause of these behaviours, as in the larger literature on ADHD, in which studies have found positive associations between ADHD symptoms and Internet addiction (Weinstein et al., 2015; Yen et al., 2007).

Most technology factors were also significantly and weakly or moderately associated with impression management. This result suggests that adolescents tend to overreport their technology hygiene behaviours to look good and underreport their maladaptive technology behaviours to look less bad. Whereas device-time/access attitudes were correlated negatively with impression management, technology-etiquette attitudes were not significantly correlated with impression management. These findings suggest that teens may not try to manage others' impressions when they gave answers regarding technology-etiquette attitudes as much as when they gave answers regarding their behaviours or attitudes about time and access to devices.

Limitations

While this research project has significant strengths and findings, it is also necessary to consider its limitations and future research directions.

Online sample. Study 2 was conducted in an online sample rather than in an experimental lab setting where variables can be more controlled. However, online research can produce comparable results to in-person research and many more studies are being conducted online than in the past due to the availability of large samples and efficiency (Arechar et al., 2018; Behrend et al., 2011; Boas et al., 2020; Logie & Maylor, 2009; Ramsey et al., 2016). In addition, adolescents currently are likely to complete much of their academic work online

compared to past generations. Yet participants in an in-person lab study can ask an assistant for help compared to online, where there might be no help. Similarly, when participants are not being monitored, they may feel less motivated to try hard on performance-based measures such as the Cognitive Reflection Test and ICAR.

Subjective measures of technology behaviours. As in Study 1, Study 2 used self-reporting measures to evaluate technology behaviours. Some researchers suggest that subjective reporting may not be as accurate as more objective measures of technology use, such as device-tracking programs to measure how much time a person spends online or the type of content they engage with. Researchers have found that participants' subjective estimates of technology use often substantially under or overreport technology use compared to the actual objective logs of technology use (Araujo et al., 2017; Ellis et al., 2019; Junco, 2013; Parry et al., 2021; Scharkow, 2016). Therefore, future research should consider using stronger measures of technology use such as recording time on social media platforms, randomly asking participants if they are using technology at times throughout the day and keeping a daily log of use. For example, Bickham et al. (2015) offered adolescents time-use diaries, gave each of them a device with signals to respond to, and asked about momentary behaviours, thoughts, and feelings.

Shared variance between variables. Another limitation of both studies involved the large correlations between cognitive reflection and cognitive ability, which are both performance-based measures. These correlations may explain how some of the technology behaviours and attitudes significantly correlated with cognitive reflection. However, cognitive reflection was often no longer significant when cognitive ability was in the same regression model. Yet, despite the high correlations in this research project, other studies have found smaller correlations between cognitive reflection and cognitive ability measures (Devine et al.,

2022; Vujic, 2017) which may suggest less shared variance between cognitive reflection and cognitive ability. In addition, other studies assessed cognitive ability in different ways, such as attention (Vujic, 2017), numeracy and vocabulary problems (Barr et al., 2015), or mental rotation (Devine et al., 2022) compared to this current research project, which may also possibly explain these findings.

Maladaptive technology behaviours relating to school and academic outcomes.

Another limitation of both studies was that some items in Study 1 (2 items), and one factor in Study 2 (4 out of the 6 items in the subscale), asked about schoolwork. This may have confounded the findings slightly since one of the outcome variables was about academic achievement, which also suggests an overlap of variance. In Study 1, only two items related to school behaviours. However, for Study 2 the correlation was only small between school and problematic behaviours and academic achievement, while problematic home and school behaviours was the only maladaptive technology behaviour subscale that was a predictor of academic achievement. Nevertheless, it still was important to assess the strength of relationship between specific maladaptive technology behaviours relating to school and overall academic achievement. For example, in the more general technology use literature, some meta-analytic research has found only a small negative effect between more frequent mobile phone use and how well students did academically (Kates et al., 2018). It is also possible that struggles in school are not always related to technology use. For instance, some adolescents do not do well in school because of learning disabilities or may not be motivated to do well. Future research may therefore not use academic outcomes as a dependent variable if using technology behaviours that are related to school as an independent variable.

Implications for Future Directions

This research project has further implications for future studies and can be relevant for clinicians, as well as teachers and parents.

