

Mechanisms linking social media use to adolescent mental health vulnerability

Amy Orben ^{1*}, Adrian Meier ², Tim Dalgleish ¹, Sarah-Jayne Blakemore ^{3,4}

¹Medical Research Council Cognition and Brain Sciences Unit, University of Cambridge, Cambridge, UK

²School of Business, Economics and Society, Friedrich-Alexander-Universität ErlangenNürnberg, Nürnberg, Germany

³Department of Psychology, University of Cambridge, Cambridge, UK

⁴Institute for Cognitive Neuroscience, University College London, London, UK

*Correspondence: amy.orben@mrc-cbu.cam.ac.uk

Published at Nature Reviews Psychology. Orben, A., Meier, A., Dalgleish, T., et al. (2024). Mechanisms linking social media use to adolescent mental health vulnerability. *Nature Reviews Psychology*, 3, 407423. <https://doi.org/10.1038/s44159-024-00307-y>

ABSTRACT

1 Research linking social media use and adolescent mental health has produced mixed and inconsistent findings and little
2 translational evidence, despite pressure to deliver concrete recommendations for families, schools and policymakers. At the
3 same time, it is widely recognized that developmental changes in behaviour, cognition and neurobiology predispose ado-
4 lescents to developing socio-emotional disorders. In this Review, we argue that such developmental changes would be a
5 fruitful focus for social media research. Specifically, we review mechanisms by which social media could amplify the devel-
6 opmental changes that increase adolescents mental health vulnerability. These mechanisms include changes to behaviour,
7 such as sharing risky content and self-presentation, and changes to cognition, such as modifications in self-concept, social
8 comparison, responsiveness to social feedback and experiences of social exclusion. We also consider neurobiological mech-
9 anisms that heighten stress sensitivity and modify reward processing. By focusing on mechanisms by which social media
10 might interact with developmental changes to increase mental health risks, our Review equips researchers with a toolkit
11 of key digital affordances that enables theorizing and studying technology effects despite an ever-changing social media
12 landscape.

13 INTRODUCTION

14 Adolescence is a period marked by profound neurobiological, behavioural and environmental changes that facilitate the transition
15 from familial dependence to independent membership in society^{1,2}. This critical developmental stage is also characterized by di-
16 minished well-being and increased vulnerability to the onset of mental health conditions^{3–5}, particularly socio-emotional disor-
17 ders such as depression, and eating disorders^{4,6} (Fig. 1). Notable symptoms of socio-emotional disorders include heightened neg-
18 ative affect, mood dysregulation and an increased focus on distress or challenges concerning interpersonal relationships, including
19 heightened sensitivity to peers or perceptions of others⁶. Although some risk factors for socio-emotional disorders do not neces-
20 sarily occur in adolescence (including genetic predispositions, adverse childhood experiences and poverty^{7–9}, the unique develop-
21 mental characteristics of this period of life can interact with pre-existing vulnerabilities, increasing the risk of disorder onset¹⁰.
22 Over the past decade, declines in adolescent mental health have become a great concern^{11,12}. The prevalence of socio-emotional
23 disorders has increased in the adolescent age range (10–24 years²)^{13–21} leading to mounting pressures on child and adolescent
24 mental health services^{16,21,22}. This increase has not been as pronounced among other age groups when compared with adoles-
25 cents^{20,22,23} (measured in ref.²⁰, ref.²² and ref.²³ as age 12–25 years, 12–20 years and 18–25 years, respectively), even if some stud-
26 ies have found increases across the entire lifespan^{24,25}. Although these trends might not be generalizable across the world²⁶ or to
27 subclinical indicators of distress¹⁵, similar trends have been found in a range of countries²⁷. Declines in adolescent mental health,
28 especially socio-emotional problems, are consistent across datasets and researchers have argued that they are not solely driven by
29 changes in social attitudes, stigma or reporting of distress^{28,29}.
30 Concurrently, adolescents lives have become increasingly digital, with most young people using social media platforms through-
31 out the day³⁰. Ninety-five per cent of UK adolescents aged 15 years use social media³¹, and 50% of US adolescents aged 13–17
32 years report being almost constantly online³². The social media environment impacts adolescent and adult life across many do-
33 mains (for example, by enabling social communication or changing the way news is accessed) and influences individuals, dyads
34 and larger social systems^{33–36}. Because social media is inherently social and relational³⁷, it potentially overlaps and interacts with

the developmental changes that make adolescents vulnerable to the onset of mental health problems^{38,39} (Fig. 2). Thus, it has been intensely debated whether the increase in social media use during the past decade has a causal role in the decline of adolescent mental health⁴⁰. Indeed, rapid changes to the environment experienced before and during adolescence might be a fruitful area to explore when examining current mental health trends⁴¹.

Although there are many environmental changes that could be relevant, a substantial body of research has emerged to investigate the potential link between social media use and declines in adolescent mental health^{42,43} using various research approaches, including cross-sectional studies⁴⁴, longitudinal observational data analyses^{45–47} and experimental studies^{48,49}. However, the scientific results have been mixed and inconclusive (for reviews, see refs. ^{43,50–53}), which has made it difficult to establish evidence-based recommendations, regulations and interventions aimed at ensuring that social media use is not harmful to adolescents^{54–57}.

Many researchers attribute the mixed results to insufficient study specificity. For instance, the relationship between social media use and mental health varies notably across individuals^{45,58} and developmental time windows⁵⁹. Yet studies often examine adolescents without differentiating them based on age or developmental stage⁶⁰, which prevents systematic accounts of individual and subgroup differences. Additionally, most studies only rely on self-reported measures of time spent on social media^{61,62}, and overlook more nuanced aspects of social media use such as the nature of the activities⁶³ and the content or features that users engage with⁵². These factors need to be considered to unpack any broader relationships^{35,64–66}. Furthermore, the measurement of mental health often conflates positive and negative mental health outcomes as well as various mental health conditions, which could all be differentially related to social media use^{52,67}.

This research space presents substantial complexity⁶⁸. There is an ever-increasing range of potential combinations of social media predictors, well-being and mental health outcomes and participant groups of varying backgrounds and demographics that can become the target of scientific investigation. However, the pressure to deliver policy and public-facing recommendations and interventions leaves little time to investigate comprehensively each of these combinations. Researchers need to be able to pinpoint quickly the research programmes with the maximum potential to create translational and real-world impact for adolescent mental health.

In this Review, we aim to delineate potential avenues for future research that could lead to concrete interventions to improve adolescent mental health by considering mechanisms at the nexus between pre-existing processes known to increase adolescent mental health vulnerability and digital affordances introduced by social media. First, we describe the affordance approach to understanding the effects of social media. We then draw upon research on adolescent development, mental health and social media to describe behavioural, cognitive and neurobiological mechanisms by which social media use might amplify changes during adolescent development to increase mental health vulnerability during this period of life. The specific mechanisms within each category were chosen because they have a strong evidence base showing that they undergo substantive changes during adolescent development, are implicated in mental health risk and can be modulated by social media affordances. Although the ways in which social media can also improve mental health resilience are not the focus of our Review and therefore are not reviewed fully here, they are briefly discussed in relation to each mechanism. Finally, we discuss future research focused on how to systematically test the intersection between social media and adolescent mental health.

69 SOCIAL MEDIA AFFORDANCES

To study the impact of social media on adolescent mental health, its diverse design elements and highly individualized uses must be conceptualized. Initial research predominately related access to or time spent on social media to mental health outcomes^{46,69,70}. However, social media is not similar to a toxin or nutrient for which each exposure dose has a defined link to a health-related outcome (doseresponse relationship)⁵⁶. Social media is a diverse environment that cannot be summarized by the amount of time one spends interacting with it^{71,72}, and individual experiences are highly varied⁴⁵.

Previous psychological reviews often focused on social media features⁷³ and affordances⁷⁴ interchangeably. However, these terms have distinct definitions in communication science and information systems research. Social media features are components of the technology intentionally designed to enable users to perform specific actions, such as liking, reposting or uploading a story^{75,76}.

By contrast, affordances describe the perceptions of action possibilities users have when engaging with social media and its features, such as anonymity (the difficulty with which social media users can identify the source of a message) and quantifiability (how countable information is).

The term affordance came from ecological psychology and visuomotor research, and was described as mainly determined by human perception⁷⁷. Affordance was later adopted for design and humancomputer interaction contexts to refer to the action possibilities that are suggested to the user by the technology design⁷⁸. Communication research synthesizes both views. Affordances are now typically understood as the perceived and therefore flexible action possibilities of digital environments, which are jointly shaped by the technologys features and users idiosyncratic perceptions of those features⁷⁹.

