

# Digital Dopamine and Human Connections: Neural Responses to Online and Offline Social Feedback

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**ABSTRACT:** In a time where digital platforms are progressively influencing the way of living, understanding their neural factors and consequences becomes even more crucial. This literature review synthesizes findings from the fields of neuroscience and psychology in order to explore how online interactions on social media differ from in-person interactions in terms of stimulating dopamine and activating the brain's reward systems. Using fMRI and behavioral data studies, this review examines how forms of social feedback and interactions, whether positive or negative, such as comments and likes in comparison with real-life facial expressions and vocal tones, differ in terms of dopamine release and neural engagement. This literature review describes how while both interaction types stimulate the brain's reward system and dopamine, they do so through distinct mechanisms, social media mainly aids short term yet high frequency dopamine bursts due to the unpredictability of feedback, while in-person interactions happen to be more stable in terms of dopamine stimulation due to greater emotional engagement as the brain analyzes facial expressions and vocal cues, which often lead to more sustained dopamine responses. This neural contrast may explain why social media can be highly addictive to users while simultaneously contributing to cognitive and emotional disruption. Overall, this review highlights how the structure and delivery of social feedback, whether it's physical or virtual, shape not only our emotional experiences and engagements but also the differences in our brains' complex responses.

**KEYWORDS:** Digital Dopamine, Social Media Engagement, Neural Rewards Pathways, Online Social Feedback, Offline Social Interaction, Human Connection.

## ■ Introduction

A smile from a friend and a notification sound may both trigger feelings of pleasure; however, they may affect the brain in different ways. The brain is thoroughly navigating a new social landscape, one where online validation progressively rivals real-life human connections and communication. Recent neuroscience studies highlight the significant role of mirror neurons, which are specialized brain cells that help individuals stimulate and interpret the emotions and actions of others, and are more strongly activated in in-person contexts rather than online ones.<sup>1</sup> The brain's reward system, specifically the striatum, is central to processing social rewards and directing interpersonal behavior.<sup>2</sup> Social media and online social interactions can trigger reward pathways similar to those activated by in-person social validation and communications between individuals. Feedback such as likes and comments elevates dopamine connections within the neural reward system.<sup>3</sup> Nevertheless, research suggests that in-person interactions often engage other neural factors and processes, specifically the theory of mind, which allows individuals to have the ability to recognize that others possess independent thoughts, intentions, and mental states by utilizing their facial expressions and vocal tones.<sup>4</sup> Yet, social media platforms are deliberately designed and shaped to boost dopamine-driven reward cycles, which creates a pattern of engagement that may be more frequent and reinforcing than those found in in-person social interactions. As a matter of fact, approximately 60% of social media users check their accounts multiple times an hour, which reflects on reward-seeking be-

haviours.<sup>5</sup> Recent research studies highlight how social media activates the brain's reward systems in ways partially overlapping with those in in-person social interactions. However, the addictive factor of online social feedback may affect the user's emotional and cognitive engagement.<sup>5,6</sup> Furthermore, an experiment tested over 500 participants in a variety of experiments measuring cognitive capacity. Participants who had a phone on their desk, even while not in use, performed significantly worse. It was concluded that the presence of smartphones has the ability to reduce cognitive capacity by approximately 10-15%, which potentially affects how deeply people engage in in-person social events.<sup>7</sup> Despite these findings, there is still a gap in understanding how these variations in brain responses during in-person and online interactions impact dopamine stimulation and affect the function of the neural reward system over time. Social media and in-person interactions both are able to activate the neural reward system; they tend to differ in terms of dopamine levels and stimulation. This paper reviews literature and dataset and statistical analysis in order to investigate how social media and in-person interactions differ in terms of activating dopamine and the neural reward systems. This literature review compares neural processes in each interaction type, examines how positive and negative social feedback affect the neural reward system and shape dopamine doses, and highlights the cognitive costs and consequences resulting from digital presence, which impact offline social engagement. This literature review argues that while both online and offline interactions activate the neural reward system, they differ in how

dopamine levels are released and sustained. Online interactions promote rapid and repetitive dopamine release, whereas in-person interactions favor more sustained and emotionally rich responses, resulting in fundamental differences in social connections between individuals.

