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CONNECTED BUT PROTECTED: GUIDING HEALTHY BRAIN DEVELOPMENT IN THE DIGITAL AGE

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YOUNG REVIEWERS:

TAEYEON
AGE: 12

TAY
AGE: 15

Understanding the impact of smartphone use on teenage brain development is crucial. Excessive smartphone use can disrupt healthy brain development by weakening connections between brain cells, making it harder to regulate emotional reactions and other brain functions. Smartphone use can also make it harder for teenagers to focus and avoid distractions, thereby increasing their dependence on digital devices. Encouraging healthy smartphone usage habits is essential for teenagers' mental and emotional wellbeing, helping them develop necessary skills for regulating their thoughts, behaviors, and emotions. This article explains important findings on the effects of excessive smartphone use on teen brain development. These studies use brain imaging techniques to reveal

changes in brain activity and connections between important brain regions, particularly areas responsible for emotional regulation and control of thoughts and actions. Additionally, by providing practical tips for developing healthy smartphone habits, this manuscript helps young readers make informed decisions about their use of electronic devices.

RELATIONSHIP BETWEEN EXCESSIVE SMARTPHONE USE AND BRAIN

Smartphones are excellent tools that help us stay connected, learn new things, and have fun. Did you realize, though, that using a smartphone improperly can change how your brain functions? Using smartphones too much can affect how we handle our emotions. Excessive smartphone use refers to the inability to control smartphone usage despite its negative effects, such as trouble concentrating and interference with the activities of daily life. Previously, we found that people who use smartphones excessively showed reduced brain activity in two important brain areas when processing emotional facial expressions: the dorsolateral prefrontal cortex and dorsal anterior cingulate cortex (Figure 1) [1]. These areas are crucial for controlling our thoughts and actions (which is called **cognitive control**) and regulating our emotions. When people with high smartphone use see an angry face, their brain activity in these regions is lower than that of people with normal smartphone use. This reduced brain activity makes it harder for people to process and respond to other people's emotions appropriately.

COGNITIVE CONTROL

The ability to manage your thoughts and actions to achieve goals, which helps you to focus, make good decisions, and prevent yourself from being distracted.

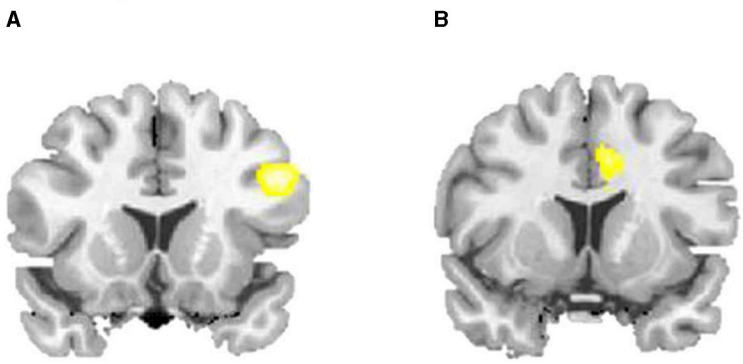

Figure 1

Brain regions related to cognitive control and emotional regulation: right dorsolateral prefrontal cortex **(A)** and right dorsal anterior cingulate cortex **(B)**.

BRAIN CHANGES IN GROWING KIDS

As kids grow, their brains go through a lot of changes. The parts of the brain that help manage emotions and make decisions are still growing. This means kids might sometimes find it difficult to understand and respond to the emotions of others, regardless of how much they

use their smartphones. Understanding how smartphones can impact the brain and learning how to use these devices in a healthy way is especially important for kids because their brains are still developing. Let us explore the effects of smartphones on brain development and discover tips for using them wisely.

HOW SMARTPHONE USE AFFECTS BRAIN CONNECTIVITY

FUNCTIONAL CONNECTIVITY

It refers to how different parts of the brain show the connection and interactions between them. It is about understanding how different parts of the brain are linked and collaborate differently to help you function effectively.

Excessive smartphone use can alter **functional connectivity** in the brain. Functional connectivity is like a telecommunications network that links various parts of the brain together. When these networks work normally, people do a better job at regulating their emotions and making decisions. But if people cannot control smartphone use, the brain's functional connectivity can become too weak or too strong. Altered functional connectivity makes it harder to regulate emotions and to control smartphone use.

We wanted to understand how smartphone overuse affects brain connections and how it relates to feeling stressed when not using the phone. In our original study, we compared 38 teens who used smartphones excessively with 42 teens who did not [2]. Excessive use was determined by a medical professional using the Korean Smartphone Addiction Proneness Scale (K-SAPS) for Youth [3]. Adolescents with high scores on the K-SAPS were included in excessive smartphone use (SP) group. Normal users—those with lower K-SAPS scores—were designated as Healthy Control (HC). Adolescents with SP spent 32.55 h per week on their smartphones compared to 15.18 h for HC.