Latent action possibilities can vary across different users, uses and technologies⁷⁹. For example, stories are a feature of Instagram designed to share content between users. Stories can also be described in terms of affordances when users perceive them as a way to determine how long their content remains available on the platform (persistence) or who can see that content (visibility)⁸⁰⁻⁸⁴. Low persistence (also termed ephemerality) and comparatively low visibility can be achieved through a technology feature (Instagram stories), but are not an outcome of technology use itself; they are instead perceived action possibilities that can vary across different technologies, users and designs⁷⁹.

The affordances approach is particularly valuable for theorizing at a level above individual social media apps or specific features, which makes this approach more resilient to technological changes or shifts in platform popularity^{79,85}. However, the affordances approach can also be related back to specific types of social media by assessing the extent to which certain affordances are built into a particular platform through feature design³⁵. Furthermore, because affordances depend on individuals perceptions and actions, they are more aligned than features with a neurocognitive and behavioural perspective to social media use. Affordances, similar to neurocognitive and behavioural research, emphasize the role of the user (how the technology is perceived, interpreted and used) rather than technology design per se. In this sense, the affordances approach is essential to overcome technological determinism of mental health outcomes, which overly emphasizes the role of technology as the driver of outcomes but overlooks the agency and impact of the people in question⁸⁶. This flexibility and alignment with psychological theory has contributed to the increasing popularity of the affordance approach^{35,73,74,85,87} and previous reviews have explored relevant social media affordances in the context of interpersonal communication among adults and adolescents^{35,88,89}, adolescent body image concerns⁷³ and work contexts³³. Here, we focus on the affordances of social media that are relevant for adolescent development and its intersection with mental health (Table 1).

105 BEHAVIOURAL MECHANISMS

Adolescents often use social media differently to adults, engaging with different platforms and features and, potentially, perceiving or making use of affordances in distinctive ways³⁵. These usage differences might interact with developmental characteristics and changes to amplify mental health vulnerability (Fig. 3). We examine two behavioural mechanisms that might govern the impact of social media use on mental health: risky posting behaviours and self-presentation.

110 Risky Posting Behaviour

Sensation-seeking peaks in adolescence and self-regulation abilities are still not fully developed in this period of life⁹⁰. Thus, adolescents often engage in more risky behaviours than other age groups⁹¹. Adolescents are more likely to take risks in situations involving peers^{92,93}, perhaps because they are motivated to avoid social exclusion^{94,95}. Whether adolescent risk-taking behaviour is inherently adaptive or maladaptive is debated. Although some risk-taking behaviours can be adaptive and part of typical development, others can increase mental health vulnerability. For example, data from a prospective UK panel study of more than 5,500 young people showed that engaging in more risky behaviours (including social and health risks) at age 16 years increases the odds of a range of adverse outcomes at age 18 years, such as depression, anxiety and substance abuse⁹⁶.

Social media can increase adolescents engagement in risky behaviours both in non-mediated and mediated environments (environments in which the behaviour is executed in or through a technology, such as a mobile phone and social media). First, affordances such as quantifiability in conjunction with visibility and association (the degree with which links between people, between

people and content or between a presenter and their audience can be articulated) can promote more risky behaviours in non-mediated environments and in-person social interactions. For example, posts from university students containing references to alcohol gain more likes than posts not referencing alcohol and liking such posts predicts an individual's subsequent drinking habits⁹⁷. Users expecting likes from their audience are incentivized to engage in riskier posting behaviour (such as more frequent or more extreme posts containing references to alcohol). The relationship between risky online behaviour and offline behaviour is supported by meta-analyses that found a positive correlation between adolescents' social media use and their engagement in behaviours that might expose them to harm or risk of injury (for example, substance use or risky sexual behaviours)⁹⁸. Further, affordances such as persistence and visibility can mean that risky behaviours in mediated and non-mediated environments remain public for long periods of time, potentially influencing how an adolescent is perceived by peers over the longer term^{39,99}.

Adolescence can also be a time of more risky social media use. For most forms of semi-public and public social media use, users typically do not know who exactly will be able to see their posts. Thus, adolescents need to self-present to an imagined audience¹⁰⁰ and avoid posting the wrong kind of content as the boundaries between different social spheres collapse (context collapse¹⁰¹). However, young people can underestimate the risks of disclosing revealing information in a social media environment¹⁰². Affordances such as visibility, replicability (social media posts remain in the system and can be screenshotted and shared even if they are later deleted³⁹), association and persistence could heighten the risk of experiencing cyberbullying, victimization and online harassment¹⁰³. For example, adolescents can forward privately received sexual images to larger friendship groups, increasing the risk of online harassment over the subject of the sexual images¹⁰⁴. Further, low bandwidth (a relative lack of socio-emotional cues) and high anonymity have the potential to disinhibit interactions between users and make behaviours and reactions more extreme^{105,106}. For example, anonymity was associated with more trolling behaviours during an online group discussion in an experiment with 242 undergraduate students¹⁰⁷.

Thus, social media might drive more risky behaviours in both mediated and non-mediated contexts, increasing mental health vulnerability. However, the evidence is still not clear cut and often discounts adolescent agency and understanding. For example, mixed-methods research has shown that young people often understand the risks of posting private or sexual content and use social media apps that ensure that posts are deleted and inaccessible after short periods of time to counteract them³⁹ (even though posts can still be captured in the meantime). Future work will therefore need to investigate how adolescents understand and balance such risks and how such processes relate to social media's impact on mental health.

147 Self Presentation and Identity

The adolescent period is characterized by an abundance of self-presentation activities on social media⁷⁴, where the drive to present oneself becomes a fundamental motivation for engagement¹⁰⁸. These activities include disclosing, concealing and modifying one's true self, and might involve deception, to convey a desired impression to an audience¹⁰⁹. Compared with adults, adolescents more frequently take part in self-presentation¹⁰², which can encompass both realistic and idealized portrayals of themselves¹¹⁰. In adults, authentic self-presentation has been associated with increased well-being, and inauthentic presentation (such as when a person describes themselves in ways not aligned with their true self) has been associated with decreased well-being¹¹¹⁻¹¹³.

Several social media affordances shape the self-presentation behaviours of adolescents. For example, the editability of social media profiles enables users to curate their online identity^{84,114}. Editability is further enhanced by highly visible (public) self-presentations. Additionally, the constant availability of social media platforms enables adolescents to access and engage with their profiles at any time, and provides them with rapid quantitative feedback about their popularity among peers^{89,115}. People receive more direct and public feedback on their self-presentation on social media than in other types of environment^{116,117}. The affordances associated with self-presentation can have a particular impact during adolescence, a period characterized by identity development and exploration.

Social media environments might provide more opportunities than offline environments for shaping one's identity. Indeed, public self-presentation has been found to invoke more prominent identity shifts (substantial changes in identity) compared with private self-presentation^{118,119}. Concerns have been raised that higher Internet use is associated with decreased self-concept clarity.

Only one study of 101 adolescents as well as adults reviewed in a 2021 meta-analysis¹²⁰ showed that the intensity of Facebook use (measured by the Facebook Intensity Scale) predicted a longitudinal decline in self-concept clarity 3 months later, but the converse was not the case and changes in self-concept clarity did not predict Facebook use¹²¹. This result is still not enough to show a causal relationship¹²¹. Further, the affordances of persistence and replicability could also curtail adolescents ability to explore their identity freely¹²².

By contrast, qualitative research has highlighted that social media enables adolescents to broaden their horizons, explore their identity and identify and reaffirm their values¹²³. Social media can help self-presentation by enabling adolescents to elaborate on various aspects of their identity, such as ethnicity and race¹²⁴ or sexuality¹²⁵. Social media affordances such as editability and visibility can also facilitate this process. Adolescents can modify and curate self-presentations online, try out new identities or express previously undisclosed aspects of their identity^{126,127}. They can leverage social media affordances to present different facets of themselves to various social groups by using different profiles, platforms and self-censorship and curation of posts^{128,129}. Presenting and exploring different aspects of ones identity can have mental health implications for minority teens. Emerging research shows a positive correlation between well-being and problematic Internet use in transgender, non-binary and gender-diverse adolescents (age 13-18 years), and positive sentiment has been associated with online identity disclosures in transgender individuals with supportive networks (both adolescent and adult)^{130,131}.