### ■ Neural Processes of Social Reward: Digital vs. In-person

Both digital and in-person social interactions activate the brain's reward system; they appear to do so in different ways. Social interactions activate the neural reward systems, specifically the striatum, which is a key brain structure that processes social rewards and guides interpersonal communication and behaviours.<sup>2</sup> Often, in-person, social interactions tend to engage a complex neural process other than dopamine release, incorporating brain regions involved in the theory of mind, which allows individuals to be able to interpret subtle social signals, such as facial expressions, and vocal tones/cues.<sup>4</sup> Recent studies highlight that these multisensory factors of in-person interaction contribute to more sustained and consistent dopamine responses and deeper emotional engagement and connections between individuals.<sup>8</sup> Meanwhile, social media and online interactions happen to trigger dopamine release through irregular and unpredictable bursts via likes and comments, leading to the engagement of reward systems in a different pattern from in-person social interactions.<sup>3,5</sup> An experiment was conducted, consisting of 32 adolescents, where participants were shown images that were either liked or disliked by their peers.<sup>9</sup> In this study it was found that receiving likes activated core neural reward regions, such as the Striatum, and the Ventral tegmental area (VTA), a brain region central to dopamine release and reward processing; the study also showed that giving likes produced similar activation patterns, reinforcing the dopamine cycle that stabilizes and sustains online engagement, although the small sample size reduces the generalizability of the findings. Furthermore, researchers argue that the way social media platforms are designed exploits the brain's reward systems in a manner similar to addictive substances, since dopamine is mostly tied to anticipation of reward rather than pleasure itself.<sup>10</sup> This unpredictable factor of these platforms makes users return continuously, forming uncontrollable use habits. Over time, these recurring surges may result in dopamine desensitization, meaning that increasingly frequent or intense stimuli are needed to trigger a similar neural response, replicating patterns of substance addiction.<sup>5,10</sup> Additionally, a recent study has shown that long-term social media use replicates biological addiction cycles and processes, establishing that habitual engagement with dopamine-driven social feedback loops can resemble the neurochemical and behavioral patterns seen in substance dependence.<sup>5</sup> This explains why social media habits often feel irresistible yet emotionally shallow in contrast to the more balanced and stable reward cycle present in in-person interaction. This social reward and validation stimulation tends to be more temporary, creating unhealthy habits and addiction for users, often lacking the emotional complexity found in in-person social connections.<sup>6,8</sup>

Understanding how these neural activations differ illuminates how the increasingly evolving social landscape shapes both physical and virtual interactions and experiences.

In-person social rewards in the brain involve synchronized activation from the striatum, as well as brain regions responsible for social cognition and the element of empathy, specifically the medial frontal cortex.<sup>2,8</sup> This integration helps advocate for the complex interpretation of intentions and emotions in individuals, which is highly crucial for social bonding situations. A recent study suggests that theory of mind regions in the neural system become more engaged in in-person interactions and settings where multisensory cues are available, granting increased interpersonal understanding and connection.<sup>4</sup> Contradictorily, social media interactions contribute fragmented social cues, mainly because of the lack of visual and verbal feedback, which, nevertheless, activate the brain's reward system through rapid dopamine doses, which are often linked to social validation.<sup>9</sup> The unpredictable factor of online feedback promotes uncontrollable and habitual behaviors, and users crave and seek the next dopamine hit.<sup>5</sup>

These neural differences suggest that although online and in-person social interactions have their way of stimulating the brain's reward systems, the quality, depth, and frequency of dopamine release vary significantly. In-person interaction incorporates factors such as emotional connection and cognitive engagement. While online social interactions may promote repetitive, yet emotionally shallow patterns of engagement. This analysis contains implications for mental health and social behaviors as individuals navigate a hybrid social environment, highly influenced by technology and social media. These neural differences become even more notable when considering the emotional valence of social feedback, which modulates and alters the brain's dopamine release and processes.

