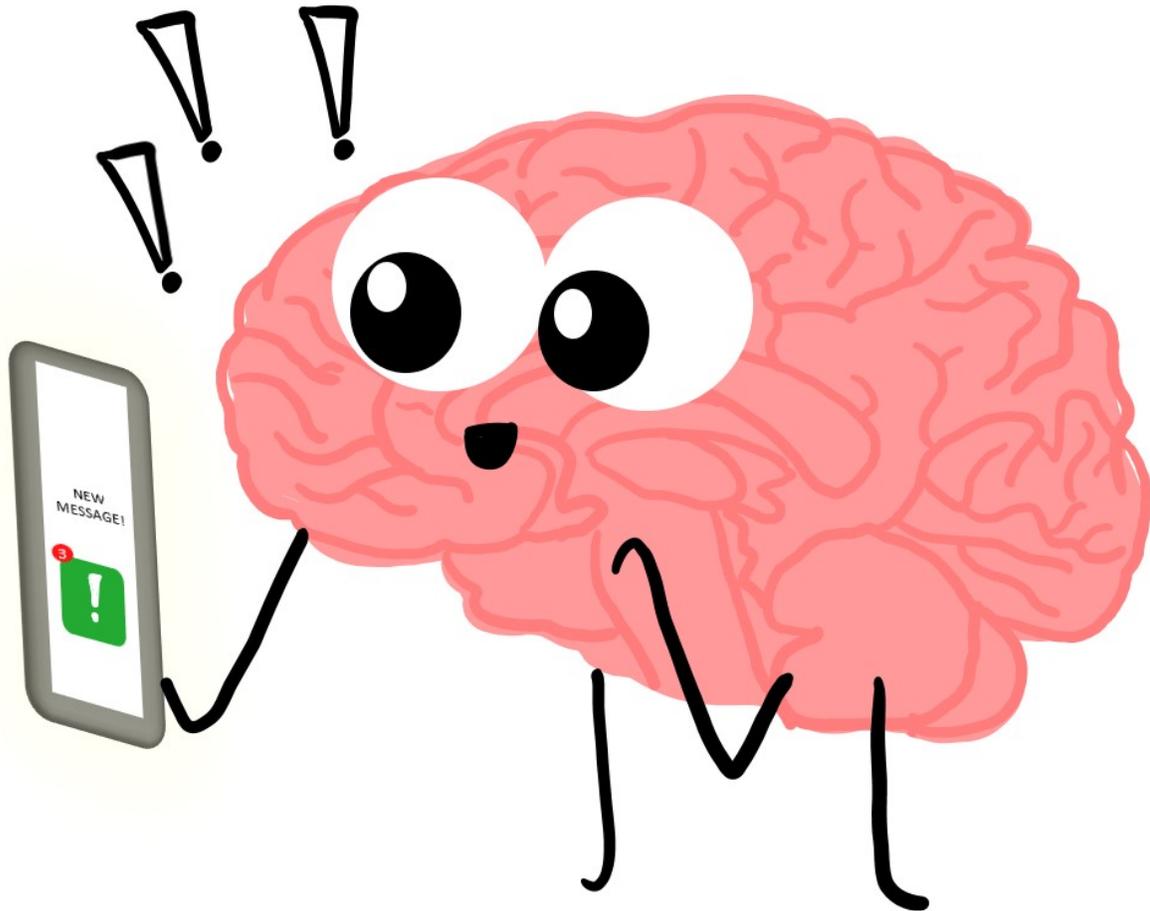




HARVARD UNIVERSITY
The Graduate School of Arts and Sciences



MAY 1, 2018

BLOG

Dopamine, Smartphones & You: A battle for your time

by Trevor Haynes

figures by Rebecca Clements

“I feel tremendous guilt,” admitted Chamath Palihapitiya, former Vice President of User Growth at Facebook, to an audience of Stanford students. He was responding to a question about his involvement in exploiting consumer behavior. “The short-term, dopamine-driven feedback loops that we have created are destroying how society works,” he explained. In **Palihapitiya’s talk**, he highlighted something most of us know but few really appreciate: smartphones and the social media platforms they support are turning us into *bona fide* addicts. While it’s easy to dismiss this claim as hyperbole, platforms like Facebook, Snapchat, and Instagram leverage the very same neural circuitry used by slot machines and cocaine to keep us using their products as much as possible. Taking a closer look at the underlying science may give you pause the next time you feel your pocket buzz.