COGNITIVE MECHANISMS

Adolescents and adults might experience different socio-cognitive impacts from the same social media activity. In this section, we review four cognitive mechanisms via which social media and its affordances might influence the link between adolescent development and mental health vulnerabilities (Fig. 3). These mechanisms (self-concept development, social comparison, social feedback and exclusion) roughly align with a previous review that examined self-esteem and social media use¹¹⁵.

Self Concept Development

Self-concept refers to a persons beliefs and evaluations about their own qualities and traits¹³², which first develops and becomes more complex throughout childhood and then accelerates its development during adolescence¹³³⁻¹³⁵. Self-concept is shaped by socio-emotional processes such as self-appraisal and social feedback¹³⁴. A negative and unstable self-concept has been associated with negative mental health outcomes^{136,137}.

Perspective-taking abilities also develop during adolescence^{133,138,139}, as does the processing of self-relevant stimuli (measured by self-referential memory tasks, which assess memory for self-referential trait adjectives^{140,141}). During adolescence, direct self-evaluations and reflected self-evaluations (how someone thinks others evaluate them) become more similar. Further, self-evaluations have a distinct positive bias during childhood, but this positivity bias decreases in adolescence as evaluations of the self are integrated with judgements of other peoples perspectives¹⁴². Indeed, negative self-evaluations peak in late adolescence (around age 19 years)¹⁴⁰.

The impact of social media on the development of self-concept could be heightened during adolescence because of affordances such as personalization of content¹⁴³ (the degree to which content can be tailored to fit the identity, preferences or expectations of the receiver), which adapts the information young people are exposed to. Other affordances with similar impacts are quantifiability, availability (the accessibility of the technology as well as the users accessibility through the technology) and public visibility of interactions⁸⁹, which render the evaluations of others more prominent and omnipresent. The prominence of social evaluation can pose long-term risks to mental health under certain conditions and for some users^{144,145}. For example, receiving negative evaluations from others or being exposed to cyberbullying behaviours^{146,147} can, potentially, have heightened impact at times of self-concept development.

A pioneering cross-sectional study of 150 adolescents showed that direct self-evaluations are more similar to reflected self-evaluations, and self-evaluations are more negative, in adolescents aged 11-21 years who estimate spending more time on social media¹⁴⁸. Further, longitudinal data have shown bidirectional negative links between social media use and satisfaction with domains of the self (such as satisfaction with family, friends or schoolwork)⁴⁷.

207 Although large-scale evidence is still unavailable, these findings raise the interesting prospect that social media might have a neg-
208 ative influence on perspective-taking and self-concept. There is less evidence for the potential positive influence of social media
209 on these aspects of adolescent development, demonstrating an important research gap. Some researchers hypothesize that so-
210 cial media enables self-concept unification because it provides ample opportunity to find validation⁸⁹. Research has also discussed
211 how algorithmic curation of personalized social media feeds (for example, TikTok algorithms tailoring videos viewed to the users in-
212 terests) enables users to reflect on their self-concept by being exposed to others experiences and perspectives¹⁴³, an area where
213 future research can provide important insights.

214 **Social Comparison**

215 Social comparison (thinking about information about other people in relation to the self¹⁴⁹) also influences self-concept develop-
216 ment and becomes particularly important during adolescence^{133,150}. There are a range of social media affordances that can am-
217 plify the impact of social comparison on mental health. For example, quantifiability enables like or follower counts to be easily com-
218 pared with others as a sign of status, which facilitates social ranking¹⁵¹⁻¹⁵⁴. Studies of older adolescents and adults aged, on aver-
219 age, 20 years have also found that the number of likes or reactions received predict, in part, how successful users judge their self-
220 presentation posts on Facebook¹⁵⁵. Furthermore, personalization enables the content that users see on social media to be curated
221 so as to be highly relevant and interesting for them, which should intensify comparisons. For example, an adolescent interested in
222 sports and fitness content will receive personalized recommendations fitting those interests, which should increase the likelihood
223 of comparisons with people portrayed in this content. In turn, the affordance of association can help adolescents surround them-
224 selves with similar peers and public personae online, enhancing social comparison effects^{63,156}. Being able to edit posts (via the
225 affordance of editability) has been argued to contribute to the positivity bias on social media: what is portrayed online is often more
226 positive than the offline experience. Thus, upward comparisons are more likely to happen in online spaces than downward or lateral
227 comparisons¹⁵⁷. Lastly, the verifiability of others idealized self-presentations is often low, meaning that users have insufficient cues
228 to gauge their authenticity¹⁵⁸.

229 Engaging in comparisons on social media has been associated with depression in correlational studies¹⁵⁹. Furthermore, qualitative
230 research has shown that not receiving as many positive evaluations as expected (or if positive evaluations are not provided quickly
231 enough) increases negative emotions in children and adolescents aged between age 9 and 19 years³⁹. This result aligns with a re-
232 inforcement learning modelling study of Instagram data, which found that the likes a user receives on their own posts become less
233 valuable and less predictive of future posting behaviour if others in their network receive more likes on their posts¹⁶⁰. Although this
234 study did not measure mood or mental health, it shows that the value of the likes are not static but inherently social; their impact
235 depends on how many are typically received by other people in the same network.

236 Among the different types of social comparison that adolescents engage in (comparing ones achievements, social status or lifestyle),
237 the most substantial concerns have been raised about body-related comparisons. One review suggested that social media affor-
238 dances create a perfect storm for body image concerns that can contribute to both socio-emotional and eating disorders⁷³. Social
239 media affordances might increase young peoples focus on other peoples appearances as well as on their own appearance by show-
240 ing idealized, highly edited images, providing quantified feedback and making the ability to associate and compare oneself with
241 peers constantly available^{161,162}. The latter puts adolescents who are less popular or receive less social support at particular risk of
242 low self-image and social distress³⁵.

243 Affordances enable more prominent and explicit social comparisons in social media environments relative to offline environments^{158,159,163-165}.
244 However, this association could have a positive impact on mental health^{164,166}. Initial evidence suggests beneficial outcomes of
245 upward comparisons on social media, which can motivate behaviour change and yield positive downstream effects on mental health^{164,166}.
246 Positive motivational effects (inspiration) have been observed among young adults for topics such as travelling and exploring na-
247 ture, as well as fitness and other health behaviours, which can all improve mental health¹⁶⁷. Importantly, inspiration experiences
248 are not a niche phenomenon on social media: an experience sampling study of 353 Dutch adolescents (mean age 13.15 years)
249 found that participants reported some level of social media-induced inspiration in 33% of the times they were asked to report on
250 this over the course of 3 weeks¹⁶⁸. Several experimental and longitudinal studies show that inspiration is linked to upward compar-

ison on social media^{157,164,166}. However, the positive, motivating side of social comparison on social media has only been examined in a few studies and requires additional investigation.

253 Social Feedback

Adolescence is also a period of social reorientation, when peers tend to become more important than family¹⁶⁹, peer acceptance becomes increasingly relevant^{170–172} and young people spend increasing amounts of time with peers¹⁷³. In parallel, there is a heightened sensitivity to negative socio-emotional or self-referential cues^{140,174}, higher expectation of being rejected by others¹⁷⁵ and internalization of such rejection^{142,176} compared with other phases in life development. A meta-analysis of both adolescents and adults found that oversensitivity to social rejection is moderately associated with both depression and anxiety¹⁷⁷.

Social media affordances might amplify the potential impact of social feedback on mental health. Wanting to be accepted by peers and increased susceptibility to social rewards could be a motivator for using social media in the first place¹⁷⁸. Indeed, receiving likes as social reward activated areas of the brain (such as the nucleus accumbens) that are also activated by monetary reward¹⁷⁹. Quantifiability amplifies peer acceptance and rejection (via like counts), and social rejection has been linked to adverse mental health outcomes^{170,180–182}. Social media can also increase feelings of being evaluated, the risk of social rejection and rumination about potential rejection due to affordances such as quantifiability, synchronicity (the degree to which an interaction happens in real time) and variability of social rewards (the degree to which social interaction and feedback occur on variable time schedules). For example, one study of undergraduate students found that active communication such as messaging was associated with feeling better after Facebook use; however, this was not the case if the communication led to negative feelings such as rumination (for example, after no responses to the messages)¹⁸³.