WITHDRAWAL SYMPTOMS

Those are the uncomfortable feelings and reactions that happen when someone stops using a substance, they have been dependent on, like certain drugs or alcohol or stops doing addictive behaviors, like playing games, using smartphones or gambling.

In teens with SP group, we found that the functional connectivity between certain brain areas like the left orbitofrontal cortex (OFC) and nucleus accumbens (NAcc), and the right OFC and midcingulate cortex (MCC) were weaker. These connections are important for cognitive control in response to emotional stimuli and reward-seeking behavior which is focusing on doing something that feels like a reward or pleasure to oneself. Surprisingly, the connection between the MCC and NAcc was stronger in teens who overused smartphones. This could mean that teens with SP were more sensitive to the rewards they got from using smartphone and found more difficult to limit their smartphone use than HC since MCC and NAcc regions are related to reward-seeking, emotional regulation and decision-making.

CORTISOL

It is a hormone that your body makes when you feel stressed. Thus, cortisol is often called as the "stress hormone".

We also looked at the **withdrawal symptoms** teens felt when not using the internet, along with their levels of a stress hormone called **cortisol**. Teens with more severe internet withdrawal symptoms had higher cortisol levels. This stress might be changing how their brain areas connect (Figure 2).

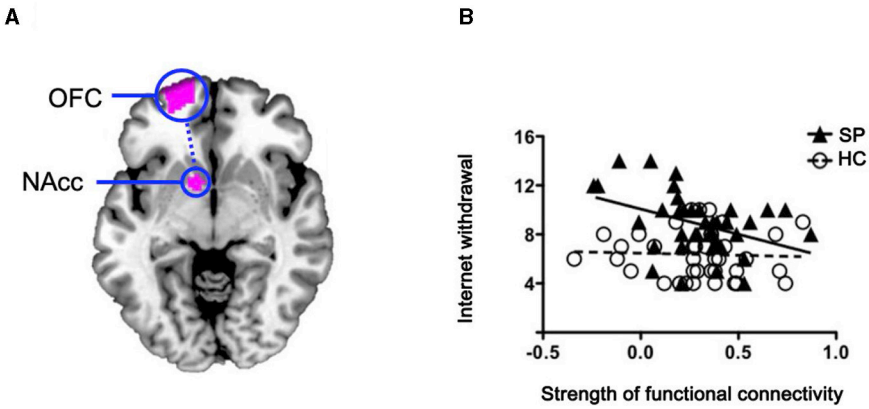

Figure 2

Figure 2

Correlations between withdrawal symptoms, cortisol concentrations, and functional connectivity. **(A)** The locations of the left OFC and left NAcc. **(B)** Adolescents with excessive smartphone use (SP) exhibit higher withdrawal symptoms from internet use and lower functional connectivity between the OFC and NAcc. That association did not show up in healthy controls (HC).

EFFECTS ON ATTENTION AND FOCUS

There is a growing worry that using smartphones too much might hurt a person's ability to focus. To study this, we compared brain activity during an attention task between two groups of teens: 33 of SP group and 33 of HC [4]. We used a type of brain imaging equipment called an fMRI scanner to measure participants' brain activity while they performed the attention task. Teens with SP showed higher brain activity in regions of the brain associated with decision-making and attention but presented worse performance on the attention task regardless of how difficult the task was. Additionally, compared to HC, SP group showed weaker connectivity between the right inferior parietal lobule and another brain area involved in attention, the right superior temporal gyrus, especially during difficult tasks (Figure 3). This weaker connection was related to their high smartphone dependence. Our findings suggest that people who use smartphones excessively are more easily distracted because their brains do not efficiently use the brain network responsible for **attention processing**— how your brain focuses on specific things while ignoring others. This study helped us understand the brain mechanisms behind why it is harder for excessive smartphone users to focus on the task and why they cannot ignore irrelevant information.

ATTENTION PROCESSING

Attention processing is how your brain focuses on specific things in order to intake important information while ignoring others. This ability allows you to concentrate, remember details, and respond to things happening around you.

DEVELOPING HEALTHY SMARTPHONE HABITS

To make sure smartphones do not negatively affect your brain, here are some tips for using them in a healthy way:

- **Set Clear Rules**: Decide on specific times when you can use your phone and stick to them. For example, avoid using your phone during meals or just before bed. Setting clear boundaries helps you understand when it is appropriate to use your device and encourages you to engage in other activities.