Never Alone

If you’ve ever misplaced your phone, you may have experienced a mild state of panic until it’s been found. **About 73% of people** claim to experience this unique flavor of anxiety, which makes sense when you consider that adults in the US spend an average of **2-4 hours per day** tapping, typing, and swiping on their devices—that adds up to over 2,600 daily touches. Most of us have become so intimately entwined with our digital lives that we sometimes feel our phones vibrating in our pockets when **they aren’t even there**.

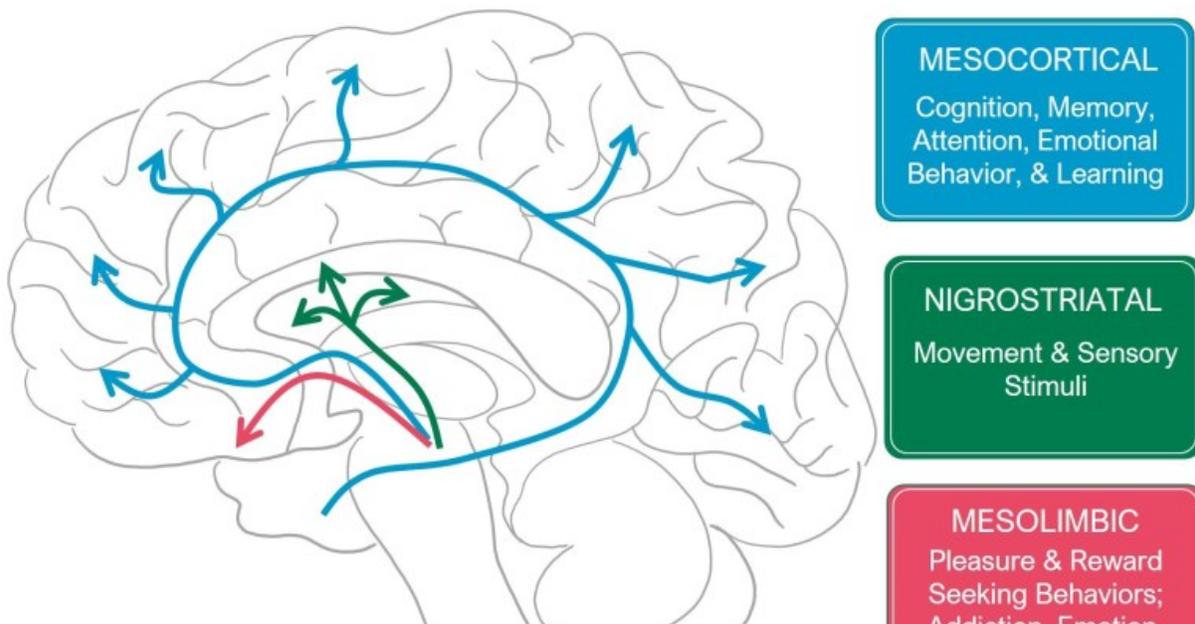
While there is nothing inherently addictive about smartphones themselves, the true drivers of our attachments to these devices are the hyper-social environments they provide. Thanks to the likes of Facebook, Snapchat, Instagram, and others, smartphones allow us to carry immense social environments in our pockets through every waking moment of our lives. Though humans have evolved to be social—a key feature to our success as a species—the social structures in which we thrive tend to contain **about 150 individuals**. This number is orders of magnitude smaller than the **2 billion potential connections** we carry around in our pockets today. There is no doubt that smartphones provide immense benefit to society, but their cost is becoming more and more apparent. Studies are beginning to show links between smartphone usage and **increased levels of anxiety and depression, poor sleep quality, and increased risk**

of car injury or death. Many of us wish we spent less time on our phones but find it incredibly difficult to disconnect. Why are our smartphones so hard to ignore?

The Levers in Our Brains – Dopamine and social reward

Dopamine is a chemical produced by our brains that plays a starring role in motivating behavior. It gets released when we take a bite of delicious food, when we have sex, after we exercise, and, importantly, when we have **successful social interactions**. In an evolutionary context, it rewards us for beneficial behaviors and motivates us to repeat them.

The human brain contains **four major dopamine “pathways,”** or connections between different parts of the brain that act as highways for chemical messages called neurotransmitters. Each pathway has its own associated cognitive and motor (movement) processes. Three of these pathways—the mesocortical, mesolimbic, and nigrostriatal pathways—are considered our “reward pathways” and **have been shown** to be dysfunctional in most cases of addiction. They are responsible for the release of dopamine in various parts of the brain, which shapes the activity of those areas. The fourth, the tuberoinfundibular pathway, regulates the release of a hormone called **prolactin** that is required for milk production.