In a study assessing threatened social evaluation online¹⁸⁴, participants were asked to record a statement about themselves and were told their statements would be rated by others. To increase the authenticity of the threat, participants were asked to rate other peoples recordings. Threatened social evaluation online in this study decreased mood, most prominently in people with high sensitivity to social rejection. Adolescents who are more sensitive to social rejection report more severe depressive symptoms and maladaptive ruminative brooding in both mediated and non-mediated social environments, and this association is most prominent in early adolescence¹⁸⁵. Not receiving as much online social approval as peers led to more severe depressive symptoms in a study of American ninth-grade adolescents (between age 14 and 15 years), especially those who were already experiencing peer victimization¹⁵³. Furthermore, individuals with lower self-esteem post more negative and less positive content than individuals with higher self-esteem. Posted negative content receives less social reward and recognition from others than positive content, possibly creating a vicious cycle¹⁸⁶. Negative experiences pertaining to social exclusion and status are also risk factors for socio-emotional disorders¹⁸⁰.

The impact of social media experiences on self-esteem can be very heterogeneous, varying substantially across individuals. As a benefit, positive social feedback obtained via social media can increase users self-esteem¹¹⁵, an association also found among adolescents¹⁸⁷. For instance, receiving likes on ones profile or posted photographs can bolster self-esteem in the short term^{144,188}. A study linking behavioural data and self-reports from Facebook users found that receiving quick responses on public posts increased a sense of social support and decreased loneliness¹⁸⁹. Furthermore, a review of reviews consistently documented that users who report more social media use also perceive themselves to have more social resources and support online⁵², although this association has mostly been studied among young adults using social network sites such as Facebook. Whether such social feedback benefits extend to adolescents use of platforms centred on content consumption (such as TikTok or Instagram) is an open question.

288 Social Inclusion and Exclusion

Adolescents are more sensitive to the negative emotional impacts of being excluded than are adults^{171,190}. It has been proposed that, as the importance of social affiliation increases during this period of life^{134,191,192}, adolescents are more sensitive to a range of social stimuli, regardless of valence¹⁹³. These include social feedback (such as compliments or likes)^{95,194}, negative socio-emotional cues (such as negative facial expressions or social exclusion)¹⁷⁴ and social rejection^{172,185}. By contrast, social inclusion (via friendships in adolescence) is protective against emotional disorders¹⁹⁵ and more social support is related to higher adolescent well-

294 being¹⁹⁶.

295 Experiencing ostracism and exclusion online decreases self-esteem and positive emotion¹⁹⁷. This association has been found in vi-
296 gnette experiments where participants received no, only a few or a lot of likes¹⁹⁸, or experiments that used mock-ups of social me-
297 dia sites where others received more likes than participants¹⁵³. Being ostracized (not receiving attention or feedback) or rejected
298 through social media features (receiving dislikes and no likes) is also associated with a reduced sense of belonging, meaningfulness,
299 self-esteem and control¹⁹⁹. Similar results were found when ostracism was experienced over messaging apps, such as not receiv-
300 ing a reply via WhatsApp²⁰⁰.

301 Evidence on whether social media also enables adolescents to experience positive social inclusion is mostly indirect and mixed.
302 Some longitudinal surveys have found that prosocial feedback received on social media during major life events (such as univer-
303 sity admissions) helps to buffer against stress²⁰¹. Adult participants of a longitudinal study reported that social media offered more
304 informational support than offline contexts, but offline contexts more often offered emotional or instrumental support²⁰². Higher
305 social network site use is, on average, associated with a perception of having more social resources and support in adults (for an
306 overview of meta-analyses, see ref.⁵²). However, most of these studies have not investigated social support among adolescents, and
307 it is unclear whether early findings (for example, on Facebook or Twitter) generalize to a social media landscape more strongly char-
308 acterized by content consumption than social interaction (such as Instagram or TikTok).

309 Still, a review of social media use and offline interpersonal outcomes among adolescents documents both positive (sense of belong-
310 ing and social capital) and negative (alienation from peers and perceived isolation) correlates²⁰³. Experience sampling research
311 on emotional support among young adults has further shown that online social support is received and perceived as effective, and
312 its perceived effectiveness is similar to in-person social support²⁰⁴. Social media use also has complex associations with friendship
313 closeness among adolescents. For example, one experience sampling study found that greater use of WhatsApp or Instagram is as-
314 sociated with higher friendship closeness among adolescents; however, within-person examinations over time showed small nega-
315 tive associations²⁰⁵.

316 NEUROBIOLOGICAL MECHANISMS

317 The long-term impact of environmental changes such as social media use on mental health might be amplified because adoles-
318 cence is a period of considerable neurobiological development⁹⁵ (Fig. 3). During adolescence, overall cortical grey matter declines
319 and white matter increases^{206,207}. Development is particularly protracted in brain regions associated with social cognition and ex-
320 ecutive functions such as planning, decision-making and inhibiting prepotent responses. The changes in grey and white matter are
321 thought to reflect axonal growth, myelination and synaptic reorganization, which are mechanisms of neuroplasticity influenced by
322 the environment²⁰⁸. For example, research in rodents has demonstrated that adolescence is a sensitive period for social input, and
323 that social isolation in adolescence has unique and more deleterious consequences for neural, behavioural and mental health de-
324 velopment than social isolation before puberty or in adulthood^{206,209}. There is evidence that brain regions involved in motivation
325 and reward show greater activation to rewarding and motivational stimuli (such as appetitive stimuli and the presence of peers) in
326 early and/or mid adolescence compared with other age groups²¹⁰⁻²¹⁴.

327 Little is known about the potential links between social media and neurodevelopment due to the paucity of research investigating
328 these associations. Furthermore, causal chains (for example, social media increasing stress, which in turn influences the brain) have
329 not yet been accurately delineated. However, it would be amiss not to recognize that brain development during adolescence forms
330 part of the biological basis of mental health vulnerability and should therefore be considered. Indeed, the brain is proposed to be
331 particularly plastic in adolescence and susceptible to environmental stimuli, both positive and negative²⁰⁸. Thus, even if adults and
332 adolescents experienced the same affective consequences from social media use (such as increases in peer comparison or stress),
333 these consequences might have a greater impact in adolescence.

334 A cross-sectional study (with some longitudinal elements) suggested that habitual checking of social media (for example, check-
335 ing for rewards such as likes) might exacerbate reward sensitivity processes, leading to long-term hypersensitization of the reward
336 system²¹⁵. Specifically, frequently checking social media was associated with reduced activation in brain regions such as the dor-

solateral prefrontal cortex and the amygdala in response to anticipated social feedback in young people. Brain activation during the same social feedback task was measured over subsequent years. Upon follow-up, anticipating feedback was associated with increased activation of the same brain regions among the individuals who checked social media frequently initially²¹⁵. Although longitudinal brain imaging measurements enabled trajectories of brain development to be specified, the measures of social media use were only acquired once in the first wave of data collection. The study therefore cannot account for confounds such as personality traits, which might influence both social media checking behaviours and brain development. Other studies of digital screen use and brain development have found no impact on adolescent functional brain organization²¹⁶.

Brain development and heightened neuroplasticity²⁰⁸ render adolescence a particularly sensitive period with potentially long-term impacts into adulthood. It is possible that social media affordances that underpin increased checking and reward-seeking behaviours (such as quantifiability, variability of social rewards and permanent availability of peers) might have long-term consequences on reward processing when experienced during adolescence. However, this suggestion is still speculative and not backed up by evidence²¹⁷.

Stress is another example of the potential amplifying effect of social media on adolescent mental health vulnerability due to neural development. Adolescents show higher stress reactivity because of maturational changes to, and increased reactivity in, the hypothalamicpituitaryadrenal axis^{218,219}. Compared with children and adults, adolescents experience an increase in self-consciousness and associated emotional states such as self-reported embarrassment and related physiological measures of arousal (such as skin conductance), and heightened neural response patterns compared with adults, when being evaluated or observed by peers²²⁰. Similarly, adolescents (age 13-17 years) show higher stress responses (higher levels of cortisol or blood pressure) compared with children (age 7-12 years) when they perform in front of others or experience social rejection²²¹.

Such changes in adolescence might confer heightened risk for the onset of mental health conditions, especially socio-emotional disorders⁶. Both adolescent rodents and humans show prolonged hypothalamicpituitaryadrenal activation after experiencing stress compared with conspecifics of different ages^{218,219}. In animal models, stress during adolescence has been shown to result in increased anxiety levels in adulthood²²² and alterations in emotional and cognitive development²²³. Furthermore, human studies have linked stress in adolescence to a higher risk of mental health disorder onset²¹⁸ and reviews of cross-species work have illustrated a range of brain changes due to adolescent stress^{224,225}.

