The neuroscience of screen addiction

Dr Wayne Warburton

What we will talk about

- Neural development in children
- How big is the problem?
- Screen addiction
- Persuasive design – hijacking our time
- Neuroscience of screen addiction
- Screens and the body
- Healthy use

The developing brain

- The human brain wires up every second of every day in response to what we experience.
- That is, our neural network of thoughts, feelings and memories constantly changes to incorporate what we learn, second by second
- The crucial times are early childhood and the teenage years
- Let's have a look:

Neural Development

Newborn 3 months 6 months 2 years

Golgi Stained Sections of Middle Frontal Gyrus Showing Growth of Pyramidal Neuron Soma and Dendrites: Courchesne et al., 2007

Neural Development

Brain develops bottom to top and from the inside out

Illustration from Mike Nagel

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Neural Development

- Adolescence the second crucial stage.
- Myelination
- White matter – the cables of the brain
- Faster processing
- Pruning
- Faster and more efficient
- BUT Frontal lobe far less developed than emotion centres

Adolescents use less of the prefrontal cortex than adults when reading emotions.

Confronted with a feeling, say, somebody looks at them with an expression of fear an adolescent will have more of an emotional response. The part of the brain that has more of that gut reaction will respond to a greater extent than the adult brain will. One of the implications of this is that the brain is responding differently to the outside world in teenagers compared to adults.

From Mike Nagel

If an adolescent is doing music, sports or academics, those are the connections that will be hard wired. If they’re lying on the couch or playing video games or watching MTV, those are the cells and connections that are going to survive.

From Jay Giedd (Chief of Brain Imaging – Child Psychiatry Branch, National Institute of Mental Health)
Neural Development

- Adolescence thus a vulnerable time
- Due to neural reconfiguration, Jay Giedd and others remark that
- "Adolescence .... may be one of the worst times to expose a brain to drugs and alcohol or even a steady dose of violent video games" (Strauch, 2003; p. 21).

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What do you think?

In the latest Common Sense Media Poll, how much time did kids spend with recreational media?

<table>
<thead>
<tr>
<th>Age group</th>
<th>Media Type</th>
<th>Average time per day</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-12</td>
<td>Media overall</td>
<td>5 hours &amp; 55 minutes</td>
</tr>
<tr>
<td>8-12</td>
<td>Screen time</td>
<td>4 hours &amp; 26 minutes</td>
</tr>
<tr>
<td>Teens 13-18</td>
<td>Media overall</td>
<td></td>
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<tr>
<td>Overall</td>
<td>Screen time</td>
<td>8 hours &amp; 56 minutes</td>
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<tr>
<td>L v H income</td>
<td>Screen time</td>
<td>8h 7m vs 5h 42m</td>
</tr>
<tr>
<td>Black v White</td>
<td>Screen time</td>
<td>8h 26m vs 6h 18m</td>
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2017 APA study (N=3,511)

- 48 percent of parents say that regulating their child’s screen time is a constant battle
- 58 percent of parents report feeling like their child is attached to their phone or tablet.
- 45 percent of parents say they feel disconnected from their families even when they are together because of technology.
- 58 percent say they worry about the influence of social media on their child’s physical and mental health.
- 86% of adults in the U.S. report that they constantly or often check their email, texts and social media accounts, and constant checkers are more stressed

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Screen Addiction

• Two levels
  • Problematic use
  • Pathological use/addiction-like

What makes something an addiction?

Grant et al (2011) (on behavioural addictions)
• The failure to resist an impulse, drive, or temptation to perform an act that is harmful to the person or to others, despite that harm.
• Repetitive engagement in these behaviours ultimately interferes significantly with functioning in other key domains; compulsion, hard to stop
• Tension before; pleasure, gratification during
• Over time becomes motivated less by positive reinforcement and more by negative reinforcement (eg relief; stops withdrawal symp).

Screens and ‘Addiction’

The American Society of Addiction Medicine (ASAM) in 2011 released a new definition of addiction as a chronic brain disorder, officially proposing for the first time that addiction is not limited to substance use.

