

Smartphones won't make your kids dumb. We think.

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Like many parents, Sandy is concerned about how much time her 18-month-old spends in front of screens. Weighing up the available evidence, Olivia Solon explains that she might be worrying too much.

Jessica's tiny fingers dart around the iPad, swiping through photos to get to a particularly entertaining video: a 12-second clip of her dancing clumsily to Beyoncé's Single Ladies. The 18-month-old taps "play" and emits a squeal of delight.

After watching the video twice, she navigates back to the home screen and opens up the YouTube app to watch an episode of the colourful animation Billy Bam Bam. Halfway through, she moves onto a Yo Gabba Gabba! game, which involves anthropomorphised fruits making their way into a character's belly.

When Jessica's mum, Sandy, tries to take away the iPad, there's a tantrum that threatens to go nuclear: wobbly lip, tears, hands balled into fists and a high-pitched wail. "She does this a lot," says Sandy. "She seems to prefer the iPad to everything else. Sometimes it's the only thing that will keep her quiet," she adds, frantically waving a pink fluffy unicorn in an attempt to appease her daughter.

Like many [parents](#), she's worried about her child's obsession with screens. She wants to know which activities are best, and how much time spent on screens is too much.

It's six years since the launch of the iPad and, with it, the rebirth of tablet computers. The academic research simply hasn't been able to catch up, which means it's hard to know the long-term impact on young brains of being exposed to tablets and smartphones.

The concern among some experts is that these devices, if used in particular ways, could be changing [children's](#) brains for the worse – potentially affecting their attention, motor control, language skills and eyesight, especially in under-fives, for whom so much brain development is taking place.

Technology companies and app developers are throwing their marketing prowess at the problem, slapping words like "educational" and "e-learning" on their products, often without any scientific basis. So what are parents to do?

People have always feared new media. Almost 2,500 years ago Socrates was decrying the spread of written language, arguing that it would erode memory and knowledge. In the 15th century it was the printing press that brought about moral panic. Benedictine monks, who profited from hand-copying reading materials, petitioned against the mechanised printers, saying: "They shamelessly print, at negligible cost, material which may, alas, inflame impressionable youths."

When radio arrived, it too was deemed a menace, blamed for distracting children from their homework. A 1936 article in Gramophone magazine reported that youngsters had "developed the habit of dividing attention between the humdrum preparation of their school assignments and the compelling excitement of the loudspeaker".

Few technologies, however, have invaded our lives – and those of our children – as stealthily as the mobile computer, most commonly the smartphone or tablet. These devices are the right size for little hands to

handle them, and the touchscreens easy for tiny fingers to manipulate. Plus there's so much you can do on these devices: watch videos, play games, draw pictures and talk to relatives thousands of miles away.

In 2011, a year after the iPad launched, just 10 per cent of US children under the age of two were found to have used tablets or smartphones, but by 2013 that figure had nearly quadrupled. A 2015 study in France found that 58 per cent of under-twos had used a tablet or mobile phone.

There's little clarity around the consequences of long-term use of such devices. The American Academy of Pediatrics (AAP) has erred on the side of caution, recommending absolutely no [screen time](#) for children under the age of two, and a two-hour daily limit for those older. These restrictions simply don't tally with how many people are integrating these devices into their children's lives, nor do they reflect the fact that some interactions with screens might actually be beneficial.

"If your child is under two and is exposed to a screen it's not going to be toxic to their brain: they won't be turned into idiots," says Michael Rich, Associate Professor of Pediatrics at Harvard Medical School and an AAP member. "But there are potential downsides... and parents need to make a series of risk–benefit analyses." The AAP is now in the process of revising its guidelines, and they are due to be published in late 2016.

So why don't we know more about the risks of children using screens? There's a fundamental problem at the basis of all the research in this area – what do we even mean by "screen time"?

Firstly, it's important to distinguish between types of screen: do we mean a television screen, a tablet, a smartphone or an e-reader? Secondly, the nature of the content matters: is it an interactive drawing game, an e-book, a Skype call with Grandma or a stream of Netflix Kids videos?

Thirdly, there's the context: is there a caregiver in the room talking to the child as they interact with the screen or are they left on their own?

To date, we have comprehensive research about children and television exposure, but we don't yet know how much of it applies to interactive screens like tablets and smartphones.

There are a few things we do know. Most child development experts agree that while passive screen time – such as putting your child in front of a device for a Peppa Pig marathon – might be entertaining, it isn't going to provide a rich learning experience. In this case, it doesn't make a difference whether they're watching on TV or a tablet: the experience is broadly the same.