There is still little conclusive neurobiological evidence about social media use and stress, and a lack of understanding about which affordances might be involved (although there has been a range of work studying digital stress; Box 1). Studies of changes in cortisol levels or hypothalamicpituitaryadrenal functioning and their relation to social media use have been mixed and inconclusive^{226,227}. These results could be due to the challenge of studying stress responses in adolescents, particularly as cortisol fluctuates across the day and one-point readings can be unreliable. However, the increased stress sensitivity during the adolescent developmental period might mean that social media use can have a long-term influence on mental health due to neurobiological mechanisms. These processes are therefore important to understand in future research.

369 SUMMARY AND FUTURE DIRECTIONS

To help to understand the potential role of social media in the decline of adolescent mental health over the past decade, researchers should study the mechanisms linking social media, adolescent development and mental health. Specifically, social media environments might amplify the socio-cognitive processes that render adolescents more vulnerable to mental health conditions in the first place. We outline various mechanisms at three levels of adolescent development – behavioural, cognitive and neurobiological – that could be involved in the decline of adolescent mental health as a function of social media engagement. To do so, we delineate specific social media affordances, such as quantification of social feedback or anonymity, which can also have positive impacts on mental health.

Our Review sets out clear recommendations for future research on the intersection of social media and adolescent mental health. The foundation of this research lies in the existing literature investigating the underlying processes that heighten adolescents risk of developing socio-emotional disorders. Zooming in on the potential mechanistic targets impacted by social media uses and af-

380 affordances will produce specific research questions to facilitate controlled and systematic scientific inquiry relevant for intervention
381 and translation. This approach encourages researchers to pinpoint the mechanisms and levels of explanation they want to include
382 and will enable them to identify what factors to additionally consider, such as participants age⁶⁰, the specific mental health out-
383 comes being measured, the types of social media being examined and the populations under study^{52,228}. Targeted and effective
384 research should prioritize the most promising areas of study and acknowledge that all research approaches have inherent limita-
385 tions²²⁹. Researchers must embrace methodological diversity, which in turn will facilitate triangulation. Surveys, experience sam-
386 pling designs in conjunction with digital trace data, as well as experimental or neuroimaging paradigms and computational mod-
387 elling (such as reinforcement learning) can all be used to address research questions comprehensively²³⁰. Employing such a multi-
388 method approach enables the convergence of evidence and strengthens the reliability of findings²³¹.

389 Mental health and developmental research can also become more applicable to the study of social media by considering how stud-
390 ies might already be exploring features of the digital environment, such as its design features and perceived affordances. Many cog-
391 nitive neuroscience studies that investigate social processes and mental health during adolescence necessarily design tasks that
392 can be completed in controlled experimental or brain scanning environments. Consequently, they tend to focus on digitally me-
393 diated interactions. However, researchers conceptualize and generalize their results to face-to-face interactions. For example, it is
394 common across the discipline to not explicitly describe the interactions under study as being about social processes in digital envi-
395 ronments (such as studies that assess social feedback based on the number of thumbs up or thumbs down received in social me-
396 dia²³²). Considering whether cognitive neuroscience studies include key affordances of mediated (or non-mediated) environments,
397 and discussing these in published papers, will make studies searchable within the field of social media research, enabling researchers
398 to broaden the impact of their work and systematically specify generalizations to offline environments²³³.

399 To bridge the gap between knowledge about mediated and non-mediated social environments, it is essential to directly compare
400 the two²³³. It is often assumed that negative experiences online have a detrimental impact on mental health. However, it remains
401 unclear whether this mechanism is present in both mediated and non-mediated spaces or whether it is specific to the mediated
402 context. For instance, our Review highlights that the quantification of social feedback through likes is an important affordance of
403 social media¹⁶⁰. Feedback on social media platforms might therefore elicit a greater sense of certainty because it is quantified com-
404 pared with the more subjective and open-to-interpretation feedback received face to face¹⁵¹. Conducting experiments in which
405 participants receive feedback that is more or less quantified and uncertain, specifically designed to compare mediated and non-
406 mediated environments, would provide valuable insights. Such research efforts could also establish connections with computa-
407 tional neuroscience studies demonstrating that people tend to learn faster from stimuli that are less uncertain²³⁴.

408 We have chosen not to make recommendations concerning interventions targeting social media use to improve adolescent mental
409 health for several reasons. First, we did not fully consider the bidirectional interactions between environment and development^{35,235},
410 or the factors modulating adolescents differential susceptibility to the effects of social media^{45,58}. For example, mental health sta-
411 tus also influences how social media is used^{47,58,59,236,237}^{47,58,59,236,237} (Box 2). These bidirectional interactions could be ad-
412 dressed using network or complexity science approaches²³⁸. Second, we do not yet know how the potential mechanisms by which
413 social media might increase mental health vulnerability compare in magnitude, importance, scale and ease and/or cost of interven-
414 tion with other factors and mechanisms that are already well known to influence mental health, such as poverty or loneliness. Last,
415 social media use will probably interact with these predictors in ways that have not been delineated and can also support mental
416 health resilience (for example, through social support or online self-help programmes). These complexities should be considered
417 in future research, which will need to pinpoint not just the existence of mechanisms but their relative importance, to identify policy
418 and intervention priorities.

419 Our Review has used a broad definition of mental health. Focusing on specific diagnostic or transdiagnostic symptomatology might
420 reveal different mechanisms of interest. Furthermore, our Review is limited to mechanisms related to behaviour and neurocog-
421 nitive development, disregarding other levels of explanation (such as genetics and culture)³⁴, and also studying predominately
422 Western-centric samples²³⁹. Mechanisms do not operate solely in linear pathways but exist within networks of interacting risk and
423 resilience factors, characterized by non-linear and complex dynamics across diverse timescales⁹. Mechanisms and predisposing

factors can interact and combine, amplifying mental health vulnerability. Mental health can be considered a dynamic system in which gradual changes to external conditions can have substantial downstream consequences due to system properties such as feedback loops^{240–242}. These consequences are especially prominent in times of change and pre-existing vulnerability, such as adolescence¹⁰.

Indeed, if social media is a contributing factor to the current decline in adolescent mental health, as is commonly assumed, then it is important to identify and investigate mechanisms that are specifically tailored to the adolescent age range and make the case for why they matter. Without a thorough examination of these mechanisms and policy analysis to indicate whether they should be a priority to address, there is insufficient evidence to support the hypothesis that social media is the primary or even just an influential and important driver of mental health declines. Researchers need to stop studying social media as monolithic and uniform, and instead study its features, affordances and outcomes by leveraging a range of methods including experiments, questionnaires, qualitative research and industry data. Ultimately, this comprehensive approach will enhance researchers ability to address the potential challenges that the digital era poses on adolescent mental health.

ACKNOWLEDGMENTS

A.O. and T.D. were funded by the Medical Research Council (MC_UU_00030/13). A.O. was funded by the Jacobs Foundation and a UKRI Future Leaders Fellowship (MR/X034925/1). S.-J.B. is funded by Wellcome (grant numbers WT107496/Z/15/Z and WT227882/Z/23/Z), the MRC, the Jacobs Foundation, the Wellspring Foundation and the University of Cambridge.

AUTHOR CONTRIBUTIONS

A.O. conceptualized the manuscript; A.O. and A.M. wrote the original draft; A.O., A.M., T.D. and S.-J.B. reviewed and edited the manuscript. All authors contributed substantially to discussion of the content, and reviewed and/or edited the manuscript before submission.

