

Understanding the neuroscience behind the peer relationship among adolescents in social media

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ABSTRACT

Social media have become an essential component of teenage life, from early adolescence through the college years, the peer relations among adolescents are, at least in part, living their social lives online. Adolescents are co-constructing their relationships and identities in the digital and offline worlds, and the distinction between offline and online relationships likely exists only in the minds of adults and not in adolescents. Many adolescents immerse themselves in social media, so ignoring its role in their social lives is not an option, and trying to limit their engagement with social media will likely not be productive. In India, it was estimated that there are 376 million social network users from 2015 to 2018 with two-thirds of Internet users belonging to the age group of 12-29 years. This study acts as a forerunner for researchers to embrace the study of adolescents' engagement with peers via social media, by understanding the neuroscience behind it. Overall, the transformation framework represents a departure from the prevailing approaches of prior peer relations work and a new model for understanding peer relations in the social media context. Thus, it suggests the need to develop safe spaces for online interactions to improve the quality of their relationships with their friends and partners.

Keywords: *Peer relationship, Neuroscience, Neurotransmitters, Social Media, Adolescents, Limbic system, Reward system, Dopamine*

Adolescence (approximately ages 10-19: WHO) being the second sensitive time of brain development, often involves dramatic changes in physical aspects, emotions, feelings, insights, and behaviour. During this timeline, peer-aged social signals become increasingly important relative to those of parents [1,2].

Physiologically, childhood involves relatively immature amygdala-prefrontal circuitry development where the maternal influence tends to buffer the cortisol stress response and modulate amygdala reactivity [3]. As the balance between mesocortical and mesolimbic dopamine systems transform during adolescence, the salience of social cues – engagement with new peers, gain social acceptance and associated social learning independent of the family environment, is reconfigured [4].

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The utilization of online social networking expanded quickly with over 3.6 billion individuals globally, where India was assessed to be home to a populace with a median age of ~ 27.1 years in 2020 [5]. Social media is considered to be an "electronic correspondence through which users make online networks and offer data, individual messages and other content. It was estimated that there were 270 million Facebook users (2019) and 340 million WhatsApp users (2020) making India the largest base of it apart from other platforms such as Instagram, Snapchat, LinkedIn, YouTube, Twitter, Quora, Pinterest, Tinder, Tumblr [5].

Social media and peer bonding

The National Consumers League (2012) reported that 32% of kids ages 8-10 and 69% of 11 and long term old had their mobile phone for communicating with peers despite age-restricted online platform registrations. Statistics show that 92% of adolescents go online daily, 89% belong to at least one social networking site, and 88% have access to cell phone [6]. 70% of online adolescents in India spend more than 5 hours on the internet in a normal week. Ease of availability with an urge of becoming independent remains one among the major reasons why online platforms are considered as primary means of interaction with peers.

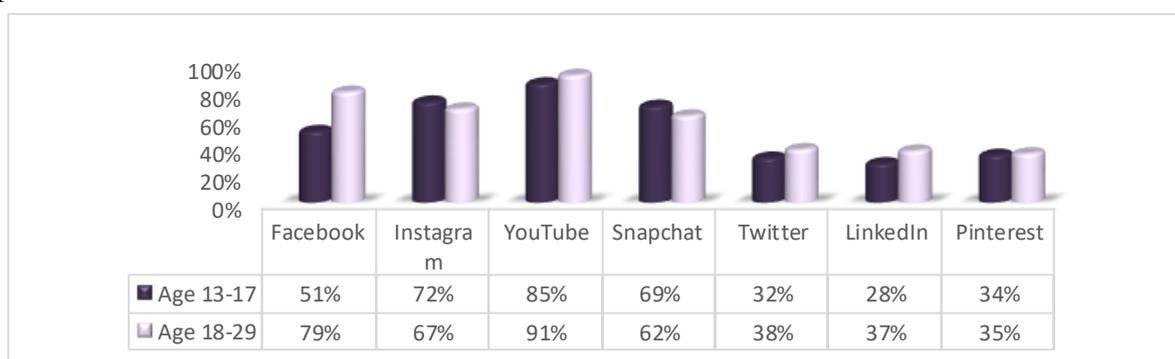


Figure 1., Illustrates the breakdown of online platform demographics by age

Peer impacts over neural networks

Drawing in with peers and shaping close bonds is a critical developmental task, which involves peer-influenced changes in social cognition, inhibitory control, and reward-related networks. Adolescence is the timespan wherein you are intensely mindful of the differentiations between who you have all the reserves of being and who you think you are. It's like the 'faker condition' – “imposter syndrome” in psychology, where a person experiences the ill effects of constant self-question and a feeling of scholarly worthlessness despite their obvious accomplishments [7].