Having a video or TV on when a child is doing something else can distract them from play and learning, negatively affecting their development. Hours of background TV has also been found to reduce child–parent interaction, which has an adverse impact on language development. This displacement is a big concern: if kids are left with screen-based babysitters then they are not interacting with caregivers and the physical world. There are only so many hours in a day, and the time spent with screens comes at the expense of other, potentially better, activities.

Under-threes, in particular, need a balance of activities, including instructed play, exploring the natural environment, manipulating physical toys and socialising with other children and grown-ups. The rise in screen use means less of all of these things. "Parents need to think strategically," says paediatrician Dimitri Christakis, Director of the Center for Child Health, Behavior and Development at the Seattle Children's Research Institute. "If your child has 12 hours awake and two of those are spent eating, how will you allocate the rest of the time?"

The problem is that tablets are extremely appealing to children and adults alike. Thanks to their design, versatility and intuitive interfaces, tablets are a perfect way for children to draw, solve puzzles and be entertained on the move. Combine that with marketing efforts of digital media companies and app developers – whose measure of success tends to be the amount of time people are glued to their creation – and you have a toy that's difficult to prise out of tiny hands.

Many apps are designed to be stimulus-driven, with exciting audiovisual rewards for completing tasks. Christakis refers to this as the "I did it!" response, which triggers the reward pathway in the brain. "The delight a child gets from touching a screen and making something happen is both edifying and potentially addictive," he says.

Because of this, tablets and smartphones make for excellent pacifiers, particularly on long plane journeys and in restaurants. "The device itself is seen as a pleasurable source of comfort and parents play into that," says Christakis.

"It's pretty common," says Jenny Radesky, Assistant Professor of Pediatrics at the University of Michigan. "It becomes the go-to, easiest tool the parent is using." Although helpful in the short term, it's important for young children to be able to develop internal mechanisms of self-regulation, whether that's learning without constant rewards or being able to sit patiently without constant digital stimulation.

Christakis says that, anecdotally, he and others are starting to see younger and younger patients using these devices compulsively. "We know there's such a thing as problematic internet use in older children and adolescents, and it stands to reason that the same would happen with infants," he says. And he's doing research to find out more about this.

In Seattle's Center for Integrative Brain Research, a cluster of tiny pink

mouse pups wriggle in a mass behind their mother. The rodent family home is a sawdust-filled clear plastic container, one of hundreds stacked up in a rotating system of shelves. These are the "control" mice used by Christakis and neuroscientist Nino Ramirez, and their team, trying to understand the impact on young brains of being exposed to fast-paced media.

Across the corridor an experiment is underway. One of the mouse containers is surrounded by bright lights and speakers. For 42 days, six hours every day, baby mice are exposed to the high-octane soundtrack of Cartoon Network shows accompanied by synchronised flashing lights in red, blue and green. The apparatus has been designed to find out what happens to the rodents' brains when they are overstimulated by media during a critical window for their development.

The results are startling. "Overstimulating them as babies primes [them] to become hyperactive for the rest of their life," says Ramirez. The overstimulated mice take more risks and find it harder to learn and stay attentive. They get confused by objects they've seen before, for example, and find it more difficult to navigate through a maze. When given the option to dose themselves with cocaine, the overstimulated mice were much more prone to addiction than the control group. These behavioural changes are matched by changes in the mice's brains.

The theory is that the same applies to children: overstimulating them with media – particularly in an age of tablets with endlessly streaming, hard-to-ration videos and flashy interactive games – may cause an imbalance in part of the cerebral cortex called the basal ganglia. It's this part of the brain that allows us to pay attention to critical tasks and ignore distractions. Such overstimulation could lead to problems in later life, particularly with focus, memory and impulsivity.

"It seems that you can overstimulate young brains to the point that day-to-

day life won't excite to the same extent," says Ramirez.

Before we trigger mass panic about a generation of hyperactive, inattentive, cocaine-using post-millennials, it's important to note that these experiments have attracted criticism for a number of reasons. Six hours of any activity per day is a huge amount of time, particularly when it involves nocturnal mammals like mice (although the researchers say the mice show no signs of stress). Furthermore, Christakis, Ramirez and colleagues don't actually show the mice a real screen with any meaningful content – it is just a flashing proxy for a screen.

The rodent research being carried out in Seattle is unique in its scope and approach, which explains why it's frequently used as evidence of the evils of screen time. While mouse models are by no means perfect, they are useful for studying the underlying mechanisms relating to basic cognitive processes, which are fairly constant throughout mammals.