Addiction, Emotion,
Perception

Figure 1: Three dopamine pathways and their related cognitive processes. Most of your dopamine is generated deep in the midbrain, and it is released in many different areas across the brain. These areas are largely responsible for behaviors associated with learning, habit formation, and addiction.

While the reward pathways (**Figure 1**) are distinct in their anatomical organization, all three become active when anticipating or experiencing rewarding events. In particular, they reinforce the association between a particular stimulus or sequence of behaviors and the feel-good reward that follows. Every time a response to a stimulus results in a reward, these associations become stronger through a process called long-term potentiation. This process strengthens **frequently used connections** between brain cells called neurons by increasing the intensity at which they respond to particular stimuli.

Although not as intense as hit of cocaine, positive social stimuli will similarly result in a release of dopamine, reinforcing whatever behavior preceded it. Cognitive neuroscientists **have shown** that rewarding social stimuli—laughing faces, positive recognition by our peers, messages from loved ones—activate the same dopaminergic reward pathways. Smartphones have provided us with a virtually unlimited supply of social stimuli, both positive and negative. Every notification, whether it's a text message, a "like" on Instagram, or a Facebook notification, has the potential to be a positive social stimulus and dopamine influx.

The Hands that Pull – Reward prediction errors and variable reward schedules

Because most social media platforms are free, they rely on revenue from advertisers to make a profit. This system works for everyone involved at first glance, but it has created an arms race for your attention and time. Ultimately, the winners of this arms race will be those who best use their product to exploit the features of the brain's reward systems.

Reward prediction errors

Research in reward learning and addiction have recently focused on a feature of our dopamine neurons called **reward prediction error (RPE) encoding**. These prediction errors serve as dopamine-mediated feedback signals in our brains (**Figure 2**). This neurological feature is something casino owners have used to their advantage for years. If you've ever played slots, you'll have experienced the intense anticipation while those wheels are turning—the moments between the lever pull and the outcome provide time for our dopamine neurons to increase their activity, creating a rewarding feeling just by playing the game. It would be no fun otherwise. But as negative outcomes accumulate, the loss of dopamine activity encourages us to disengage. Thus, a balance between positive and negative outcomes must be maintained in order to keep our brains engaged.

