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A mouse model for too much TV viewing?

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Abstract

In a new study, Christakis and colleagues investigate a mouse model for technology-induced overstimulation. We review their findings, discuss the challenges of defining overstimulation, and consider the resemblance of the phenotypes observed in Christakis *et al.* to those noted in genetic models of attention deficit hyperactivity disorder (ADHD).

In the age of smart phones, On Demand TV, handheld DVD players, and video games targeting individuals of all ages, the impact of technology on the brain – particularly the developing brain – is a matter of significant interest to both neuroscientists and the general public. One trend, in particular, that researchers have documented with concern is an increase in television viewing by infants. Some have highlighted a potential negative impact on the development of language, cognition, and attentional capacity [1], echoed in a recommendation by the American Academy of Pediatrics that media use be avoided in children under age 2 [2]. Yet, ‘technology’ is a complex entity, associated with both beneficial and detrimental effects on child development (see [3], for a review). It is thus critical to investigate what constitutes beneficial versus harmful technology exposure.

How can scientists break down the various components of ‘technology’ and study their effects on brain development and function in a controlled manner? In a creative new study, Christakis and colleagues debut a possible solution – a mouse model of ‘overstimulation’, meant to recapitulate the effects of excessive television viewing in early childhood [4].

In this study, speakers playing sounds from children’s TV shows were mounted above mouse cages and LED lights of varying colors and intensities were shone in accordance with the audio. This overstimulation paradigm (Figure 1a) was applied to mice developing from postnatal day 10 to postnatal day 52, for 6 hours every night. Later, starting at postnatal day 62, behavioral and cognitive assessments were conducted. The elevated plus maze (Figure 1b), light dark latency, and open field tests revealed that overstimulated mice were generally more active and less anxious/more likely to take risks than controls, whereas the Barnes maze and novel object recognition (Figure 1c) tests suggested that overstimulated mice had diminished short-term memory and learning difficulties [4].

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This new mouse model powerfully illustrates the detrimental effects of audio-visual overstimulation during youth. However, the study also raises a number of questions, most fundamental of which is the definition of overstimulation itself. What constitutes a mouse version of too much television? Because there is no clear consensus on this phenomenon, even in humans, it is challenging to establish the validity of a mouse model. Nevertheless, one can begin by considering the ‘construct validity’ (strength of manipulation used to mimic the human condition) and ‘face validity’ (resemblance of resulting phenotypes to key attributes of the human condition), as set forth by researchers evaluating mouse models of psychiatric illness [5].

The established extremes for studying the impact of experience on brain development are sensory deprivation and environmental enrichment. In sensory deprivation models, rodents are often raised in the absence of light or without exposure to different frequencies of sound [6]. In environmental enrichment models, they are usually raised in groups, in spacious cages filled with friends and complex, frequently changing toys – conditions that increase multisensory and cognitive stimulation, physical activity, and social interactions [7].

Excessive audiovisual stimulation, the model used in the present study, is a form of increased multisensory stimulation. However, it is very different from that occurring in environmental enrichment models, as the increased stimulation here is mandatory and experienced passively – not the result of animals actively interacting with their environment. While the passive aspect of the paradigm makes it a good model for human television viewing, the mandatory nature of the mouse overstimulation is not very similar to what young children experience (or may find rewarding). Therefore, in future studies it may be of value to add an element of choice to the overstimulation paradigm.

It may also prove worthwhile to directly compare such an overstimulation paradigm to environmental enrichment offered in a similarly structured cage. If opposing behavioral and cognitive effects are attained in a side-by-side comparison, it would not only strengthen the overstimulation model, but might also serve as a starting point from which to pare down the variables that distinguish beneficial forms of stimulation from detrimental ones.

From the face validity perspective, although there is no established list of phenotypes for overstimulation in humans as a basis for comparison, we can certainly say that the negative impact of the overstimulation paradigm on cognitive performance differs from what is observed in environmental enrichment studies, in which there is generally a positive impact on cognition [7]. One purported phenotype of early television exposure is attentional problems later in childhood – problems reminiscent of attention deficit hyperactivity disorder (ADHD) [1]. It is thus interesting to compare the phenotypes observed in the overstimulated mice to those found in genetic models of ADHD.

Notably, the hyperactivity and impaired learning and memory phenotypes of the overstimulated mice are also observed in at least two different genetic models of ADHD, the G protein–coupled receptor kinase–interacting protein-1 (GIT1) knockout mice and dopamine transporter knockout mice [8,9]. In future studies it may be interesting to conduct cognitive analyses of the overstimulated mice, beyond the Barnes maze and novel objection recognition test, and also to determine if these mice display molecular changes in GIT1, dopamine transporter, or other genetic pathways linked to ADHD. One key difference between the overstimulation phenotype and ADHD to keep in mind, however, is the impact on anxiety: here the overstimulated mice displayed signs of seemingly reduced anxiety, while in humans ADHD is often comorbid with anxiety disorders [10].

Another important topic for study, mirroring questions about excessive television exposure in humans, is whether the behavioral and cognitive changes observed in overstimulated mice

can be attributed to a reduction or disruption of other activities – effectively, ‘deprivation’ of sleep, social interaction or communication amongst the mice. Finally, from a neuroplasticity standpoint, given that we know these young animals are in the midst of critical periods of brain development [6], a natural question is whether the excessive audiovisual stimulation interferes with proper refinement of neural circuits that control locomotion, anxiety, and cognitive functions such as those tested in this study.

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Figure 1.

The effects of growing up overstimulated. **(a)** Christakis and colleagues modeled excessive television viewing by exposing young mice to sounds from children's TV shows (such as 'Pokemon', 'The Powerpuff Girls', and 'Bakugan') and LED lights of varying colors and intensities, modulated in accordance with the audio – six hours each night for six weeks. **(b)** Ten days after the overstimulation period ended, the mice underwent a battery of behavioral tests. Shown here is the elevated plus maze test. Compared to control mice, which tend to avoid open arms of the maze, overstimulated mice spent more time in the open arms and traveled greater distances within these arms. Together with results from the light dark latency and open field tests, this suggests that overstimulated mice are less anxious/more likely to take risks and more active. **(b)** Shown here is the novel object recognition test, in which a mouse's preference for a novel object over a familiar one is tested. Overstimulated mice exhibited less preference for novel objects than control mice. Together with results from the Barnes maze, this suggests that the overstimulated mice have learning deficits. Figure courtesy of Lia Min.