First, the findings can assist in the development of more complex measures of technology use for adolescents. Through its items, this research led to different ways of assessing technology use and attitudes that may have been missed in previous research. It may be valuable for future researchers to continue to develop and expand the number of different technology hygiene behaviours, maladaptive technology behaviours, and adaptive technology attitudes along with some objective measures of technology use.

Specifically, there is much more research on the negative uses of technology than positive uses, such that it can be easy to forget that there are also positive technology uses. Understanding the positive technology behaviours may also help parents and educators generate better strategies and tactics for handling and preventing negative uses while allowing for less conflict and more cohesion. Research shows current parent mediation strategies tend to have only small effect sizes regarding positive outcomes (Collier et al., 2016).

Second, future research may also want to use certain technology behaviours as independent variables to see the effects on other technology behaviours as dependent variables. This would allow researchers to see which behaviours are perhaps more important to focus on. For example, it might be useful to see whether multi-tasking predicts getting into arguments online. Or how losing sleep due to technology devices, predicts a person's ability to back up documents, or have complex passwords. This could also help unpack the most important technology behaviours, both positive and negative, and determine whether there is shared variance between variables. Another way may be to focus on technology behaviours as

independent variables, and see how they affect other maladaptive technology behaviours as dependent variables to see if these positive behaviours can be more preventive.

Third, there are important clinical and research implications that both cognitive reflection and cognitive ability can predict some attitudes and behaviours that adolescents have towards technology. Cognitive ability and cognitive reflection may offer a method of screening youths in ways that do not necessarily just relate to pathology or addiction, but ways that may be protective. For example, perhaps higher cognitive reflection or cognitive ability may offer some protection against device misuse, or present as a skill essential for treatment from technology. As Turel (2021) noted, people lose a sense of agency when using social media. Turel (2021) examined whether personal agency would change following abstinence from social media, finding that participants had increased agency relating to social media only if they had high cognitive reflection when engaging in abstinence.

Thus, researchers are only beginning to study cognitive reflection and how it relates to treatment for device overuse. Therefore, other important cognitive variables should also be examined with technology use and attitudes, such as rational mindsets, active open-mindedness, tolerance for uncertainty, and even boredom. Similarly other personality traits (such as openness and neuroticism) should be examined with technology variables. Other decision-making paradigms relating to temporal discounting, belief bias in syllogistic reasoning, or probabilistic and statistical reasoning measures could be used, as in the Toplak et al. (2017) study with adults. Research in children and adults has indicated relationships between decision-making paradigms and better real-life outcomes (Bruine de Bruin et al., 2007; Parker & Fischhoff, 2005).

Fourth, it would be beneficial to expand the number of attitudes measured because there is little research on adaptive technology attitudes. There is a limited number of measures of

technology attitudes, for instance, the Problematic Media Use Measure (PMUM), but it is used by parents for assessing negative outcomes (Domoff et al., 2019). Rosen, Whaling, Rab, et al. (2013) examined attitudes of adults with the Media and Technology Usage and Attitudes Scale (MTUAS), dividing them into positive attitudes about technology, negative attitudes about technology, multi-tasking attitudes, and anxiety and dependence attitudes. Future research could compare the psychometric properties of the technology behaviours and adaptive technology attitudes measures in the current project to the scales used by Rosen, Whaling, Rab, et al. (2013).

Based on the findings of this research, future researchers could explore where adolescents get their technology attitudes; whether from their parents, friends, or from their own experience, and if an attitude actually influences a specific behaviour. For example, if an adolescent agreed with the statement, "It is important to take breaks from my electronic devices," it might be valuable to discover whether this response was a result of their own experience, the advice of friends or parents, or something they learned online, and if this attitude would consequently affect their behaviour of taking breaks differently. As well, it might be important clinically and educationally to study gender differences in the sources of adolescents' attitudes; for example, are female attitudes more influenced by their friends compared to males?

It is also essential for teachers and parents to strive to understand the attitudes adolescents have towards technology; some may be realistic and practical and others not. By asking adolescents their viewpoints, teachers and parents may be able to understand their behaviours, in particular, why adolescents behave the way they do and how mature they are with devices. Similarly, understanding adolescent attitudes may lead to a more nuanced approach in terms of assessing whether adolescents are ready or willing to change their technology use. Clinically, more mature attitudes could indicate who gets specific treatment for Internet or gaming addiction

and how successful they are likely to be in treatment, similar to how clinicians evaluate a client's stage of change (Prochaska et al., 2013), i.e., if an adolescent is in the contemplation or action phase for therapy.