AUTHOR COMPETING INTERESTS

The authors declare no competing interests

REFERENCES

- [1] R. Savin-Williams. *Adolescence: An Ethological Perspective*. Springer, 1987.
- [2] Susan M. Sawyer, Peter S. Azzopardi, D. Wickremaratne, and George C. Patton. The age of adolescence. *The Lancet Child & Adolescent Health*, 2:223–228, 2018.
- [3] Tomáš Paus, Matcheri Keshavan, and Jay N. Giedd. Why do many psychiatric disorders emerge during adolescence? *Nature Reviews Neuroscience*, 9:947–957, 2008.
- [4] Marco Solmi, Joaquim Radua, Massimiliano Olivola, Elia Croce, Luca Soardo, Gonzalo Salazar de Pablo, Jimmy Il Shin, James B. Kirkbride, Peter Jones, Julie H. Kim, and Paolo Fusar-Poli. Age at onset of mental disorders worldwide: large-scale meta-analysis of 192 epidemiological studies. *Molecular Psychiatry*, 27:281–295, 2022.
- [5] Amy Orben, Richard E. Lucas, Delia Fuhrmann, and Rogier A. Kievit. Trajectories of adolescent life satisfaction. *Royal Society Open Science*, 9:211808, 2022.
- [6] Ronald M. Rapee, Ella L. Oar, Cassandra J. Johnco, Miriam K. Forbes, Jasmine Fardouly, Natasha R. Magson, and Claire E. Richardson. Adolescent development and risk for the onset of social-emotional disorders: a review and conceptual model. *Behaviour Research and Therapy*, 123:103501, 2019.
- [7] Celso Arango, Covadonga M. Diaz-Caneja, Patrick D. McGorry, Judith Rapoport, Iris E. Sommer, Jacob A. Vorstman, David McDaid, Anita Maráz, Esteban Serrano-Drozowskyj, R. Freedman, and William Carpenter. Risk and protective factors for mental disorders beyond genetics: an evidence-based atlas. *World Psychiatry*, 20:417–436, 2021.
- [8] Konstantinos Ioannidis, Aslak D. Askelund, Rogier A. Kievit, and Anne-Laura van Harmelen. The complex neurobiology of resilient functioning after childhood maltreatment. *BMC Medicine*, 18:32, 2020.
- [9] Helena C. Kraemer, Eric Stice, Alan Kazdin, David Offord, and David Kupfer. How do risk factors work together? mediators, moderators, and independent, overlapping, and proxy risk factors. *The American Journal of Psychiatry*, 158:848–856, 2001.
- [10] Benjamin L. Hankin and Lyn Y. Abramson. Development of gender differences in depression: an elaborated cognitive vulnerability–transactional stress theory. *Psychological Bulletin*, 127:773–796, 2001.
- [11] Stephan Collishaw, Barbara Maughan, Lavanya Natarajan, and Andrew Pickles. Trends in adolescent emotional problems in england: a comparison of two national cohorts twenty years apart. *Journal of Child Psychology and Psychiatry*, 51:885–894, 2010.
- [12] James M. Pitchforth, Russell M. Viner, and Dougal S. Hargreaves. Trends in mental health and wellbeing among children and young people in the uk: a repeated cross-sectional study, 200014. *The Lancet*, 388:S93, 2016.
- [13] Rebekah Levine Coley, Marion OBrien, and Bethany Spielvogel. Secular trends in adolescent depressive symptoms: growing disparities between advantaged and disadvantaged schools. *Journal of Youth and Adolescence*, 48:2087–2098, 2019.
- [14] Praveetha Patalay and Suzanne H. Gage. Changes in millennial adolescent mental health and health-related behaviours over 10 years: a population cohort comparison study. *International Journal of Epidemiology*, 48:1650–1664, 2019.
- [15] James M. Pitchforth, Alison E. Fahy, Tamsin J. Ford, Miranda Wolpert, Russell M. Viner, and Dougal S. Hargreaves. Mental health and well-being trends among children and young people in the uk, 19952014: analysis of repeated cross-sectional national health surveys. *Psychological Medicine*, 49:1275–1285, 2019.
- [16] Oleguer Plana-Ripoll, John J. McGrath, Peter de Jonge, James Scott, Øystein Karlstad, Paolo Fusar-Poli, Lars V. Kessing, Sandra M. Meier, Kim M. Iburg, and Thomas M. Laursen. Temporal changes in sex- and age-specific incidence profiles of mental disordersa nationwide study from 1970 to 2016. *Acta Psychiatrica Scandinavica*, 145:604–614, 2022.
- [17] Jean M. Twenge, Ashley B. Cooper, Thomas E. Joiner, Megan E. Duffy, and Sarah G. Binau. Age, period, and cohort trends in mood disorder indicators and suicide-related outcomes in a nationally representative dataset, 20052017. *Journal of Abnormal Psychology*, 128:185–199, 2019.
- [18] Christel L. van Vuuren, Daan G. Uitenbroek, Marcel F. van der Wal, and Mai J. M. Chinapaw. Sociodemographic differences in 10-year time trends of emotional and behavioural problems among adolescents attending secondary schools in amsterdam, the netherlands. *European Child & Adolescent Psychiatry*, 27:1621–1631, 2018.
- [19] Stephan Collishaw. Annual research review: secular trends in child and adolescent mental health. *Journal of Child Psychology and Psychiatry*, 56:370–393, 2015.
- [20] Renee D. Goodwin, Andrea H. Weinberger, John H. Kim, Marco Wu, and Sandro Galea. Trends in u.s. depression prevalence from 2015 to 2020: the widening treatment gap. *American Journal of Preventive Medicine*, 63:726–733, 2022.
- [21] Ramin Mojtabai and Mark Olfson. National trends in mental health care for us adolescents. *JAMA Psychiatry*, 77:703, 2020.
- [22] Ramin Mojtabai, Mark Olfson, and Beth Han. National trends in the prevalence and treatment of depression in adolescents and young adults. *Pediatrics*, 138(6):e20161878, 2016.
- [23] Renee D. Goodwin, Andrea H. Weinberger, John H. Kim, Marco Wu, and Sandro Galea. Trends in anxiety among adults in the united states, 20082018: rapid increases among young adults. *Journal of Psychiatric Research*, 130:441–446, 2020.
- [24] Sofie G. Beerten, Margot Rotsaert, Sibyl Anthierens, Stijn Bartholomeeusen, Geert Goderis, Patrick Luyten, Sofie Truijen, and Sarah Van de Velde. Trends in the registration of anxiety in belgian primary care from 2000 to 2021: a registry-based study. *British Journal of General Practice*, 73:e460–e467, 2022.
- [25] Ronny Walrave, Katrien Vanthomme, Sabine Drieskens, Veerle Buffel, and Sylvie Gadeyne. Trends in the epidemiology of depression and comorbidities from 2000 to 2019 in belgium. *BMC Primary Care*, 23:163, 2022.
- [26] Matti Vuorre and Andrew K. Przybylski. Global well-being and mental health in the internet age. *Clinical Psychological Science*, 2023.
- [27] Annika Steffen, Jörg Thom, Frank Jacobi, Jakob Holstiege, and Jörg Bätzing. Trends in prevalence of depression in germany between 2009 and 2017 based on nationwide ambulatory claims data. *Journal of Affective Disorders*, 271:239–247, 2020.
- [28] Tamsin Ford. Editorial perspective: why i am now convinced that emotional disorders are increasingly common among young people in many countries. *Journal of Child Psychology and Psychiatry*, 61:1275–1277, 2020.
- [29] Eoin McElroy, Marc Tibber, Pasco Fearon, Praveetha Patalay, and George B. Ploubidis. Socioeconomic and sex inequalities in parent-reported adolescent mental ill-health: time trends in four british birth cohorts. *Journal of Child Psychology and Psychiatry*, 64:758–767, 2022.