All addictions, whether chemical or behavioral, share certain characteristics including salience, compulsive use … tolerance … withdrawal, and the continuation despite negative consequences. (Cash et al, 2012, p 292.)

Not about drugs – about brains. More about the reward circuitry in the brain and related brain structures than it is about the external chemicals or behavior that “turn on” that reward circuitry. (ASAM, 2011)
Gaming Disorder and IGD

- Internet Gaming Disorder – DSM-V
  ‘Disorders requiring further study’, 2013
  - Diagnosis similar to gambling disorder
  - Many studies have followed

- Gaming Disorder – WHO: ICD-11
  - Endorsed by World Health Assembly, May 2019
  - Will take force January, 2022

Proposed IGD criteria

- PREOCCUPATION WITH THE INTERNET and or VIDEO GAMES
- WITHDRAWAL as INDICATED by symptoms of irritability, anxiety, or sadness
- TOLERANCE as evidenced by increasing amount, level, type of use to achieve satisfaction
- UNSUCCESSFUL ATTEMPTS TO CONTROL, stop or change the behavior
- LOSS OF INTEREST, previous hobbies, entertainment as a direct result of, and with the exception of, Internet use

Proposed IGD criteria

- CONTINUED USE despite psycho-social/physical problems likely to have been caused or exacerbated by use
- DECEIVING or LYING TO OTHERS regarding the amount of time engaged in Internet or Video gaming
- USES THE INTERNET TO ESCAPE or relieve a negative or dysphoric mood (e.g. feelings of helplessness, guilt, anxiety, stress, worries)
- LOSING or JEOPARDIZING A SIGNIFICANT RELATIONSHIP/job/educational opportunity

Proposed IGD criteria

- Five of the nine criteria
- Over a 12 month period
- Impairment must be significant

Gaming Disorder in ICD-11

- Defined as a pattern of gaming behavior (“digital-gaming” or “video-gaming”) characterized by
  - impaired control over gaming,
  - increasing priority given to gaming over other activities to the extent that gaming takes precedence over other interests and daily activities, and
  - continuation or escalation of gaming despite the occurrence of negative consequences.
- For gaming disorder to be diagnosed, the behaviour pattern must be of sufficient severity to result in significant impairment in personal, family, social, educational, occupational or other important areas of functioning
- Would normally have been evident for at least 12 months.

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Persuasive design – WHY?

Addiction is a deliberate ploy

• Games, social media, most tech is about advertising and in-app purchases. Need viewer’s attention

• Fortnite, free game. $2.4b in 2018. $318m in May 2018 alone.

• Want you exposed for hours, not minutes

• Davidow, 2012: “either they hijack neuroscience to gain market share and make large profits, or they let competitors do that and run away with the market”. “Addiction is good for business”.

Persuasive design – HOW?

• Hire persuasive design experts to make screen tech more addictive

• Bogost, 2012: Smartphones – ‘the cigarette of the century’.

• Ramsay Brown, founder Dopamine Labs: “Your kid is not weak-willed because he can’t get off his phone … Your kid’s brain is being engineered to get him to stay on his phone.”

WHO?

• Dr. B.J. Fogg (Stanford) – psychologist father of persuasive technology (aka persuasive design)

“Addiction is good for business”.

Persuasive design – WHO?

Dopamine labs (now Boundless Mind) in Venice, LA

• Neuroscientists specialising in persuasive design and addictive tech

• Use AIs and persuasion profiles to change behaviour in ways the user is unaware of, or which they think are their own choices.

• “Neuroscience has shown us that habits are programmable, and data has shown us that each person requires their own unique program”

• “Sesame makes returning to your app irresistible for your users.”

Tech titans reveal the truth

• Tristan Harris (ex Google): “The job of these companies is to hook people, and they do that by hijacking our psychological vulnerabilities.”

• Marc Benioff, CEO of the cloud computing company Salesforce: “product designers are working to make those products more addictive”. Such technologies are not “understood by parents” which gives social media firms an “unfair advantage”.