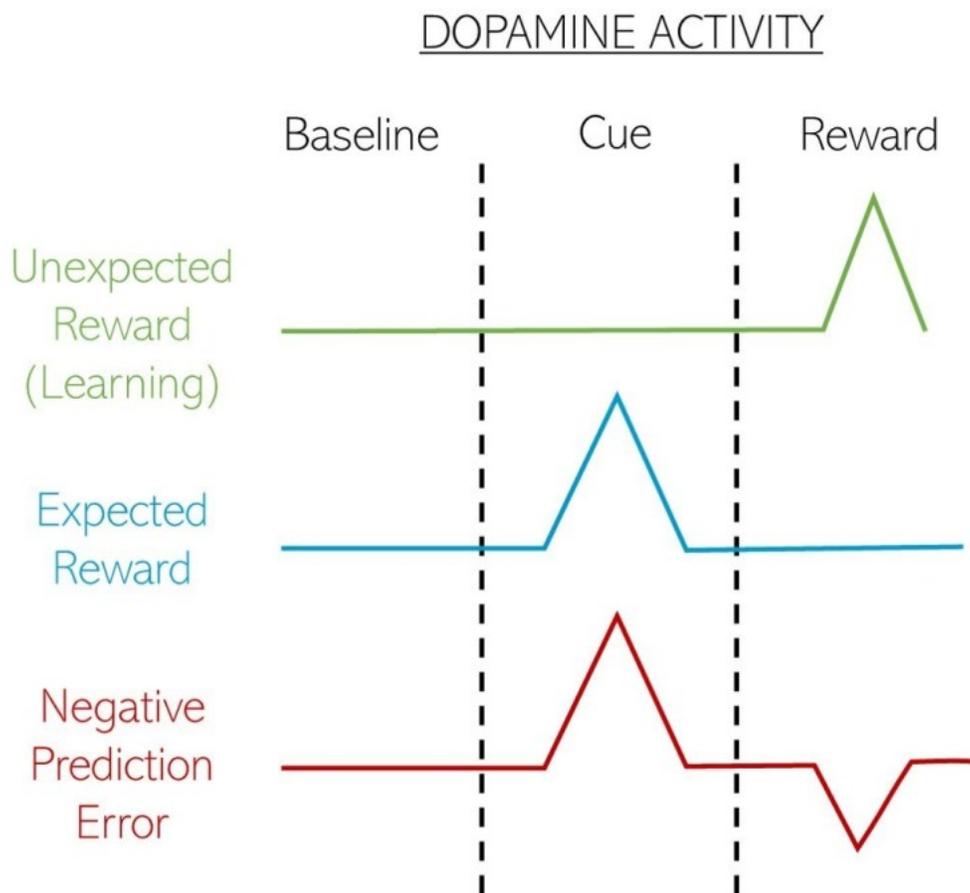


Figure 2: Reward prediction and subsequent dopamine activity. Unexpected rewards increase the activity of dopamine neurons, acting as positive feedback signals for the brain regions associated with the preceding behavior. As learning takes place, the timing of activity will shift

until it occurs upon the cue alone, with the expected reward having no additional effect. And should the expected reward not be received, dopamine activity drops, sending a negative feedback signal to the relevant parts of the brain, weakening the positive association.

Variable reward schedules

How do social media apps take advantage of this dopamine-driven learning strategy? Similar to slot machines, many apps implement a reward pattern optimized to keep you engaged as much as possible. **Variable reward schedules** were introduced by psychologist B.F. Skinner in the 1930's. In his experiments, he found that mice respond most frequently to reward-associated stimuli when the reward was administered after a varying number of responses, precluding the animal's ability to predict when they would be rewarded. Humans are no different; if we perceive a reward to be delivered at random, and if checking for the reward comes at little cost, we end up checking habitually (e.g. **gambling addiction**). If you pay attention, you might find yourself checking your phone at the slightest feeling of boredom, purely out of habit. Programmers work very hard behind the screens to keep you doing exactly that.

The Battle for Your Time

If you've been a Facebook user for more than a few years, you've probably noticed that the site has been expanding its criteria for notifications. When you first join Facebook, your notification center revolves around the initial set of connections you make, creating that crucial link between notification and social reward. But as you use Facebook more and begin interacting with various groups, events, and artists, that notification center will also become more active. After a while, you'll be able to open the app at any time and reasonably expect to be rewarded. When paired with the low cost of checking your phone, you have a pretty strong incentive to check in whenever you can.

Other examples highlight a more deliberate effort to monopolize your time. Consider Instagram's implementation of a variable-ratio reward schedule. As explained in this **60 Minutes interview**, Instagram's notification algorithms will sometimes withhold "likes" on your photos to deliver them in larger bursts. So when you make your post, you may

be disappointed to find less responses than you expected, only to receive them in a larger bunch later on. Your dopamine centers have been primed by those initial negative outcomes to respond robustly to the sudden influx of social appraisal. This use of a variable reward schedule takes advantage of **our dopamine-driven desire for social validation**, and it optimizes the balance of negative and positive feedback signals until we've become habitual users.

Question Your Habits

Smartphones and social media apps aren't going anywhere anytime soon, so it is up to us as the users to decide how much of our time we want to dedicate to them. Unless the advertisement-based profit model changes, companies like Facebook will continue to do everything they can to keep your eyes glued to the screen as often as possible. And by using algorithms to leverage our dopamine-driven reward circuitry, they stack the cards—and our brains—against us. But if you want to spend less time on your phone, there are a variety **strategies** to achieve success. Doing things like disabling your notifications for social media apps and keeping your display in black and white will reduce your phone's ability to grab and hold your attention. Above all, mindful use of the technology is the best tool you have. So the next time you pick up your phone to check Facebook, you might ask yourself, "Is this really worth my time?"

Trevor Haynes is a research technician in the Department of Neurobiology at Harvard Medical School.

For more information:

- **Tips** for building a healthier relationship with your phone
- A **list of stories** from NPR about smartphone addiction
- A **high-level primer** on dopamine and how it affects your brain, body, and mood

Share this:



22 thoughts on “Dopamine, Smartphones & You: A battle for your time”



Stephen Hartley

NOVEMBER 26, 2018 AT 8:14 AM

A thought-provoking article, thank you. A couple of personal responses follow; use of the masculine pronoun is for brevity, and not intend to be discriminatory.