Finally, this research project showed some of the implications that a variety of specific technology behaviours and attitudes have on real-life outcomes and correlates. For teachers and parents, it is important they realize that adolescents engage daily in technology hygiene behaviours and maladaptive technology behaviours that can affect many aspects of their lives that don't involve a screen. However, these technology behaviours might have been missed if the study had only measured general use, or perhaps Internet addiction. Therefore, this research program can be developed further to incorporate other real-world correlates that affect adolescents within other spheres that are both positive and negative, including social (i.e., friendships, peers), physical (i.e., athletics, disease), emotional (i.e., distress tolerance, affect tolerance), and mental health (i.e., depression or anxiety, resilience). Another example that relates to the social domain is loneliness, which has been explored in some research (Twenge et al., 2021) and may be used to determine whether it relates to other attitudes towards technology. In addition, it might be beneficial to further explore how individuals with impulsivity problems, like ADHD or other disorders such as anxiety and depression, have different behaviours or attitudes about technology.

Conclusions

Technology use is likely to continue to be pervasive in the lives of teenagers, especially with more augmented reality, AI, and technology being taught in classrooms, along with the creation of more technology jobs in the future. Almost everywhere around the world, technology

is essential to everyday life both in terms of leisure and work. Overall, the nature of how technology behaviours and attitudes relate to cognitive reflection is understudied compared to other processes, partly because of the complexity of judgment and decision-making considerations. The relationships between cognitive reflection and cognitive ability with technology attitudes and behaviours in adolescents also suggest a need for more research to understand earlier periods of development before adolescence, when children begin to be introduced to electronic devices.

These findings inform psychological research on the nature of technology behaviours and attitudes as well as rational thinking, which can also inform educational research. The current results point to the need for further examination of the technology attitudes that should be considered in the development of education approaches that can help students identify different technology behaviours and attitudes with correlates in the real-world.

In conclusion, this research has implications for technology use, as well as judgment and decision-making studies. The hope is that this research project has instilled and highlighted the importance of how different technology behaviours and attitudes relate to cognitive reflection and cognitive ability and to real-world outcomes. Technology will only continue to further influence these real-life outcomes. Technology is here to stay, and it is important that adolescents find ways to use it that will enable them to be better thinkers and happier people.

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Appendix A

Adolescent's technology hygiene behaviour items used in Study 1

Rating scale
1 = yes, 0 = no.

Scoring
Higher scores indicate higher technology hygiene behaviours.
(R) indicates item reverse scored.

Items
Electronic media use includes any materials for playing video games, playing computer games, or accessing the Internet for fun activities.

Do you:

1. Talk to your parents about online content on the Internet and which websites are appropriate to visit?	Yes	No
2. Open attachments in emails that are sent by someone you don't know? **(R)**	Yes	No
3. Backup important work and documents on your computer?	Yes	No
4. Have time limits on how much recreational time you spend using electronic media at home?	Yes	No
5. Do you use the privacy settings on social networking sites, such as Facebook, to protect your personal information and privacy?	Yes	No
6. Have virus protection on your home computers?	Yes	No

Appendix B

Parent ratings of adolescent technology hygiene behaviour items used in Study 1

Rating scale
1 = yes, 0 = no.

Scoring
Higher scores indicate higher technology hygiene behaviours.
(R) indicates item reverse scored.

Items
Electronic media use includes any materials for playing video games, playing computer games, or accessing the Internet for recreational activities.

Does your son/daughter:

1. Talk to you about online content on the Internet and which websites are appropriate to visit?	Yes	No
2. Open attachments in emails that are sent by someone that he/she doesn't know? **(R)**	Yes	No
3. Backup important work and documents on your computer?	Yes	No
4. Have time limits on how much recreational time he/she spends using electronic media at home?	Yes	No
5. Use the privacy settings on social networking sites, such as Facebook, to protect his/her personal information and privacy?	Yes	No
6. Have virus protection on his/her home computers?	Yes	No

Appendix C

Adolescent's maladaptive technology behaviour items used in Study 1

Rating scale
Items 1–4, 1 = yes, 0 = no. Items 5–10, number.