• Former Facebook president Sean Parker: “The thought process that went into building these applications, Facebook being the first of them… was all about: ‘How do we consume as much of your time and conscious attention as possible?’”

Facebook exploits “vulnerability in human psychology”

“God only knows what it’s doing to our children’s brains.”
Targeting vulnerability

- People are wired to seek basic needs – social belonging, control/mastery, self-esteem
- Screen products exploit this by generating a temporary sense of belonging, competency and achievement.
- Girls – social media: Boys - video games
- Facebook, 2017: leaked documents obtained by The Australian: Facebook showed advertisers how it has the capacity to identify when teenagers feel “insecure” and “worthless”
- Boast: can micro-target ads down to “moments when young people need a confidence boost.”

The Fogg Behaviour Model

- **Motivation:** Key motivator: desire for “social acceptance”; powerful desire to “avoid being socially rejected”
- **Ability:** Digital products should be designed so that users don’t have to “think hard” and are easy to use
- **Prompts:** Should be triggered to use a site. Many attention grabbing tricks here:
  - Incessant notifications
  - Reminder someone is missing out (FOMO)
  - Check to see if anyone liked your post or photo
  - These demand the users’ attention and compel users to stay on the site and return again and again

The Fogg Behaviour Model

![Fogg Behavior Model](image)

Features that compel us to watch/check in/respond right now or feel that we are missing our on something really important (FOMO kicks in):

- **App notifications** (check your app) – align an external trigger (eg ping) with internal state (bored, uncertain, insecure etc.).
- **Autoplay** (‘bottomless bowl’ phenomenon; people eat 73% more calories at ‘all you can eat’)
- Snapchat “snapstreaks” (measure of no. and quality of friendships)
- “like backs” (rule of reciprocation; respond to one positive action with another)

Constant triggers gain your attention

- **Randomness:** keeps you tuned in, just in case. Key part of gambling addiction also. Reward anticipation.
- **Zeigarnik effect:** never ending story, no closure, keeps you attending
- **In-app purchases:** keep you playing and buying. Then ‘invested’ in your purchase. Also, the more you make, the more the company knows about you (and your friends) to add to your persuasion profile. They then tailor products just for you and offer them at the time you are most likely to buy.
- “likes”
- **Messages that self-destruct**

Dopamine labs/Boundless Mind: Create a habit

- **How Boundless AI Works**
  - Pick a User Behavior
    A frequent user action that is valuable for your user and your business, such as opening an app or completing a task.
  - Pick an Enhancement
    A fun, visual cue used to reward the user for completing that action and activating their habit system.
  - Connect to Boundless AI
    Connect to our API to access our tools and options (AI builds persuasion profile)
  - Watch Your Engagement Grow
    Monitor how your app is performing, and get feedback on how to improve.

- **Identify what you want from target.**
- **We will provide the habit forming cue to reward that action**
- **Put each user on an individualised program (AI builds persuasion profile)**
- **Builds habits automatically (out of awareness)**
Dopamine

- **Aim**: Release dopamine into the brain’s pleasure centres: a very complex system but a key part is dopamine to nucleus accumbens via mesolimbic pathway
- In addiction, dopamine to prefrontal cortex is reduced
- When a reward is unpredictable, dopamine is released when anticipating the reward
- Compulsion to continually check email, social media etc, is driven in some cases by dopamine releases that occur in anticipation of receiving good news.
- Phantom phone notifications

What design features make a video game addictive?

6. Easy to use; Low cognitive effort; Effort usually translates to achievement
7. Increasingly tedious tasks seduce the player to “play” indifferently (Yee, 2013)
8. Arousing, Generates strong emotions
9. Targets vulnerabilities (eg isolation); meets basic needs (e.g., control, self esteem, inclusion); vanishes when screen is turned off
10. Games evolves when player is absent; regular upgrades
11. Do not reward short and unscheduled periods of play

What design features make a video game addictive?

