



## The Internet and the Brain

# Issue Brief

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This issue brief focuses on the relationship between the Internet and brain development. While we address both brain structure and brain function, the research emphasis is on development of executive function.

### **ABOUT THE INTERNET AND THE BRAIN**

The human brain is a complex entity whose development is shaped not only by genetics but also by its environment.<sup>1</sup> It triples in volume in the first 2 years of life, building and pruning the connections that allow humans to perceive the world through their senses, think, make decisions, consider risk, build empathy and relationships, and engage in the whole range of human experience. Babies and children are building these capabilities as they grow. In particular, the pre-frontal cortex is often cited as the epicenter of the brain's higher-level executive functions, which include such tasks as "judgment, decision making and problem solving, as well as emotional control and memory."<sup>2</sup> The prefrontal cortex develops throughout childhood and adolescence in response to genetics and external stimuli, and it isn't completely formed until approximately age 26.

Environmental factors have a profound impact on how the brain develops. Given the amount of time that children spend online each day,<sup>3</sup> the Internet may be considered an environmental factor that could have a significant influence on brain development. The question is how Internet exposure affects brain development, and what determines whether those effects are positive or negative.

Questions related to the brain and Internet use cross many academic disciplines. Specifically, the topic of Internet addiction in relation to brain structure and function is prevalent due to the currency of the topic, as well as the lack of seminal research in this area.

### **WHAT IS THE RELATIONSHIP BETWEEN THE BRAIN AND INTERNET USE?**

#### *Cognition*

According to the American Psychological Association, cognition is a broad set of "processes of knowing, including attending, remembering, and reasoning; also the content of the processes, such as concepts and memories."<sup>4</sup> Using IQ tests, researchers determined that adolescents addicted to the Internet had lower IQ scores in several areas, most noticeably comprehension and vocabulary; however, this study could not definitively determine whether the lower cognitive performance was a result of being addicted to the Internet, or if those with existing cognitive defects are more prone to Internet addiction.<sup>5</sup> In contrast, a study examining longitudinal data of children's computer use determined that cognitive effects were positive.<sup>6</sup> In addition to traditional cognitive processes, cognitive bias and a sense of self are also studied. Another study focused on maladaptive cognition, in which an individual believes that their online self is better than their real-world self.<sup>7</sup> Adolescents in this study who suffer from this type of thinking are more likely to be addicted to the Internet.

#### *Internet Addiction and the Brain*

Brain imaging studies also indicate some abnormalities in adolescents suffering from Internet addiction, including lower grey matter<sup>8</sup> and structural brain changes over the duration of the addictive behavior.<sup>9</sup> One imaging study found that young men (aged 20-25) craved playing a game online, and these cravings were similar to those experienced by people with a substance addiction.<sup>10</sup> Another study with similar findings determined that game-playing cravings stimulated the prefrontal cortex.<sup>11</sup>

In addition to illuminating the relationship between Internet addiction and brain structure, these studies raise an interesting question about the relationship between Internet addiction and substance use, and whether the brain experiences them in similar ways. Studies have found that youth who use alcohol, tobacco, or drugs may be at a higher risk for Internet addiction, given their addictive tendencies,<sup>12</sup> and that the same parts of the brain are stimulated in individuals suffering from substance addiction or Pathological Gambling as in individuals suffering from online gaming addiction.<sup>13</sup> Also of note is that one study found that the brains of young adult men were stimulated when they won a gaming task,<sup>14</sup> suggesting that the brain responds more to winning than losing.

#### *Selected Executive Functions*

The frontal lobe, responsible for impulse control and other executive functions, is one of the last areas of the brain to develop myelin.<sup>15</sup> This leaves the brain at risk for challenges related to executive functions for a longer period of time. How and whether Internet use relates to those challenges and to that development is still being explored.

One such function is impulse control. Cognitive tests have shown that children often react impulsively under normal circumstances, not taking the time they need to complete certain tasks.<sup>16</sup> As children mature into adolescents, a continued lack of impulse control can lead to risk-taking behaviors, including substance abuse, especially if they have been exposed to abuse or domestic violence as children.<sup>17</sup> This relationship may also exist relative to Internet use: A study of adolescents (age 12-18) demonstrated that those who were addicted to the Internet were more impulsive according to two measures. However, the researchers could not determine whether impulse control led to or was a result of addiction.<sup>18</sup> As adolescents mature into adults, this propensity for impulsivity may decline; one study of adults aged 25-30 found no relationship between impulsivity and Internet addiction.<sup>19</sup>

Decision making is another executive function that may be affected by Internet use, especially Internet addiction. For example, the Iowa Gambling Task (IGT) was created to test an individual's decision-making skills as they relate to uncertainty, reward, and punishment.<sup>20</sup> Several studies employ the IGT with those addicted to the Internet, and one study found that young adults who are addicted to an online multiplayer game (i.e. World of Warcraft) made riskier decisions than those not addicted to the game.<sup>21</sup> In another study, researchers found that young adults had "difficulties in balancing immediate rewards against long-term negative consequences."<sup>22</sup>

## **EFFECTS DEPEND ON CONTENT**

### *New Media Versus Old Media*

Defining "Internet" content use can raise questions about the lines between traditional media and new media. For example, are videos viewed online categorized as Internet or as video? Children can watch video (e.g., favorite funny videos on YouTube) on laptops, tablets, and mobile phones. Is such viewing akin to watching their favorite comedic sitcom on an actual television set? Although the motivation for choosing online video or television may differ,<sup>23</sup> the act of viewing video could have the same effect. Results on the effects of television viewing on both altering brain structures and executive function<sup>24-26</sup> are extensive, and more studies are needed as online video continues to replace traditional television viewing.<sup>27</sup>

#### *Social Media*

With the advent of social media, recent studies have explored how this phenomenon has affected cognition. In particular, researchers are studying the impact of adolescents and young adults using Facebook. One study found that users who viewed their Facebook profile had an immediate increase in self-esteem but a decrease in cognitive abilities (measured by a simple math test).<sup>28</sup> The authors posited that the boost in self-esteem might have led to a decreased motivation to perform well. Another study examined whether active or passive use of social networking sites affected cognitive skills, and determined that Facebook use, whether occasionally or regularly, had no impact on working memory, verbal ability, spelling, and math.<sup>29</sup>

## **CONCLUSION**

The topic of brain development and media effects is wide in scope, with research focusing on both brain structure and brain function, but there is still one area that has the potential for growth. Most of the research on the brain and Internet use focuses on adolescents, young adults, and adults. As it becomes common for children as young 2 years old to spend more time online, we will need research to understand how their online activities impact and alter the brain.

Additionally, more research is needed in order to understand the long-term effects of Internet use on the brain. As adolescents are still developing, the research has shown how difficult it can be to determine whether brain structures and functions can be permanently altered.

Lastly, future research is needed to clarify the definition of Internet. A significant body of research exists in regards to the effects of television on the developing brains of children and adolescents, some of which might provide a foundation for various activities online. As technology and the concept of the Internet moves away from screens, mobile phones, and tablets, and into devices such as watches and eyeglasses, researchers will need to continue to explore the effects of these devices on brain development.

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