“Programmers work very hard behind the screens to keep you doing exactly that.” As a Computer Science graduate, it does slightly irritate me how often “programmers” are held accountable for “socially undesirable” business outcomes. For example, contrary to what was reported in the press, programmers at Volkswagen did not specify the behaviour of vehicle emissions systems. A strategist proposed a design, management sanctioned its use, and programmers built and implemented it, in compliance with the design. If the programmer objects to the design on ethical grounds, then he makes his concerns known to his employer, or consults his professional body for advice. Strategy design and selection is not typically an area of the business in which programmers creates value.

Very interesting that you raise awareness of Instagram’s alleged controlled release of rewards; this is a behaviour which I had anecdotally observed in recent months, so in some ways it is reassuring to receive confirmation.

REPLY



Trevor

DECEMBER 21, 2018 AT 5:55 PM

Thanks for the feedback Stephen. Totally fair comment on the programmer’s role – you are right that is primarily a business decision. Programmers should not be

portrayed as the ones making these decisions, and that's my mistake if that's how it came off. Although they do consciously play a direct role in "hacking the brain", so I would argue they are not innocent bystanders. If a programmer at Facebook or Instagram was ethically opposed what their company was doing, surely they could find a job elsewhere, no? I think we can agree that with the wrong incentive structures, good people are forced to do ethically questionable things, and the incentive structures surrounding these companies are problematic, at best. Regardless, I appreciate you reading the article, and taking the time to reply with your thoughts!

REPLY



Eric Jones

DECEMBER 18, 2018 AT 5:03 PM

Wow. Your article touches base on a good amount of research I am doing for the North East Regional Honors Conference in regards to Classical Conditioning and tying that behavior theory to the way Facebook interacts with consumers. There was an app developer who created a program that would block notifications and consumers no longer found enjoyment in using the social media programs.

Would it be possible to email me the works cited page as some of the sub-links are protected in a Harvard database?

REPLY



Trevor Haynes

JANUARY 22, 2019 AT 12:08 PM

Hi Eric

Sorry for only replying now – if it is not too late, feel free to email me at trevorhaynes0@gmail.com and I'll see if I can help.

Trevor

REPLY



Youcef Chakib Hacene

FEBRUARY 12, 2019 AT 11:06 AM

Dear Trevor,

Thanks for this article. I am not a neuroscientist nor am I looking to become one. I want nonetheless to learn more. Could you please recommend a book or a literature review that would provide more teaching regarding the subject matter? I am looking for something informative but not expert level at the same time.

I have background in life and material sciences if that helps.

Kind regards,

Youcef Chakib Hacene

REPLY



George

FEBRUARY 23, 2019 AT 11:04 PM

Read "The Shallows" by Nicholas Carr.

REPLY





Trevor Haynes

APRIL 1, 2019 AT 11:30 AM

Check out <http://www.tristanharris.com/essays/> for lots of material on this subject

REPLY



Mona Arora

OCTOBER 13, 2019 AT 4:57 AM

Search cal Newport you will find valuable info.. thanks

REPLY



Pablo Torre

FEBRUARY 20, 2019 AT 9:24 AM

I started looking into this subject after learning to identify the symptoms of a dopamine bunk from Sapolsky's lecture on depression... and then identifying said symptoms when looking at the FB feed... particularly around the time when "all you find is old stuff you've already seen" and get denied the dopamine-boost from finding something new and shiny on your FB wall...

I noticed that too much FB lead me to a serious lack of motivation, drive and energy to do pretty much anything else... and after I started "budgeting" the time on it and blocking the newsfeed I would have a lot more drive to learn/do many more things on the days when I used little or no FB at all...

Your article brings a lot of clarity on some of the underlying mechanisms, and also confirms some of my intuitions around the "Negative Prediction Error". Thank you for sharing.

REPLY



Bill Ovington

MARCH 19, 2019 AT 9:58 AM

Hi Trevor : Thanks for your insight. This explains to me the behaviour of people constantly using their smartphones even when they are physically in the presence of friends and family. I find this behaviour strange.

My early exposure to cell phones and texting was at work as a construction supervisor and I was constantly inundated with negative communications – even angry communications. I experienced phantom cell phone buzzing even when I didn't have the cell phone with me. So I developed a negative attitude to cell phones and I cringe whenever it rings or a text message arrives. My preference now is not to carry my cell phone with me wherever I go. I also avoid social media sites for similar reasons.

I wonder if similar effect is contributing to obesity. Dopamine release from eating “fast” foods influences us to eat “fast” food again and probably in larger quantities. Do you have any thoughts on this ?