As mice have relatively short lifespans, it's possible to examine developmental trajectories over much shorter timeframes and get real insight into what's going on inside their brains. All of this can be done in a controlled environment that simply would not be possible with human subjects.

If, as suggested, cognitive development is affected by exposure to media, then this kind of research could inform the types of screen-based interactions we allow young children to have. Should parents be concerned? "They should be vigilant and careful about the amount of time and the content their children have access to," says Christakis.

Although it's a challenge to conduct controlled experiments with babies, it is possible to observe what happens with children 'in the wild'. From this, we can draw possible links to their habits with mobile devices.

In California, Maria Liu heads up the Myopia Control Clinic at UC Berkeley's School of Optometry. She's seen a sharp increase in young children with myopia (shortsightedness). "It's increasing at an alarming rate worldwide and a well-accepted contributing factor is the early introduction of handheld devices to kids."

In our early years, our eyeballs are very adaptive and plastic, so spending lots of time focusing on objects close-up will make the eyes more likely to be near-sighted. "The eyeball will grow longer to compensate for the prolonged near stress," Liu says. She doesn't have any evidence-based recommendations for a time limit on use of devices, but says "frequent breaks from near work" are very important.

Tablets and smartphones are typically viewed much closer to the face than things like televisions or desktop computers. Although books are also read up close, studies have shown that children tend to hold them further away than they do screens.

The other problematic aspect of screens is that they have been shown to disrupt sleep. The blue light emitted by the super-sharp displays can interfere with our natural bodily rhythms, preventing melatonin, an important sleep hormone, from being released. This in turn can lead to sleep impairments in adults and children alike. Sandy says that if Jessica uses the tablet before bed she gets "noticeably riled up". So, she says, they try to use books instead. This issue is why the latest version of Apple's software for iPads and iPhones comes with "Night Shift", which automatically swaps the blueish light for a warmer hue before bedtime.

In London, Max, who is 12 months old, is sitting on his mother Helen's lap in a small, darkened room. On his head is a rubbery cap covered in electrodes. They are measuring the electrical activity in his brain as he looks at physical objects and at digital representations of those objects on an iPad screen. On each of Max's ankles is a smartwatch of sorts, one

measuring his movements and the other his heart rate. The cap uses electroencephalography (EEG) to record his brain's electrical activity, to understand whether real and virtual objects trigger different brain responses and how that relates to subsequent learning.

The experiment is part of the TABLET project in the Babylab at Birkbeck, University of London. It's the first ever scientific study investigating how children aged six months to three years are using touchscreen devices and how this influences their cognitive, brain and social development.

In a second experiment, Max sits in a curtained-off booth facing a screen that displays a 15-minute loop of video that includes trippy abstract animations and sounds, as well as still pictures and videos starring PhD students as stand-in children's TV presenters. He's completely mesmerised, and his eyes dart from object to object on the screen. Eye-tracking cameras capture the dance of his gaze, and outside the booth research fellow Celeste Chung keeps track of how his eye movements match up with the items on screen.

"All the child is doing is looking at the screen, but their gaze behaviour tells us about their learning and anticipations," says Tim Smith, a cognitive scientist who heads up the Babylab.

The team is trying to understand how easily Max, and dozens of other babies like him, can focus attention and block out distractions when working on a particular task. In one of the tests, an object appears at the centre of the screen and then a second object appears, near the edge of the screen, shortly after. In order to look at the second object, the child needs to disengage from the central one, which requires self-control. This is a very important measure of executive function, the brain's 'air traffic control system', which helps a child analyse tasks, break them into steps and focus on them until they are done – a key predictor of success

in later life.

Like Christakis, Smith is interested in finding out whether there really is a link between the reward learning found in many apps and a child's ability to focus. "We might find that if tablets are being used for a lot of reward learning and the child becomes driven by an external stimulus then they might develop an impairment in executive function because they aren't used to controlling their own attention," he says.

Smith isn't entirely convinced by the mouse model used by Christakis and Ramirez in Seattle, although he agrees that their six hours of media stimulation a day could be reflective of a small number of children's home environments where there are multiple devices and televisions that can contribute to sensory overload. "Some of the parents in our study are reporting three hours of tablet use a day [for their children]," says Smith. "That is a large proportion of their waking hours using a screen that doesn't conform to the laws of physical reality."

As for the effects on language and motor development, he hypothesises that there could be displacement going on. "The technology may be used as a nanny in place of face-to-face learning. Babies always learn better from people, but we don't always have time." Devices like iPads may give lots of stimulation but lack the nuanced real-time social feedback that helps develop language, says Smith. Similarly, tablets and phones may make children dexterous at fine motor control with all the tapping and swiping, but they may have less motivation to get up and explore the world around them.