Scoring
Higher scores indicate higher maladaptive technology behaviours.

Items

Electronic media use includes any materials for playing video games, playing computer games, or accessing the Internet for fun activities.

Have any of the following happened because of your electronic media use:

1. I have failed to do my homework because I was using electronic media.	Yes	No
2. My grades have gone down because of my electronic media use.	Yes	No
3. I have argued with my parents because of my electronic media use.	Yes	No
4. I have not gotten enough sleep because of my staying up late to use electronic media.	Yes	No

5. How many times have you posted messages about someone else on the Internet that you thought was funny but might be embarrassing to that person?
_____ times

Which of the following types of electronic media do you use and how much do you use each form of media?

6. Number of hours a day on social networking sites, such as Facebook and Twitter	_____ hours
7. Number of text messages sent a day	_____ texts
8. Number of hours a day playing video games	_____ hours
9. Number of hours a day on virtual worlds, such as Minecraft	_____ hours
10. Number of hours a day downloading music and videos	_____ hours

Appendix D

Parent ratings of adolescent maladaptive technology behaviour items used in Study 1

Rating scale
Items 1–4, 1 = yes, 0 = no. Items 5–10, number.

Scoring
Higher scores indicate higher maladaptive technology behaviours.

Items
Electronic media use includes any materials for playing video games, playing computer games, or accessing the Internet for recreational activities.

Have any of the following happened to your son/daughter because of his/her electronic media use:

1. Failed to do my homework because I was using electronic media.	Yes	No
2. Grades have gone down because of electronic media use.	Yes	No
3. Argued with my parents because of electronic media use.	Yes	No
4. Not gotten enough sleep because of staying up late to use electronic media.	Yes	No

5. How many times has your son/daughter posted messages about someone else on the Internet that he/she thought was funny but might be embarrassing to that person?
_____ times

Which of the following types of electronic media does your son/daughter use and how much does he/she use each form of media?

6. Number of hours a day on social networking sites, such as Facebook and Twitter	_____ hours
7. Number of text messages sent a day	_____ texts
8. Number of hours a day playing video games	_____ hours
9. Number of hours a day on virtual worlds, such as Minecraft	_____ hours
10. Number of hours a day downloading music and videos	_____ hours

Appendix E

Adolescent's antisocial behaviour items used in Study 1

Rating scale
Number entered.

Scoring
Higher scores indicate higher antisocial behaviours.

Items

1. How many times have you stayed out at night without your parent's permission?
_____ times
2. How many times have you lied to get your way?
_____ times
3. How many times have you started physical fights?
_____ times
4. How many times have you stolen other people's things?
_____ times
5. How many times have you vandalized other people's property?
_____ times
6. How many times have you gotten in trouble and had to go to the principal's office?
_____ times
7. How many times have you skipped school?
_____ times
8. How many detentions or suspensions have you had at school for your behaviour?
_____ times
9. How many times have you been late for class?
_____ times
10. How many times have you cheated on a test?
_____ times

Appendix F

Parent ratings of adolescent antisocial behaviour items used in Study 1

Rating scale
Number entered.

Scoring

Higher scores indicate higher antisocial behaviours.

Items

1. How many times has your son/daughter stayed out at night without your permission?
_____ times
2. How many times has your son/daughter lied to get his/her way?
_____ times
3. How many times has your son/daughter started physical fights?
_____ times
4. How many times has your son/daughter stolen other people's things?
_____ times
5. How many times has your son/daughter vandalized other people's property?
_____ times
6. How many times has your son/daughter gotten in trouble and had to go to the principal's office?
_____ times
7. How many times has your son/daughter skipped school?
_____ times
8. How many detentions or suspensions at school for his/her behaviour?
_____ times
9. How many times has your son/daughter been late for class?
_____ times
10. How many times has your son/daughter cheated on a test?
_____ times

Appendix G

Adolescent's time spent on electronic devices used in Study 2

Electronic devices are tools that allow you to communicate (call or text or message), access social media, play video games or use the Internet.

Common electronic devices include: Smartphones, Cellphones, Laptops, Desktop Computers, Game Consoles, Portable Game Consoles, Tablets, Smart Watches, Televisions, Smart Televisions, Virtual Reality Headsets, and E-readers.