With numerous discussions close by between the so-called – ‘materialists’, ‘physicalists’ and ‘reductionists’ who bring down the mechanisms of mind thoughts, emotions, consciousness to neural networks and the ‘cognitive researchers’ and ‘idealists’ who take an alternate view and state that the mind isn't reducible to neural networks [8,9]. The media influence over the ontogenesis of brain regions involved in social interactions remains ambiguous. Certain researches emphasize on the alterations in adrenarcheal and gonadal hormones during the adolescent years [10,11] being the cause for basic structural and functional development that happens in social cognitive neural networks [12]. Frontal and prefrontal lobes of the brain that help in “decision making”, planning, executing, and solving problems [13] are the last areas to reach a stable “matured” state. This is due to the back-to-

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front pruning that continues in pre-adolescents⁴. This highlights the reason where teenagers might rely on the amygdala (*associated with emotions, impulses, aggression and instinctive behavior*) to make decisions and solve problems more than adults do thereby sometimes resulting in illogical, emotional or impulsive behaviors.

Adolescents can be illustrated as the peak of the inverted U-shaped maturational curve, involving socio-affective & cognitive-behavioural areas of the brain— amygdala, striatum, anterior insula, posterior superior temporal sulcus, orbitofrontal cortex, ventral lateral prefrontal cortex and anterior cingulate cortex [14,15]. This Emotion-guided attention might lead to the changes in the perception of peers during adolescents' development of social neural networks [15].

Socio-emotional cues from peer teenagers suggest a valuation response in acceptance or avoidance behaviours in adolescents. This is associated with greater activation in limbic structures that involves the amygdala, hippocampus, nucleus accumbens, and ventral medial prefrontal cortex [16]. Along with the above-stated changes, adolescents tend to move away from parental guidance and towards the motivational influence of peers due to insufficient prefrontal – cognitive regulation (SIPN and the dual-systems model) [15]. Among younger adolescents, it was also hypothesized that lesser closeness to parents reported less activation in the dorsolateral prefrontal cortex (*DLPFC involved in higher-order functions*) and greater DS (*Dorsal striatum involved in reward and punishment*) activation than those who reported greater closeness with parents, thereby involved in peer-oriented risk-taking behaviours and lessened inhibitory control responses [17]. These activations within regions of brain varied with adolescents' age and their social connectivity which re-emphasizes to build positive inclination towards peer-groups.

The neuroscience behind peer influence on social platforms

Peer relationship always stays a significant and positive part of online media. Varied individuals converse with each other and share their thoughts, leisure activities, difficulties or interests, engaging in co-survey, widening affiliations without having fear of being judged or dehumanized [18]. As illustrated, the peer-influenced decision-making is common among adolescents regardless of the logical judgment, that can have both positive and negative influence while using social media. To understand these effects of online media on peer relationship among adolescents, it is necessary to explore the obscured neural mechanisms behind it (*Fig.2*)

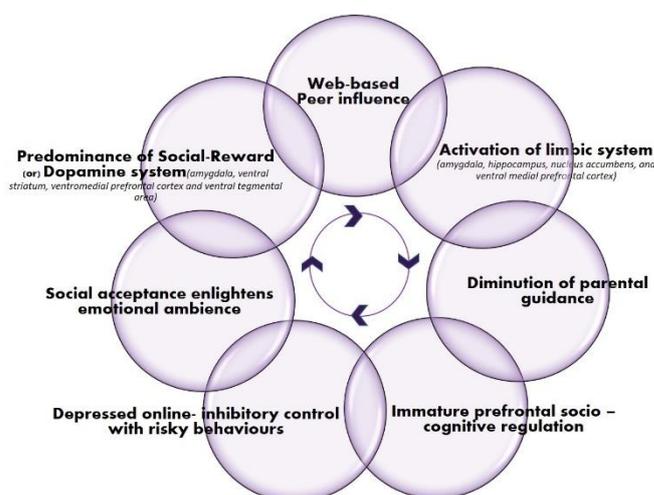


Figure 2., Illustrates the research hypothesis on the mechanism of neural networks behind online platform-based peer-influence among adolescents