After around an hour of assessment, Max's patience for screen-touching, eye-tracking, brain-monitoring and other distractions from his busy schedule of rampaging around and eating bread sticks wanes. He starts to grizzle and wriggle and claw at the EEG cap. These movements corrupt the brain activity data. "That's the interesting challenge with infants,"

says Smith. "They're completely non-compliant to instructions."

What about the educational potential of devices? There are thousands of apps, e-books and videos purporting to have educational value for children, yet very few have been able to support this claim with solid research.

"The app marketplace is a digital Wild West," says Mike Levine, Chief Executive of the Joan Ganz Cooney Center in New York, which has analysed hundreds of children's literacy apps in a series of reports. "Most of the apps labelled as educational provide no research-based advice or guidance... Less than 10 per cent of the apps we looked at had any stated evidence of efficacy [in the descriptions in the app store]."

Unintentionally, some interactive "enhancements" to stories (such as animations, sounds and features that let kids tap and swipe) might actually be decreasing the overall educational value. While enhancements might appear to be engaging children, they could, in fact, be distracting them from the educational content.

This idea was put to the test by Adriana Bus and colleagues, at Leiden University in the Netherlands, who tracked children's eyes while they read interactive e-books. They found that when there were animated parts of the picture not directly relevant to the narrative – for example, trees moving in the wind in the background – the children's eyes were diverted to those points of motion rather than taking in the story. Relevant animations, on the other hand, can be beneficial, particularly for children who struggle with language and reading comprehension.

Even if apps are found to have educational value, toddlers still learn better from experiences in the real world than they do from equivalent two-dimensional representations on screen. Studies in the US have shown that when dealing with visual–spatial problems, such as finding

hidden objects or solving puzzles, toddlers (under around 30 months) perform much better when the problem is presented in real life rather than on screen.

"It is thought that the cognitive load of transferring information from two dimensions... to three dimensions... is too great for children prior to age 30 months," write Jenny Radesky and her colleague Barry Zuckerman in their study of digital play. Children this young are still developing the ability to choose what to pay attention to and what to ignore, and they have trouble generalising from symbolic representations to the real world.

Preschool-aged children need to interact with actual physical objects in order to develop their parietal cortex, which controls visual–spatial processing and helps develop maths and science skills in later life. To address this, some app developers are introducing companion toys that can be manipulated by little hands alongside the apps.

What we don't yet fully understand is how much value there is to the tactile element of touching interactive screens, something that requires a connection between the eyes, fingers and brain, and that passive viewing lacks. Does manipulating a digital object on screen enhance the learning process and make it easier to transfer knowledge into the physical world? And can understanding this mechanism help us develop better digital learning tools?

Regardless of our feelings towards tablets and smartphones, these devices are here to stay. So how do we get the most out of them? Thanks to some 100 years of research into how children learn, we can make educated guesses about what sort of interactions, in what sort of circumstances, are best.

Devices such as tablets and smartphones can make the most impact in

lower-income households. In these households, people tend to have less access to developmental resources – such as music lessons, extra tuition or just extra hours of social interaction – and so spend more time with digital media. Provided the content is high-quality, tablets and smartphones can have a big impact.

For example, a study from Stanford University in the US found that, by 18 months, toddlers from disadvantaged families are already several months behind their more advantaged peers on language proficiency. With the right content and context, digital devices can help bridge the divide.

"It's a bit privileged and unrealistic to say no to technology," says Levine. "I worry that we are seeing people wagging their fingers at others because they do not have the privileges of time and resources that other families might have.

"There's no way we're going to improve the educational performance of young children without using technologies."

Instead of banning devices, we should be demanding better apps built on solid research. For children aged between three and five, it's entirely possible that a well-designed app can help improve vocabulary and basic maths skills. "My youngest is speech-delayed, and the videos he watches have definitely helped him learn new words," says Lisa, a mother of four- and six-year-old sons who have been using mobile technology since they were 18 months old.

All of the paediatricians, child development and education specialists I spoke to agreed that, for children under 30 months, there is no substitute for human interaction. So why not develop apps that act as mediators between infant and caregiver? BedTime Math is one example. The app delivers engaging maths story problems for parents and their children. It

is one of the few tools that have been shown to make kids smarter; children who used the app even just once a week for a year improved their maths by more than a control group did. The impact was particularly strong for children whose parents were anxious about maths.