1. You will be asked to rate how often you currently use these devices for different purposes.

Please list the top 3 electronic devices you use.

The electronic device I use the most _____

The electronic device I use second most _____

The electronic device I use third most _____

2. How much time, on average, do you spend each day using electronic devices?

- Less than 30 minutes
- Between 30 minutes and 1 hour
- Between 1 to 2 hours
- Between 2 to 3 hours
- Between 3 to 4 hours
- Between 4 to 5 hours
- Between 5 to 6 hours
- Between 6 to 7 hours
- Between 7 to 8 hours
- More than 8 hours

Appendix H

Adolescent's technology hygiene behaviour items used in Study 2

Rating Scale

1 = Never, 2 = Almost Never, 3 = Occasionally, 4= About Half the Time, 5 = Frequently, 6 = Almost Always, 7=Always.

Scoring

Higher scores indicate higher endorsements of technology hygiene behaviour items. Brackets indicate a score that was included with one of the technology hygiene behaviour factors.

Items

We would like to know about your current use and experience with electronic devices. Please indicate how often you engage in the following behaviours.

1. Check that an important file or document has been saved. (Security and privacy behaviours)

2. Create an extra backup of important files and documents. (Security and privacy behaviours)

3. Set time limits on using electronic devices and generally keep to the limit. (Device-limiting behaviours)

4. Focus on school or work tasks without thinking about doing other things on my electronic devices. (Device-limiting behaviours)

5. Use strategies like putting my electronic devices away at least half an hour before I go to sleep. (Device-limiting behaviours)

6. Turn the sound off on my electronic devices at nighttime so that any new alerts or messages do not interrupt my sleep. (Security and privacy behaviours)

7. Use strategies like putting my electronic devices in another room or another place to disconnect so that I can focus on studying or work. (Device-limiting behaviours)

8. Create different passwords for different online accounts. (Security and privacy behaviours)

9. Double-check that a website is a secure site when I am paying for something online. (Security and privacy behaviours)

10. Use “more secure” password protection (such as a combination of numbers, symbols, and letters) on my electronic devices. (Security and privacy behaviours)

11. Use two-step verification (such as entering a password on my email, and a code on my phone) to login into important online accounts, such as banking or payment information. (Security and privacy behaviours)

12. Use the stricter than the default privacy settings on social networking sites (such as limiting who sees photos or posts on Instagram or TikTok) to protect my personal information and privacy. (Security and privacy behaviours)

13. Take time to read the terms and conditions of a website when I sign up for online services (such as social networking platforms). (Not included in technology subscales)

14. Avoid clicking on links in texts or emails from someone whose number or name I don’t recognize. (Security and privacy behaviours)

Appendix I

Adolescent's adaptive technology attitudes items used in Study 2

Rating Scale

1=Strongly Disagree, 2=Disagree Slightly, 3=Disagree, 4=Neither Agree Nor Disagree, 5= Slightly Agree, 6=Agree, 7=Strongly Agree.

Scoring

Higher scores indicate higher endorsements of adaptive technology attitudes items. **(R)** indicates item reverse scored. Brackets indicate a score that was included with one of the adaptive technology attitude factors.

Items

Please rate the following:

1. It is important to take breaks from my electronic devices. (Technology-etiquette attitudes)

2. I do better in classes where electronic devices are not allowed. (Device-time/access attitudes)

3. I see no problem with multi-tasking (performing two or more tasks at the same time) on my electronic device as I do homework. **(R)** (Not included in technology subscales)

4. If I am doing something fun on my electronic device at the same time as homework, then I probably won't get my homework done. (Device-time/access attitudes)

5. I see no problem with entering my credit card/payment information on websites with which I am not familiar. **(R)** (Technology-etiquette attitudes)

6. When I am tired and choose to communicate through my electronic device with others, it is easy to make silly mistakes in my messages. (Technology-etiquette attitudes)

7. When I am sending personal information, I am careful to ensure that the recipient is the right person. (Technology-etiquette attitudes)

8. Backing up important files and documents on my electronic devices often saves me time in the long run. (Technology-etiquette attitudes)

9. If I did not have access to electronic devices at bedtime, I would probably get a better sleep. (Device-time/access attitudes)