13. Cannot save between levels so need to go to next level or lose progress
14. Design features slow down play forcing you to play longer
15. Immersion in a cool virtual world; BUT lose awareness of external surroundings
16. ‘Invested’ through in-app purchases etc.
17. Top players rich and idolised
18. Seen as harmless so people don’t worry about the potential for addiction

The big lie: Pleasure versus happiness

- Happiness/contentment linked to the neurotransmitter serotonin.
- Due to the interplay between dopamine and serotonin in the addiction process, serotonin levels can become reduced
- Thus seeking pleasurable, rewarding sensations that increase dopamine can come to some degree, at the expense of serotonin, and, potentially, happiness
- Addicts unhappy – tolerance reduces pleasure and serotonin deficits further impact happiness/depression
- People want to be happy; **Big Tech want you to equate pleasure (which can be addictive and commercially valuable) with happiness (which people desire).**
- Message: you can buy happiness (with our digital product).

Increases in suicide rates and depression coincide with the smart device revolution
Ryan, 2018; see Twenge et al 2018
Twenge et al 2018

Depression increasing for females

Twenge et al 2018

Having at least one suicide risk factor increases with device use

Tech-based fixes

- **Autoplay**: typically the default – go into settings and turn off
- **App notifications**: typically the default – go into phone or app settings and turn off
- **Snapstreaks**: explain what Snapchat are doing; limit to one time per day
- **Randomness**: turn off app notifications – go into phone or app settings and turn off; set a timer for once a day and check then (regularity vs randomness)
- **In-app purchases**: Don’t make them. Buy the full, paid versions of games – cheaper and safer in the long run.

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Neurological impacts of screen overuse

Taken together, studies show screen addiction is associated with:

- Structural and functional changes in the brain regions involving:
  - Executive function
  - Emotional processing
  - Decision making
  - Cognitive control

(See Dunckley, 2016)

Neurological impacts of screen overuse

Grey matter atrophy (shrinkage, loss of tissue volume) in grey matter areas where cognitive processing occurs.

(see See Dunckley, 2016; Zhou et al., 2011; Yuan et al., 2011; Weng et al., 2012, 2013)

- Frontal lobe – executive functions
- Planning
- Prioritising
- Organising
- Impulse control

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Neurological impacts of screen overuse

Grey matter atrophy (shrinkage, loss of tissue volume) in grey matter areas where cognitive processing occurs. (see Dunckley, 2016; Zhou et al., 2011; Yuan et al., 2011; Weng et al., 2012, 2013)

• Striatum
• Reward
• Suppression of antisocial impulses

Reduced cortical thickness in frontal lobe (Hong et al., 2013; Yuan et al., 2013)

• Impairment on cognitive tasks
• Less efficient information processing
• Reduced impulse inhibition

(Deng et al., 2013).

Dopamine and reward system

• Key part of the reward system; Heavily implicated in the formation and maintenance of addiction
• Extensive gaming and screen use may produce long-term changes to reward circuitry, similar to drug dependence
• Dopamine released during gaming (Koepp, 1995; Weinstein, 2010) – pleasure
• Not the huge increase as with drugs (up to 1400% increase) BUT increases within normal range (50-100%); can cause addiction (see ASAM earlier).

Compromised white matter integrity (see Dunckley, 2016; Lim et al., 2012; Yuan et al., 2011; Hong et al., 2013; Weng et al., 2013)

(Think myelin sheath and neuron efficiency)

• Poor communication between brain centres including between front brain higher functions and mid brain survival, emotion functions
• signals from brain to body

Attention deficits

• Christakis et al 2014 longitudinal study
• 2613 children aged 1 and 3 years
• Followed till 7 years
• For every hour of television watch per day, 9% increase in subsequent attentional problems consistent with ADHD
• Doulton et al 2007 longitudinal study
• Level of TV viewing at ages 5 and 11 years predicted attentional problems in adolescence
• A range of possible confounding factors held constant

Neurological impacts of screen overuse

Grey matter atrophy (shrinkage, loss of tissue volume) in grey matter areas where cognitive processing occurs.