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Brain development among adolescents is the turning point of one's life where social media assumes the biggest share by passively driving the sense of acceptance and well-being [19]. Utilization of emotional ambience plays a key role in drawing engagement towards social platforms. Users have the option to earn favourable comments, emoticons and likes that fosters creative development of self-identity, construct empathy or discover a network who is battling with comparable issues [20]. Many online platforms are personal story-driven, that allows users to post their pictures, videos or stories, thereby directly alluding to this blitheness.

Cortical changes during social acceptance and negligence

Sufficient pieces of evidence exist on changes in white matter connections with synaptic pruning and increasing synaptic density in the brain during early adolescence. Neuroimaging studies have also revealed that the grey matter volume over social neural networks – the medial prefrontal cortex, superior temporal cortex and temporoparietal junction peaks up before the age of 10 years, whereas dynamic non-linear region-specific changes in it continue throughout adolescence.

Self-centred peer reviews and social acceptance were stated to stir-up the reward systems of the adolescent brain that involved increased activity in the ventral striatum, ventromedial prefrontal cortex and ventral tegmental area (*associated with the subjective experience of pleasure, emotions and reward especially social and monetary rewards*) [21]. Sensitivity to “likes” of peers on social media is a strong reinforcer among adolescents thereby encouraging their self-esteem.

Socially rejected, maltreated, or insecure attachment demonstrated enhanced activity in the orbitofrontal cortex, ventral striatum, subgenual anterior cingulate cortex (ACC) and insula (*associated with violating behaviour*) that impacts opinions, behaviour and conclusions. This can result in exaggerated demotivation of self-image with lower self-esteem. Cyberbullying forms the trigger point to the above quotes of ostracism. In contrast, peer engagement reduced ACC response in adolescents

Neurochemical transitions

Among various postulates, one of the salient speculations for immature excitement and impulsive behaviour during adolescent life is explained by predominant glutamatergic neurotransmission yet under-developing Gamma-aminobutyric acid (GABA)ergic neurotransmission in the prefrontal cortex during adolescence. Grossly, latter results in an unfledged limbic system that may also be affected by environmental neurotoxins. This, in turn, leads to peer-influenced risky, pleasure-seeking behaviours that involve social maladjustments and addictive behaviours – drug & alcohol abuse, cigarettes, caffeine, wearing provocative apparel, for instance, unprotected sex and pornography [19].

Neuroimaging evidence on emotional ambiances

Cognitive Neuroimaging studies have demonstrated rationale proportionality between empathy and activity in the medial prefrontal cortex, the superior temporal sulcus and the temporal-parietal junction (*associated with social brain network*). Emotional arousals via social media comments encourage media-based interactions among adolescents; thereby furnishing a more noteworthy feeling of the direction of life, expanded degrees of bliss, improved emotional wellness, and be embellished with a feeling of acknowledgement.

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The SIPN model explains how the emotionally gripping media controls precedence over cognitive reflection and biases subsequent information processing. This allows adolescents to consider even fake news as real in online social platforms. Intense activity is noted in the dorsolateral prefrontal cortex (DLPFC) on playing violent video games due to its late maturation among adolescence. This provides sustained insights to regulate cognitive self-control and manage their anger after being socially excluded by peers. Elevated TPJ (Temporo-parietal junction) response to positive social cues and reduced response to negative cues may underlie a tendency to recruit mentalizing networks more in the context of social approach signals, which may facilitate positive mutual engagement with peers [15].

Table 1: Summarizes the functions of various neural networks and their impact on behaviors.