10. I pay better attention to people who I am with when I don't use my electronic device at the same time. (Device-time/access attitudes)

11. It is important to have stricter than the default security settings on my electronic devices to help protect my personal information. (Technology-etiquette attitudes)

12. I don't see the benefit of limiting my electronic device use. **(R)** (Device-time/access attitudes)

13. Posting things on the Internet can have negative consequences. (Technology-etiquette attitudes)

14. It is important not to spend too much time on electronic devices. (Device-time/access attitudes)

Appendix J

Adolescent's maladaptive technology behaviour items used in Study 2

Rating Scale

1 = Never, 2 = Almost Never, 3 = Occasionally, 4= About Half the Time, 5 = Frequently, 6 = Almost Always, 7=Always.

Scoring

Higher scores indicate higher endorsements of maladaptive technology behaviour items. Brackets indicate a score that was included with one of the maladaptive technology behaviour factors.

Items

Please indicate how often you engage in the following behaviours:

1. Fail to complete homework because I am using electronic devices. (Problematic school and home behaviours)

2. Get lower grades because I am using electronic devices. (Problematic school and home behaviours)

3. Cheat on schoolwork by using electronic devices. (Problematic school and home behaviours)

4. Open new Internet tabs/windows not related to school while doing schoolwork. (Problematic school and home behaviours)

5. Fail to do my chores or important tasks because of my use of electronic devices. (Problematic school and home behaviours)

6. Argue with my parent(s) because of using electronic devices too much. (Problematic school and home behaviours)

7. Argue with my parent(s) because of staying up too late using electronic devices. (Careless device behaviours that can lead to regret)

8. Lose sleep time or go to bed too late because of electronic devices. (Device-absorption behaviours)

9. Receive a text or message or email, respond instantly and then regret it. (Careless device behaviours that can lead to regret)

10. Accidentally text or message sensitive or personal information to the wrong person. (Careless device behaviours that can lead to regret)

11. Get into arguments with a stranger online and later regret it. (Careless device behaviours that can lead to regret)

12. Use my electronic device instead of paying attention to someone that I am with. (Not included in technology subscales)

13. Use my electronic device and not pay attention to traffic while driving a car or riding a bike. (Careless device behaviours that can lead to regret)

14. Use my electronic device and not pay attention to other pedestrians and traffic while walking on a busy street. (Careless device behaviours that can lead to regret)

15. Accidentally go over my data limit. (Careless device behaviours that can lead to regret)

16. Think about using my electronic devices when I am doing something else. (Device-absorption behaviours)

17. Check my electronic devices for a new alert or message even when I haven't received a notification. (Device-absorption behaviours)

18. Check my electronic device while I'm supposed to be paying attention to something else. (Device-absorption behaviours)

19. Get bothered when I hear or see a new alert or message and cannot get to my electronic device. (Device-absorption behaviours)

20. Use autofill on forms without first checking the content of the form. (Autofill is when previously stored information is automatically entered onto a webpage.) (Device-absorption behaviours)

21. Get distracted by sexually provocative images/videos from electronic devices. (Immediate device-gratification behaviours)

22. Binge-watch TV shows, or movies, instead of doing schoolwork or some important tasks. (Device-absorption behaviours)

23. Decide to reduce my time on electronic devices and not follow through. (Device-absorption behaviours)

24. Download or stream digital content when I am not certain it is legal. (Immediate device-gratification behaviours)

25. Enter false information about myself, such as my age, to get access to content online. (Immediate device-gratification behaviours)

26. Visit websites even though I have been notified that they are not secure or may contain malware. (Immediate device-gratification behaviours)

27. Use predictable passwords (such as “password” or “123456789”). (Careless device behaviours that can lead to regret)

28. Use the same password for my different online accounts. (Immediate device-gratification behaviours)

29. Play video games for such a long time that I miss something important I have to do. (Immediate device-gratification behaviours)

30. Spend money on “in-game purchases” in virtual worlds (like Minecraft or Fortnite) or video games that I later regret. (Careless device behaviours that can lead to regret)

31. Buy or make purchases online and later regret it. (Not included in technology subscales)

32. Sign up for free stuff or coupons online without considering that the information may be collected and used for other purposes. (Immediate device-gratification behaviours)