• Insula
• Development of empathy, compassion
• Ability to integrate physical signals with emotions
• Links to violent behaviour
• Impacts depth and quality of relationships

Neurological impacts of screen overuse

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Neurological impacts of screen overuse

Executive functions
- Lillard & Peterson, 2011.
- 4 year olds have 9 minutes of watching popular, fast-paced, fantasy TV
- Immediate impairment to executive functions
- Likely due to ‘speed of editing’ and novelty of content
- Recent brain studies suggest both violent media and screen overuse cause reduced executive function, including longer-term effects.

Neurological impacts of screen overuse

Empathy deficits
- Normally empathy activates affective pain regions (dorsal anterior cingulate cortex, insula) associated with having experienced such suffering yourself.
- With repetition, empathy is learned
- During internet use, such areas show almost no activation (Sigman 2012).
- 40% drop in empathy from 1979-2009 (Konrath, et al., 2011). Most of this from 2000 onwards

REMEmber
- In teenagers, emotion- and reward-sensitive areas develop faster than inhibitory, regulatory mechanisms such as the prefrontal cortex
- This makes teenagers more likely to struggle to inhibit the seeking of behaviours they find rewarding – to do what feels good.

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Social interaction vs Electronic Media Use


Social isolation
- Despite the technology and communication revolution, rates of loneliness have doubled since the 1980s
- Cigna (health insurer) 2018 report: N=20,000, loneliness scale
- 46% of Americans are considered lonely.
- Generation Z (adults ages 18-22) and Millennials (adults ages 23-37) are lonelier and claim to be in worse health than older generations.
- Students have higher loneliness scores than retirees.
- “Loneliness has the same impact on mortality as smoking 15 cigarettes a day, making it even more dangerous than obesity”. (Cigna 2018 report).
- Former US Surgeon-General Vivek Murthy: social isolation is associated with a reduction in lifespan “even greater than that associated with obesity”. https://hbr.org/cover-story/2017/09/work-and-the-loneliness-epidemic
Social isolation

- Humans need face to face interaction and human touch
- Social isolation linked with global alterations to genes
- Key hormones not released (e.g. oxytocin)
- Greater risk of:
  - Inflammatory diseases such as diabetes, cardiovascular disease, high blood pressure
  - Autoimmune disorders such as arthritis, lupus.
  - Reduced immune function, susceptibility to illness
  - Weight gain and smoking more
  - Higher mortality
  - Reduced memory and mental performance
  - Depression (Holt-Lunstead, 2017; Sigman, 2009; Tate, 2018)

Physical Health

Leon Straker

- Physiological load of playing video games similar to resting or watching TV - heart rate, respiration rate, estimated energy expenditure, trunk and limb muscle activity and movement
- Screen use is sedentary; displaces activity; tracks to adulthood; links to serious illness
- Poor posture – muscular-skeletal risk
- Enhances fine motor skills at expense of gross motor skills

Obesity

- Meta analyses show that increased TV time is linked with a greater prevalence of overweight/obesity (McKetta & Rich, 2011)
- Equivalent to consuming an extra 100 calories per hour of television watched
- Not just about being sedentary
- Stronger for TV than other screen use because of the influence of advertising and snacking while watching.
- Important moderators – context of use, family environment and limit setting, SES, gender and sleep.

Sleep

- Kids need their sleep!
- Chris Seton (2017) notes 4 ways that screens sabotage sleep
  - Takes up sleep time
  - Used in bed, mixed messages – is the bed a place to do wakeful activities?
  - Excitatory to the brain – wakeful neurochemicals like dopamine and adrenaline
  - The blue light effect

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IMPROVE tool for assessment

- The I M P R O V E tool from NIIRA  

  - I take an Internet Inventory
  - M Monitor usage and activities over time
  - P Parenting factors
  - R Real world activities
  - O Other mental health issues
  - V Vulnerability factors
  - E Is there now extra help needed?