- [30] OECD. *Society at a Glance 2019: OECD Social Indicators*. Organisation for Economic Co-operation and Development, 2019.
- [31] Ofcom. Online nation. <https://www.ofcom.org.uk/research-and-data/online-research/online-nation>, 2021. Accessed 2022.
- [32] Monica Anderson and Jingjing Jiang. *Teens Social Media Habits and Experiences*. Pew Research Center, 2018.
- [33] Leaetta A. McFarland and Robert E. Ployhart. Social media: a contextual framework to guide research and practice. *Journal of Applied Psychology*, 100:1653–1677, 2015.
- [34] Moritz Büchi. Digital well-being theory and research. *New Media & Society*, 26:172–189, 2024.
- [35] Jacqueline Nesi, Sophia Choukas-Bradley, and Mitchell J. Prinstein. Transformation of adolescent peer relations in the social media context: part 1a theoretical framework and application to dyadic peer relationships. *Clinical Child and Family Psychology Review*, 21:267–294, 2018.
- [36] Sy Taffel. Perspectives on the postdigital: beyond rhetorics of progress and novelty. *Convergence*, 22:324–338, 2016.
- [37] Zizi Papacharissi. We have always been social. *Social Media + Society*, 1:205630511558118, 2015.
- [38] Eveline A. Crone and Elly A. Konijn. Media use and brain development during adolescence. *Nature Communications*, 9:588, 2018.
- [39] Emily Weinstein and Carrie James. *Behind Their Screens: What Teens Are Facing (and Adults Are Missing)*. MIT Press, 2022.
- [40] Jean M. Twenge, Thomas E. Joiner, Megan L. Rogers, and Gabrielle N. Martin. Increases in depressive symptoms, suicide-related outcomes, and suicide rates among u.s. adolescents after 2010 and links to increased new media screen time. *Clinical Psychological Science*, 6:3–17, 2017.
- [41] David Gunnell, Judi Kidger, and Hannah Elvidge. Adolescent mental health in crisis. *BMJ*, 361:k2608, 2018.
- [42] Candice L. Odgers, Stephen M. Schueller, and Mizuko Ito. Screen time, social media use, and adolescent development. *Annual Review of Developmental Psychology*, 2:485–502, 2020.
- [43] Patti M. Valkenburg, Adrian Meier, and Ine Beyens. Social media use and its impact on adolescent mental health: an umbrella review of the evidence. *Current Opinion in Psychology*, 44:58–68, 2022.
- [44] Noah Kreski, Robert Anthenelli, Deborah S. Hasin, Katherine M. Keyes, Katie A. McLaughlin, Mark Olfson, Jonathan Platt, and Melanie M. Wall. Social media use and depressive symptoms among united states adolescents. *Journal of Adolescent Health*, 68:572–579, 2020.
- [45] Ine Beyens, Jorien L. Pouwels, Irene I. van Driel, Loes Keijsers, and Patti M. Valkenburg. The effect of social media on well-being differs from adolescent to adolescent. *Scientific Reports*, 10:10763, 2020.
- [46] Madeline Jensen, Melissa J. George, Melissa R. Russell, and Candice L. Odgers. Young adolescents digital technology use and mental health symptoms: little evidence of longitudinal or daily linkages. *Clinical Psychological Science*, 7:1416–1433, 2019.
- [47] Amy Orben, Tobias Dienlin, and Andrew K. Przybylski. Social medias enduring effect on adolescent life satisfaction. *Proceedings of the National Academy of Sciences of the USA*, 116:10226–10228, 2019.
- [48] Hunt Allcott, Luca Braghieri, Sarah Eichmeyer, and Matthew Gentzkow. The welfare effects of social media. *American Economic Review*, 110:629–676, 2020.
- [49] Lisa-Marie Nassen, Heidi Vandebosch, Karolien Poels, and Kathrin Karsay. Opt-out, abstain, unplug, a systematic review of the voluntary digital disconnection literature. *Telematics and Informatics*, 81:101980, 2023.
- [50] Tobias Dienlin and Niklas Johannes. The impact of digital technology use on adolescent well-being. *Dialogues in Clinical Neuroscience*, 22:135–142, 2020.
- [51] Candice L. Odgers and Madeline R. Jensen. Annual research review: adolescent mental health in the digital age: facts, fears, and future directions. *Journal of Child Psychology and Psychiatry*, 61:336–348, 2020.
- [52] Adrian Meier and Leonard Reinecke. Computer-mediated communication, social media, and mental health: a conceptual and empirical meta-review. *Communication Research*, 48:1182–1209, 2021.
- [53] Amy Orben. Teenagers, screens and social media: a narrative review of reviews and key studies. *Social Psychiatry and Psychiatric Epidemiology*, 55:407–414, 2020.
- [54] Vaughan Bell, Dorothy V. M. Bishop, and Andrew K. Przybylski. The debate over digital technology and young people. *BMJ*, 351:h3064, 2015.
- [55] UK Government. Online safety act 2023, 2023. Accessed 2023.
- [56] Nigel Hawkes. Cmo report is unable to shed light on impact of screen time and social media on childrens health. *BMJ*, 364:l643, 2019.
- [57] US Department of Health and Human Services. Social media and youth mental health: The u.s. surgeon generals advisory, 2023.
- [58] Patti M. Valkenburg and Jochen Peter. The differential susceptibility to media effects model. *Journal of Communication*, 63(2):221–243, 2013.
- [59] Amy Orben, Andrew K. Przybylski, Sarah-Jayne Blakemore, and Rogier A. Kievit. Windows of developmental sensitivity to social media. *Nature Communications*, 13(1):1649, 2022.
- [60] Amy Orben and Sarah-Jayne Blakemore. How social media affects teen mental health: a missing link. *Nature*, 614(7948):410–412, 2023.
- [61] Hannah Shaw, David A. Ellis, Kevin Geyer, Brittany I. Davidson, Fynn V. Ziegler, and Andrew Smith. Quantifying smartphone use: choice of measurement impacts relationships between usage and health. *Technology, Mind, and Behavior*, 1(2), 2020.
- [62] Douglas A. Parry, Brittany I. Davidson, Chase J. R. Sewall, Joshua T. Fisher, Hannah Mieczkowski, and Daniel S. Quintana. A systematic review and meta-analysis of discrepancies between logged and self-reported digital media use. *Nature Human Behaviour*, 5:1535–1547, 2021.
- [63] Philippe Verduyn, Nikoloz Gugushvili, and Ethan Kross. Do social networking sites influence well-being? the extended active-passive model. *Current Directions in Psychological Science*, 31(1):62–68, 2022.
- [64] Brittany I. Davidson, Hannah Shaw, and David A. Ellis. Fuzzy constructs in technology usage scales. *Computers in Human Behavior*, 133:107206, 2022.
- [65] Daniel J. Shaw, Linda K. Kaye, Ntombizodwa Ngombe, Klaus Kessler, and Charlotte R. Pennington. Its not what you do, its the way that you do it: an experimental task delineates among passive, reactive and interactive styles of behaviour on social networking sites. *PLoS ONE*, 17(11):e0276765, 2022.
- [66] Noëmi Griffioen, Mandy Van Rooij, Anna Lichtwarck-Aschoff, and Isabela Granic. Toward improved methods in social media research. *Technology, Mind, and Behavior*, 1(1), 2020.
- [67] Patti M. Valkenburg. Social media use and well-being: what we know and what we need to know. *Current Opinion in Psychology*, 45:101294, 2022.
- [68] Chia-chen Yang, Samantha M. Holden, and Jenny Ariati. Social media and psychological well-being among youth: the multidimensional model of social media use. *Clinical Child and Family Psychology Review*, 24(4):631–650, 2021.
- [69] Yvonne Kelly, Afshin Zilanawala, Claudia Booker, and Amanda Sacker. Social media use and adolescent mental health: findings from the uk millennium cohort study. *EclinicalMedicine*, 6:59–68, 2019.
- [70] Amy Orben and Andrew K. Przybylski. The association between adolescent well-being and digital technology use. *Nature Human Behaviour*, 3(2):173–182, 2019.
- [71] Muntasir Sultan, Cosima Scholz, and Wouter van den Bos. Leaving traces behind: using social media digital trace data to study adolescent wellbeing. *Computers in Human Behavior Reports*, 10:100281, 2023.
- [72] Linda K. Kaye, Amy Orben, David A. Ellis, Simon C. Hunter, and Stephen Houghton. The conceptual and methodological mayhem of screen time. *International Journal of Environmental Research and Public Health*, 17(10):3661, 2020.
- [73] Sophia Choukas-Bradley, Sarah R. Roberts, Anjali J. Maheux, and Jacqueline Nesi. The perfect storm: a developmentalsociocultural framework for the role of social media in adolescent girls body image concerns and mental health. *Clinical Child and Family Psychology Review*, 25(4):681–701, 2022.
- [74] Megan A. Moreno and Yalda T. Uhls. Applying an affordances approach and a developmental lens to approach adolescent social media use. *Digital Health*, 5:2055207619826678, 2019.
- [75] Amanda D. Smock, Nicole B. Ellison, Cliff Lampe, and Donghee Yvette Wohn. Facebook as a toolkit: a uses and gratification approach to unbundling feature use. *Computers in Human Behavior*, 27(6):2322–2329, 2011.
- [76] Joseph B. Bayer, Phuoc Triëu, and Nicole B. Ellison. Social media elements, ecologies, and effects. *Annual Review of Psychology*, 71:471–497, 2020.
- [77] James J. Gibson. *The Ecological Approach to Visual Perception*. Houghton Mifflin, Boston, MA, 1979.
- [78] Donald A. Norman. *The Psychology of Everyday Things*. Basic Books, New York, NY, 1988.
- [79] Sarah K. Evans, Katy E. Pearce, Jessica Vitak, and Jeffrey W. Treem. Explicating affordances: a conceptual framework for understanding affordances in communication research. *Journal of Computer-Mediated Communication*, 22(1):35–52, 2017.
- [80] Joseph B. Bayer, Nicole B. Ellison, Sarita Y. Schoenebeck, and Emily B. Falk. Sharing the small moments: ephemeral social interaction on snapchat. *Information, Communication & Society*, 19(7):956–977, 2016.
- [81] Jesse Fox and Bree McEwan. Distinguishing technologies for social interaction: the perceived social affordances of communication channels scale. *Communication Monographs*, 84(3):298–318, 2017.
- [82] Robin Kreling, Adrian Meier, and Leonard Reinecke. Feeling authentic on social media: subjective authenticity across instagram stories and posts. *Social Media + Society*, 8(2):205630512210862, 2022.
- [83] Paul M. Leonardi. Social media, knowledge sharing, and innovation: toward a theory of communication visibility. *Information Systems Research*, 25(4):796–816, 2014.
- [84] Jeffrey W. Treem and Paul M. Leonardi. Social media use in organizations: exploring the affordances of visibility, editability, persistence, and association. *Annals of the International Communication Association*, 36(1):143–189, 2013.
- [85] Nicole B. Ellison, Carolyn Pyle, and Jessica Vitak. Scholarship on well-being and social media: a sociotechnical perspective. *Current Opinion in Psychology*, 46:101340, 2022.
- [86] Amy Orben. The sisyphus cycle of technology panics. *Perspectives on Psychological Science*, 15(5):1143–1157, 2020.
- [87] Isabela Granic, Hiroki Morita, and Hanneke Scholten. Beyond screen time: identity development in the digital age. *Psychological Inquiry*, 31(3):195–223, 2020.
- [88] Abigail Lieberman and Juliana Schroeder. Two social lives: how differences between online and offline interaction influence social outcomes. *Current Opinion in Psychology*, 31:16–21, 2020.
- [89] Patti M. Valkenburg and Jochen Peter. Online communication among adolescents: an integrated model of its attraction, opportunities, and risks. *Journal of Adolescent Health*, 48(2):121–127, 2011.
- [90] Laurence Steinberg et al. Around the world, adolescence is a time of heightened sensation seeking and immature self-regulation. *Developmental Science*, 21(2):e12532, 2018.
- [91] Sarah-Jayne Blakemore and Trevor W. Robbins. Decision-making in the adolescent brain. *Nature Neuroscience*, 15(9):1184–1191, 2012.
- [92] Laurence Steinberg. A social neuroscience perspective on adolescent risk-taking. *Developmental Review*, 28(1):78–106, 2008.
- [93] Jason Chein, Dustin Albert, Lindsey O'Brien, Kathryn Uckert, and Laurence Steinberg. Peers increase adolescent risk taking by enhancing activity in the brains reward circuitry. *Developmental Science*, 14(2):F1–F10, 2011.