REPLY



Mandy Jones

JULY 8, 2019 AT 8:18 AM

Check out Dr. Robert Lustig's work on addiction and food, especially his latest book “The Hacking of the American Mind” since it links the work of Tristan Haynes to sugar/processed food addiction. Very interesting!

REPLY



Mandy Jones

JULY 8, 2019 AT 8:20 AM

*Tristan Harris (not Haynes, I got confused)

REPLY



IndyRes

MAY 5, 2019 AT 6:10 PM

Thanks for calling this obsessive smart-phone use what it is: an addiction. My workplace, believe it or not, allows people to have access to their smart phones and other devices while supposedly performing their job duties (duties that require a high degree of critical thinking and analysis). This strikes me as insanity, but I think leadership takes the standpoint that it's impossible to fight.

REPLY



Susanne Mary Sullivan

JUNE 7, 2019 AT 2:42 AM

Excellent article, thanks. Depth and detail much appreciated. Am struggling with time-wasting myself despite some knowledge of neurocognitive area. Pathways etc very helpful. There's never been a bigger drug cartel in history yet we let them make millions off us while literally feeding every man, woman and child user a mega dose of addictive drugs daily, reducing the quality of our living and, critically, of our thinking. Time extreme measures were taken to force deactivation of algorithms (unless actively chosen by informed users) by Facebook, Google and Co. Dealing drugs is illegal, especially undisclosed.

REPLY



VEDA RAVISHANGAR

JULY 5, 2019 AT 10:54 AM

Thank you so much. Behind your every words bringing some thing important for present and future generation healthy and peace life. Science & Technology is need in every aspects but it cannot control the humanity so need to bring some solution in this matter. Certain powerful herbs, sounds, aroma bringing down such mass trapping systems. so we need your guide in this matter.

REPLY



Logan Antwine

AUGUST 8, 2019 AT 11:56 PM

Social media is developed do be addicting and it has impacted the younger youths brain development.

REPLY



Steven Moude

AUGUST 15, 2019 AT 9:14 AM

not correct! im 16 and im totally not addicted! liars

REPLY



Bob Sacket

AUGUST 15, 2019 AT 9:17 AM

your right. no one really is addicted. HARVARD LIES!

REPLY



buh

SEPTEMBER 23, 2019 AT 1:59 PM

you just lost the game

REPLY



lloyd

OCTOBER 4, 2019 AT 8:07 AM

Great article Trevor. quite insightful. I think, instead of diving into the semantics of arguing if these behaviours should be classified as addictions or not, we should acknowledge the subtle but serious effects these gadgets are having in the quality of our lives. Social media, needless to say, is a great communication tool that has, in many ways, re-inforced what we have come to call the "global village". It is however, in our best interests to curb its negative effects (which cant be done if we persist in denial) Companies lose millions in productivity on a daily basis because of distracted employees who cant resist fidgeting with their gadgets every 5 mins. Children lose the valuable connection (quality time devoid of technological distractions) with their parents...the list is endless! Granted, its not everyone who's so dangerously hooked, but what becomes of humanity if those who have the power to effect change become innocent by standers? The nomarncy of people's lives has to be restored because "cyber zombies" will not be master performers!

REPLY



Rajesh Nandakumar

OCTOBER 4, 2019 AT 11:33 PM

Trevor this is an interesting article and is the basis of one of my research work on “Customer Behavior can be altered when you introduce AI or IOT in Retail & Banking Industry”.

If there is an ongoing work that I can contribute and learn will be more than happy to be engaged. I’m available at Rajesh.nandakumar@gmail.com.

And thanks for those reading recommendations in the reading section. Appreciate the input from fellow readers.

REPLY



Gloria Edith

OCTOBER 17, 2019 AT 12:02 AM

I have a 13 year old that only recently I allowed to use Snapchat. But as soon as I did, I regretted it! I saw a difference in behavior almost immediately. I monitor her phone and age appropriate apps, but it’s almost a second job in terms of time consuming (worthwhile of course). I cringe when I see a parent hand over their cell phone to a rowdy kid just to shut them off. Let’ not even get into the fact that so many parents don’t even set parental controls on those devices. It’s like handing the kid a loaded gun. It’s a shame that kids know how to use and manipulate the devices better than their parents in some cases. I call for parental training as an ethical mandate by the digital world, if we don’t educate the parents first, both parent and kid are headed down a rabbit hole that they will not be able to climb out of.

REPLY

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