Warning signs

- Early warning signs from clinical practice:
  - Withdrawal from other activities
  - Increased time in room
  - Irritability
  - Tiredness
  - Decline in daily functioning
  - Decline in grades

Counselling factors

- When to help; when to refer – Tam, 2013
  - From the ‘Level 1 – 4’ model as outlined:
    - Level 1 ~ ‘in-home’ efforts, self-help
    - Level 2 ~ school counsellor
    - Level 3 ~ clinical psychologist
    - Level 4 ~ (‘addiction’) psychiatric in-patient unit plus medication considerations

Counselling factors

- Sensitive, holistic mental health assessment
- Always treat the underlying cause
  - Isolation
  - Agency, control, mastery
  - Social potency
  - Self-esteem
  - Feels undervalued by others

Counselling factors

- Balanced approach – video games have many positive aspects and potentials
- Help teenager to develop insight into their own behaviour
  - Why is it so rewarding?
  - What needs does it meet?
  - When and where do I play?
  - How do I feel when playing?
  - How do I feel when not playing?

- Build identity around achievements that don’t vanish when the screen is turned off.
  - Factors to take into account in decisions:
    - May be a key part of identity
    - May be a key part of relationships
    - Feelings of social obligation?
    - May meet key needs
    - Rewards and success are usually not immediate or guaranteed in real life. Prepare a life strategy that works in the real world

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A healthy media diet

- How much
- Content
- Age appropriateness

Screens and sleep

- Dr Chris Seton the real expert here
- A screen-free time before bedtime
  - 2 hours recommended but every bit helps
- Establish a routine in the ways Dr Chris Seton has suggested
- Look for pre-sleep activities that are relaxing rather than stimulating
- Device basket

Active monitoring

In a recent study increased parental monitoring of screen use was associated with reductions in screen time, violent media exposure, aggressive behaviour and BMI, and increases in hours of sleep, pro-social behaviour and school performance.

Power of monitoring
(Gentile et al., 2014; JAMA-Pediatrics)

Access and balance

- Keep screens out of the bedroom
- This will usually help to lessen the amount of use and moderate the type of use
- Aim for more physical activity time than sitting screen time
- This isn't easy, but in an ideal world parents would be creating lots of fun opportunities each day for activity, this can include replacing sedentary e-games with active e-games but should also include more real-world activity than e-based activity.

Exercise

- Cannot overstate the importance of regular exercise (40 minutes 5 times a week of reasonably vigorous exercise) on mental health
- Helps restore homeostasis (cardiovascular system, hormones, brain chemicals move back towards homeostatic levels)
- Double whammy – too much screen time often reduces exercise time and can cause things to get out of whack.
Looking after the body

• When playing video games, have an active break after 30 minutes
• This minimises prolonged sitting and sustained close-vision effects and helps to switch to other activity
• Encourage a good safe screen/playing technique. That is, a technique that:
  • Avoids poor postures;
  • Avoids repetitive movements;

Managing resistance to making screen time changes

From clinical practice, the following can help: (see Marshall, 2019)

• Control the WiFi – Internet a reward not a right.
• Use software to control WiFi. Profile for each child, allowing you to turn internet access on and off; also set schedules.
  • KoalaSafe
  • Family Zone
  • Parent power
  • Norton Core (and others).
• Content filters Qustodio, Net Nanny, Surfie [good for mobiles] (although most teens can work around them).

Managing resistance to making screen time changes

• Don’t make it a war over devices; control the internet instead.
• Make a family plan and honour it
  https://www.healthychildren.org/English/media/Pages/default.aspx
• Minimise mobile data so it doesn’t undermine the family plan
• Need face to face time with friends for social development. Don’t buy into the argument that online interaction is the same – it isn’t!

Be a good role model

• Model appropriate screen use and participation in real world activities
  • Children copy their parents, so modelling healthy screen use is crucial;
  • Children are more likely to be active if their parents are. In Canada, programs that replaced screen time with family time were met with initial resistance by kids, but after 6 months or so family members came to prefer family time.

Creating a new generation of healthy screen users?

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