With so much focus on what children are doing, it's easy for parents to forget about their own screen use. "Tech is designed to really suck you in," says Radesky, "and digital products are there to promote maximal engagement. It makes it hard to disengage, and leads to a lot of bleed-over into the family routine."

One approach that has been shown to help under-threes learn better is to build tools that use "nudge technologies" geared at the parents. This could be text messages or emails that remind parents to sing or talk with their baby, to help both parents and child disengage from technology and apply learnings to the real world. Children's tablet maker LeapFrog does something similar with its LeapPad devices. Parents receive emails about what their child has learned from the touchscreen, along with ideas of how they could apply this new knowledge away from the screen.

"The extent to which parents are tied up with these devices in ways that disrupt the interactions with the child has potential for a far bigger impact," says Heather Kirkorian, who heads up the Cognitive Development & Media Lab at the University of Wisconsin-Madison. "If I'm on the floor with a child but checking my phone every five minutes, what message does that send?" How much parents play with and talk to their kids is a very powerful predictor of how the kids will develop, she adds.

Radesky has studied the use of mobile phones and [tablets](#) at mealtimes by giving mother-child pairs a food-testing exercise. She found that mothers who used devices during the exercise started 20 per cent fewer verbal and 39 per cent fewer nonverbal interactions with their children.

During a separate observation of 55 caregivers eating with one child or more, she saw that phones became a source of tension in the family. Parents would be looking at their emails while the children would be making excited bids for their attention.

"You would see parents losing it and raising their voices because it's extremely irritating to be focusing on something and have a child escalate their requests for attention," she explains, adding that some parents would do things like shove their child's hand away. Restricting the use of devices at critical family moments such as mealtimes and before bed can help reduce these frictions and encourage more face-to-face conversations.

Infants are wired to look at parents' faces to try to understand their world, and if those faces are blank and unresponsive – as they often are when absorbed in a device – it can be extremely disconcerting for the children. Radesky cites the "still face experiment", which was devised by developmental psychologist Ed Tronick in the 1970s. In it, a mother is asked to interact with her child in a normal way before putting on a blank expression and not giving them any visual social feedback. As the video shows, the child becomes increasingly distressed as she tries to capture her mother's attention.

"Parents don't have to be exquisitely present at all times, but there needs to be a balance and parents need to be responsive and sensitive to a child's verbal or nonverbal expressions of an emotional need," says Radesky.

Although we are still in the early days of understanding the impact that mobile computers are having on [young children](#), the key piece of advice from the child experts I spoke to was to make sure that device use is just one part of a rich diet of activities, particularly for under-threes, who seem to struggle to learn from screens.

Interactive, creative touchscreen experiences should be preferred over passive TV-like viewing. Parents should take educational claims from [app developers](#) with a hefty pinch of salt.

Where possible, a [device](#) should be used as a tool to enhance interactions with the child, whether that's as a launchpad for discussion ("What's the cow doing over there?" "What sound does the duck make?") or as a way to inspire educational conversations that spill into the rest of the day, as appears to happen with BedTime Math.

Tronick's still face experiment did not involve screens, but a number of researchers have cited it as evidence that parents shouldn't be distracted by their smartphones when they are around their babies. This is true to an extent, but Tronick himself underplays its significance. "It's all a bit exaggerated," he says, adding that most children do plenty of activities every day that don't involve screens.

He is concerned that the worries about kids' use of screens is born out of an "oppressive ideology that demands that parents should always be interacting with their child".

"It's based on a somewhat fantasised, very white, very upper-middle-class ideology – tiger moms and helicopter parents – that says if you're failing to expose your child to 30,000 words you are neglecting them." Tronick believes that just because a child isn't learning from the screen doesn't mean there's no value to it – particularly if it gives parents time to have a shower, do some housework or simply have a break from their child.

"Many parents, particularly low-income parents, are horrifically stressed and concerned they don't get the support they need and find parenting really lonely. Those are the big problems," he says.

Parents can get a lot out of using their devices to speak to a friend or get some work out of the way. This can make them feel happier, which lets them be more available to their child the rest of the time. For Sandy, this is a relief to hear. "Sometimes I'm at the end of my tether," she says, adding that she shouldn't have to feel guilty about giving her child the iPad so she can have some "me time". With some parents, there's a lot of snobbery about screen use, she says.

"As a mum, I put my 18-month-old in front of an HBO baby poetry video," says Radesky. "It's cute and calm and I can wash the dishes or do something that's a reset for me. That's a benefit, but it's something parents need to be very honest about. The video is not educating my 18-month-old. It's a break for me as a parent."

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