### ■ The Power of Emotion: How Positive or Negative Social Feedback Impacts Dopamine Responses

The emotional valence of social feedback (whether positive or negative) significantly shapes dopamine release and the neural reward systems in both online and offline social interactions. Positive feedback, like praise or peer approval, consistently activates regions of the brain known as the striatum and the medial frontal cortex, reinforcing social bonds between individuals and encouraging continued social interactions and neural engagement.<sup>2,11</sup> A recent study shows that receiving likes and comments on social media platforms generates similar dopamine-driven responses, which motivates users to keep up their online presence.<sup>3</sup> Through research, it is shown that this positive social reinforcement is enhanced by the unpredictable nature of social media, resulting in habits of addiction and compulsive use of these platforms.<sup>5</sup>

On the other hand, negative social feedback engages more complex neural processes related to feelings of rejection, emotional distress, and regulation, which modulate dopamine responses in different ways. As described in a relevant research study, it was shown how experiences of social rejection or crit-

icism activate brain regions that involve stress and negative effects, which potentially surpass the typical dopamine reward response.<sup>6</sup> This effect is mainly showcased in online environments, in which negative comments and public criticism may be amplified, resulting in increased anxiety, contributing to depression.<sup>5</sup> The intensified emotional impact of negative social feedback may reduce motivation for social engagement in an individual, contrasting with the impacts of the positive stimuli.<sup>11</sup>

To add on, the context in which social feedback is received regulates these neural and behavioral effects. For example, in-person interactions incorporate deeper and emotionally significant response cues in the neural system, things like facial expressions, body language, and vocal tones, which help individuals interpret feedback and sustain emotional responses.<sup>4</sup> On the contrary, the unpredictable and public nature of online feedback may intensify emotional reactions, making negative feedback harder to take in and cope with than expected.<sup>6</sup> This neural response cycle and patterns highlight that the same social stimuli can produce different dopamine responses depending on the form of interaction.

In summary, positive and negative social feedback influence the brain's reward system and dopamine responses differently. In-person interactions provide more distinct emotional cues, while online feedback tends to be more erratic, affecting how the brain responds. Together, these dynamics reveal that feedback valence is not just a small element of interaction processes but a key determinant of how the brain's reward system functions, including consequences for motivation, overall emotional health, and social connections. While feedback valence impacts dopamine in the moment, the constant presence of online platforms in daily life introduces additional cognitive costs that redesign long-term social engagement in both online and in-person settings.

### ■ Cognitive Costs and Consequences: How Digital Existence Shapes Real-World Connections

Smartphone presence and social media habits can significantly affect the brain's cognitive capacity, emotional engagement, and neural processing, which creates new challenges for meaningful in-person connections and interactions. Evolving online behaviors are changing the way individuals interact with one another in the real world. These patterns can disrupt traditional social norms, altering the brain's reward system while weakening an individual's ability to maintain essential social skills, reducing emotional engagement, and resulting in the depth of in-person relationships.

In today's world, social media platforms are increasingly influencing the way individuals connect and communicate with one another in both online and in-person environments. A recent study used fMRI methods to demonstrate that the mere presence of smartphones reduces one's cognitive capacity by 10-15%, impairing attention and working memory even when the smartphone is not actively being used. This decrease in cognitive resources limits the ability to fully interpret and process

essential social cues, which are vital for in-person interactions and emotional bonding.<sup>7</sup> Moreover, another study reports that over 60% of social media users check their accounts multiple times an hour, showcasing reward-driven obsessive behaviour that fragments attention across physical and digital social settings, weakening sustained emotional engagement.<sup>5</sup>

In-person interactions involve complex processes that the neural system engages, such as the theory of mind and emotional regulation, which depend on rich and nonverbal cues and contextual cues.<sup>4,8</sup> These processes amplify sustained emotional engagement and social understanding between individuals, supporting deeper dopamine-driven reward responses in in-person interactions. Distinctly, online social interactions are often brief and less emotionally engaging. Recent studies indicate that social media exploits dopamine-driven reward cycles, creating addictive patterns that may disrupt emotional depth and social cognition even in offline settings, ultimately decreasing empathy and weakening in-person social connections.<sup>5,6</sup> Which links back to the idea that while digital social interactions provide frequent dopamine bursts, they tend to lack the cognitive and emotional capacities needed for rich in-person social engagement.