Literature	Neural network	Function	Persuaded behavior
Vijayakumar, N et al., (2018); Forbes, E. E et al., (2010)	↑ Adrenarcheal and gonadal hormones	Pubertal development	Hormonal attraction towards peer-group
Giedd, J. N et al., (1999)	↓ Frontal and prefrontal lobes	Decision making & executive function	Determination to stand independent
Nelson, E. E et al., (2005)	↑ Limbic system	Motivation, emotion, learning & memory	Socio-emotional valuation towards peer-group
Morningstar, M et al., (2019)	↓ Dorsolateral prefrontal cortex (DLPFC)	Higher-order functions	Lesser closeness to parents
Giedd, J. N et al., (2010)	↑ Amygdala	Emotional & aggressive response	Illogical, emotional or impulsive behaviors.
Albert, D et al (2011)	↑ Dorsal striatum	Reward, reinforcement and punishment	Peer oriented risk-taking behaviors with lessened inhibitory control.
Tamir, D. I et al., (2013)	↑ Ventral striatum, ventromedial prefrontal cortex and ventral tegmental area	The subjective experience of pleasure, emotions, social & monetary rewards	Seeking Self-centered peer reviews and social acceptance
Kennedy, K., (2019)	↑ Orbitofrontal cortex, ventral striatum, subgenual anterior cingulate cortex (ACC) and insula	Violating behavior	Exaggerated demotivation of self-image with lower self-esteem and social exclusion
Kennedy, K., (2019)	↓ Anterior cingulate cortex (ACC)	Violating behavior	Mutual peer engagement
Morningstar, M et al., (2019)	↑ Medial prefrontal cortex, the superior temporal sulcus and the temporoparietal junction (TPJ)	Empathy and social recognition	Media-based peer- interactions with a feeling of acknowledgement.
Markram et al., (2014)	↓ Gamma-aminobutyric acid (GABA)ergic neurotransmission in the prefrontal cortex	Inhibitory-excitatory balance in mature brains	Social maladjustments and addictive behaviors
M Ernst et al., (2015)	↑ Dopamine system	Neural processing of reward and motivated behavior.	Enlightened sense of self-esteem

NOTE: ↑ *Increased activity*; ↓ *Decreased activity*

Besides these cognitive tricks, increased levels of FOMO (Fear of missing out) when not on social media, possibly prompt an idea known as online media dependence/enslavement, an idea strengthened by the formation of the Berge Facebook Addiction Scale [22]. Contrast

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regions were also activated when experiencing salient emotions, hence leaving it undetermined whether environment influences brain development or vice versa.

The technical limitations of neuroimaging, that includes poor temporal resolution especially in MRIs, mapping metabolisms, dynamics of neural networks by tracking the amount of electrical activity produced by the brain and other responses across different temporal and spatial scales, makes it difficult to reveal changes in mind [23,24].

Negative implications

Adolescence is a crucial stage for characterizing self-personality and adolescents are inclined to social comparison [25]. Diminished activity in the cognitive network of the brain, arising due to pessimistic peer relations, has negative impacts over brain development. Explicit use of social media in the night time before bed corresponds with more adverse effects than in the day. Logically, it is evidenced by invigorating brain activity before sleep or exposure to blue light from screens that stifles melatonin levels, thereby diminishing quality and quantity of sleep.

This in turn raises the liability of self-destruction like suicide, anxiety, anger, drug use and depression [26,27].

The World Health Organization (WHO, 2017) detailed that 10-20% of adolescents overall experience mental health problems. 1 in every 5 teenagers, aged 13-18, have or will have a psychological ailment and 90% of the individuals die by suicide due to it as per “The National Alliance on Mental Illness (NAMI)”. It also reported that 11% of those with a psychological ailment will adapt to a mood disorder, such as depression or bipolar disorder and 8% will be diagnosed with General Anxiety Disorder (GAD), panic disorder, obsessive-compulsive disorder, or social anxiety disorder.

In the event of total online communication among peers, where the adolescents aren't getting enough direct exposure on identifying with individuals, will progressively lead to a large number of grown-up adults who are restless about our species' essential methods for communication – talking.

CONCLUSION

Deliberate deactivation of certain online platforms detailed small but significant, enhancements in levels of prosperity, levels of bliss and life fulfilment along with self-reported lower levels of depression and anxiety. Nevertheless, as patterns demonstrate, the web-based media use isn't disappearing in near future. The majority of the current research spins around the utilization of online media. Likewise, online media also has worldwide scale permittance to information along with peer review that with proper parental guidance characterizes adolescents' self-personality and growth.

This review spotlights the understanding of the normative interrelated changes to neural systems and social behavior in adolescence, which is necessary for the distinguishing typical developmental trajectories and deviations in teenagers who struggle to form meaningful peer relationships.

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Conflict of Interest

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