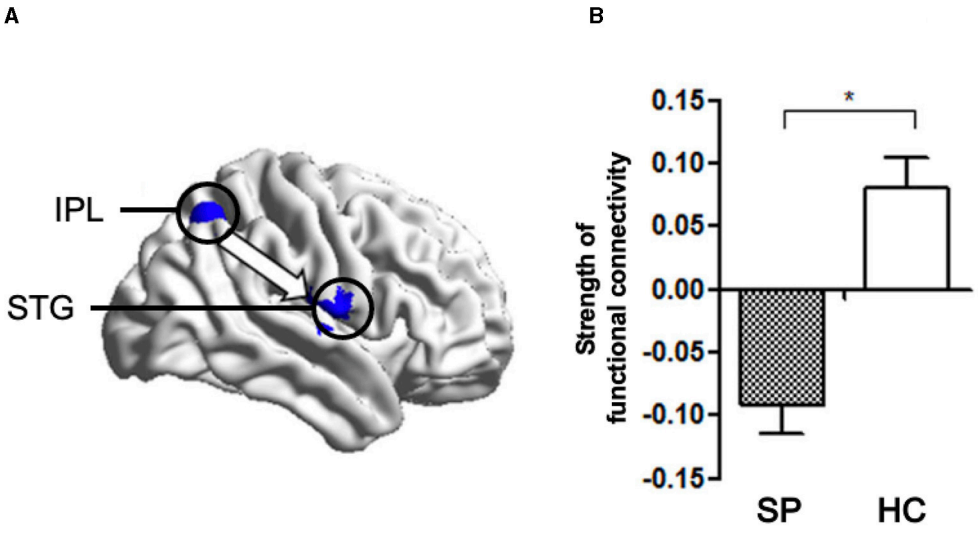

Figure 3

The effect of excessive smartphone use on the functional connectivity of the right inferior parietal lobule (IPL) and right superior temporal gyrus (STG) in an attention task. **(A)** The locations of the of the right inferior parietal lobule and right superior temporal gyrus. **(B)** Compared with the healthy controls (HC), the excessive smartphone user group (SP) showed decreased functional connectivity in these brain regions. The symbol (*) indicates a statistically significant difference between two groups.

- **Encourage Physical Activity**: Physical exercise is great for your brain. It helps you think better and feel happier. Try to spend some time each day being active, whether it is playing sports, riding your bike, or just playing outside. Regular exercise can counterbalance the negative effects of excessive smartphone use and promote overall wellbeing.
- **Promote Social Interaction**: Spend time with friends and family without using your phone. Talking to people face-to-face helps you build social skills and understand emotions better. Joining clubs, playing with friends, or participating in team sports can enhance your social interactions and reduce your dependence on digital devices.
- **Monitor and Support**: Keep track of how much time you spend on your phone and ask for help if you think you might be using it too much. Talk to your parents or teachers about setting limits that work for you. Using an application to manage smartphone usage, with help from your parents, can also be a good approach. Regularly checking on your smartphone usage and having open discussions about it can create a supportive environment for developing healthy digital habits.
- **Model Healthy Behavior:** Watch how adults use their phones. If they use them in a balanced way, it is easier for you to do the same. Try to follow their example and put your phone away during important activities. Adults can set good examples by demonstrating balanced smartphone use and prioritizing real-life interactions over digital ones.

IMPORTANT FINAL TAKE HOME MESSAGE

Our study helped us understand how too much smartphone use can affect the brain, especially in teenagers. Teens who use smartphones

too much have weaker connections between the OFC and NAcc, which is linked to more stress and withdrawal symptoms. This suggests that overusing smartphones might change the brain's reward system and make it harder to manage emotions and stress. Also, teens who use smartphones excessively are more easily distracted because their brains are not efficiently using the network responsible for attention focusing.

Smartphones are fantastic tools for staying connected, learning, and having fun, but it is important to use them wisely. By understanding how these devices can affect your brain and following some simple tips, you can make sure you are using your phone in a way that keeps your brain healthy and helps you grow. Remember, it is all about balance. Use your phone to connect and learn, but do not forget to spend time doing other important things that help your brain develop in the best way possible.

Using smartphones in moderation, engaging in physical and social activities, and understanding the impact of excessive use are all key to maintaining a healthy balance. By setting clear rules, encouraging physical activity, promoting social interaction, monitoring usage, and modeling healthy behavior, you can develop healthy smartphone habits that support your mental and emotional wellbeing as you grow. Make sure you stay "connected but protected" and enjoy the benefits of technology while keeping your brain healthy and strong.

ORIGINAL SOURCE ARTICLE

Choi, J., Cho, H., Choi, J. S., Choi, I. Y., Chun, J. W., and Kim, D. J. 2021. The neural basis underlying impaired attentional control in problematic smartphone users. *Transl. Psychiat.* 11:129. doi: 10.1038/s41398-021-01246-5

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CONFLICT OF INTEREST: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

YOUNG REVIEWERS

TAEYEON, AGE: 12
Charming smile 😄: If I smile, you will fall for my charm! Artistic soul 🎨, Bookworm 📚, Music lover 🎶, and Always ready for a new adventure 🌍.

TAY, AGE: 15
The whole experience with neuro brain science was great. I was glad I was able to help neuroscientists and I hope I become one of them in the future.

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