Moreover, persistent digital connectivity shifts social norms around availability and responsiveness. Selective engagements and fractionate attention damage reciprocity and emotional presence, which are often found in in-person interactions and connections.<sup>4,7</sup> These changes have the ability to reduce the quality and depth of human connections that rely on consistent, repetitive dopamine hits in and out of online environments.

To sum up, online social behaviours and recurring smartphone presence disrupt resourcing and neural reward factors responsible for deep emotional connection. These disruptions tend to go against traditional social skill norms, highlighting the significance of understanding how to keep up meaningful interpersonal connections.

While lots of studies highlight the cognitive and emotional setbacks of digital engagement and interactions, others highlight its potential benefits. It appears that online interactions can expand social networks, provide community support, and offer social validation for individuals who lack the ability and access to in-person communication.<sup>12</sup> For some individuals, especially those experiencing social anxiety or geographic isolation, social media connections are able to create a sense of belonging that in-person interactions cannot always provide. From this perspective, the dopamine-driven reward cycles of social media platforms may not solely promote addictive behavior but support strategies for building and maintaining social relationships. That being said, these benefits do not invalidate the cognitive costs and addictive patterns that were previously discussed; they highlight the complexity of online platforms as both tools for social interaction and potential sources of neural and behavioral disruption.

### ■ Conclusion

This literature review has shown that both online and in-person interactions are able to activate the brain's reward system;

they differ in factors like depth, stability, and levels of dopamine stimulation. Social media creates short-term and recurring dopamine bursts due to the unpredictable reinforcement, such as likes and comments,<sup>10,12</sup> in contrast, in-person communication depends on emotionally richer cues such as vocal tones, body language, and facial expressions, which strengthen more emotionally grounded responses from individuals.<sup>4,8</sup> These differences convey significant implications; digital interactions are supported by an addictive design, where erratic social feedback may result in compulsive use of these social media platforms, alongside dopamine desensitization. Which can be similar to substance addiction and dependence.<sup>5,10</sup> Conversely, in-person social interactions tend to engage brain systems and regions that relate to empathy and social cognition, resulting in stronger bonds between individuals.<sup>2</sup> Moreover, emotional valence is also a crucial and significant factor in exploring the effects of these processes. Positive online and offline social feedback strengthens and activates the neural reward pathways, yet digital environments may intensify addictive patterns and habits, while negative online feedback can heighten stress and anxiety levels amongst users.<sup>6</sup> Finally, constant smartphone presence weakens attention spans and working memory, decreasing emotional depth levels in in-person interactions.<sup>7</sup> As social norms transition to constant connectivity, this new division of attention may impact individuals' ability to show empathy and maintain reciprocal social connections and interactions.<sup>6</sup> Collectively, these findings showcase a key tension which appears to be: online validation fuels and supports reward-seeking neural systems, but oftentimes at the expense of deep human connections in offline settings. To sum up, future research should cover the long-term differences and effects of dopamine engagement in digital and non-digital environments and how they affect mental health, overall social skills, and abilities. Scientific methods that merge both neuroimaging and real-world behavioral data may be especially significant and useful for understanding how online platforms and smartphones are reshaping human sociality.

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Salma Swar is a 16-year-old junior in high school, from Bahrain, currently living in Riyadh, Saudi Arabia, with a strong interest in neuroscience, psychology, and the impacts of digital technology on human behavior. Her research focuses on understanding the neural and cognitive mechanisms underlying social interactions in both online and offline contexts. Salma Swar has explored topics such as dopamine responses, neural reward systems, and the behavioral consequences of digital engagement. In addition to academic pursuits, she is passionate about sports, and mainly gets her social interaction through that. Her main goal is to bridge human science and technology and to promote mental health awareness.