- [94] Sarah-Jayne Blakemore and Kathryn L. Mills. Is adolescence a sensitive period for sociocultural processing? *Annual Review of Psychology*, 65:187–207, 2014.
- [95] Sarah-Jayne Blakemore. Avoiding social risk in adolescence. *Current Directions in Psychological Science*, 27(2):116–122, 2018.
- [96] Rachel Campbell et al. Multiple risk behaviour in adolescence is associated with substantial adverse health and social outcomes in early adulthood: findings from a prospective birth cohort study. *Preventive Medicine*, 138:106157, 2020.
- [97] Sandra Kurten et al. Like to drink: dynamics of liking alcohol posts and effects on alcohol use. *Computers in Human Behavior*, 129:107145, 2022.
- [98] Anna Vannucci, Emily G. Simpson, Sarah Gagnon, and Christine M. Ohannessian. Social media use and risky behaviors in adolescents: a meta-analysis. *Journal of Adolescence*, 79:258–274, 2020.
- [99] Kate Eichhorn. *The End of Forgetting: Growing Up with Social Media*. Harvard University Press, Cambridge, MA, 2019.
- [100] Eden Litt and Eszter Hargittai. The imagined audience on social network sites. *Social Media + Society*, 2:205630511663348, 2016.
- [101] Jessica Vitak. The impact of context collapse and privacy on social network site disclosures. *Journal of Broadcasting & Electronic Media*, 56(4):451–470, 2012.
- [102] Sonia Livingstone. Taking risky opportunities in youthful content creation: teenagers use of social networking sites for intimacy, privacy and self-expression. *New Media & Society*, 10(3):393–411, 2008.
- [103] Luca Marciano, Peter J. Schulz, and Ann-Linda Camerini. Cyberbullying perpetration and victimization in youth: a meta-analysis of longitudinal studies. *Journal of Computer-Mediated Communication*, 25(3):163–181, 2020.
- [104] Chantal Mori, Jeff R. Temple, Devon Browne, and Sheri Madigan. Association of sexting with sexual behaviors and mental health among adolescents: a systematic review and meta-analysis. *JAMA Pediatrics*, 173(8):770–779, 2019.
- [105] John Suler. The online disinhibition effect. *CyberPsychology & Behavior*, 7(3):321–326, 2004.
- [106] Michelle F. Wright, Bridget D. Harper, and Sebastian Wachs. The associations between cyberbullying and callous-unemotional traits among adolescents: the moderating effect of online disinhibition. *Personality and Individual Differences*, 140:41–45, 2019.
- [107] Lara Nitschinsk, Stephanie J. Tobin, and Eric J. Vanman. The disinhibiting effects of anonymity increase online trolling. *Cyberpsychology, Behavior, and Social Networking*, 25(6):377–383, 2022.
- [108] Ashwini Nadkarni and Stefan G. Hofmann. Why do people use facebook? *Personality and Individual Differences*, 52(3):243–249, 2012.
- [109] Mark R. Leary and Robin M. Kowalski. Impression management: a literature review and two-component model. *Psychological Bulletin*, 107(1):34–47, 1990.
- [110] Shanyang Zhao, Sherri Grasmuck, and Jason Martin. Identity construction on facebook: digital empowerment in anchored relationships. *Computers in Human Behavior*, 24(5):1816–1836, 2008.
- [111] N. A. J. D. Bij de Vaate, Jolanda Veldhuis, and Elly A. Konijn. How online self-presentation affects well-being and body image: a systematic review. *Telematics and Informatics*, 47:101316, 2020.
- [112] Leonard Reinecke and Sabine Trepte. Authenticity and well-being on social network sites: a two-wave longitudinal study on the effects of online authenticity and the positivity bias in sns communication. *Computers in Human Behavior*, 30:95–102, 2014.
- [113] Conall Twomey and Gary O'Reilly. Associations of self-presentation on facebook with mental health and personality variables: a systematic review. *Cyberpsychology, Behavior, and Social Networking*, 20(10):587–595, 2017.
- [114] Mariek Vanden Abeele, Alexander P. Schouten, and Marjolijn L. Antheunis. Personal, editable, and always accessible: an affordance approach to the relationship between adolescents mobile messaging behavior and their friendship quality. *Journal of Social and Personal Relationships*, 34(6):875–893, 2017.
- [115] Helena-Verena Krause, Kerstin Baum, Anja Baumann, and Hanna Krasnova. Unifying the detrimental and beneficial effects of social network site use on self-esteem: a systematic literature review. *Media Psychology*, 24(1):10–47, 2021.
- [116] Caleb T. Carr and Amanda C. Foreman. Identity shift iii: effects of publicness of feedback and relational closeness in computer-mediated communication. *Media Psychology*, 19(2):334–358, 2016.
- [117] Joseph B. Walther, Brandon Van Der Heide, Sung Gwan Kim, David Westerman, and Stephanie Tom Tong. The effect of feedback on identity shift in computer-mediated communication. *Media Psychology*, 14(1):1–26.
- [118] Amy L. Gonzales and Jeffrey T. Hancock. Identity shift in computer-mediated environments. *Media Psychology*, 11(2):167–185, 2008.
- [119] Anita E. Kelly and R. Rocio Rodriguez. Publicly committing oneself to an identity. *Basic and Applied Social Psychology*, 28(2):185–191, 2006.
- [120] Cristina E. Petre. The relationship between internet use and self-concept clarity: a systematic review and meta-analysis. *Cyberpsychology: Journal of Psychosocial Research on Cyberspace*, 15(2), 2021.
- [121] Markus Appel, Celine Schreiner, Susanne Weber, Marlene Mara, and Timo Gnamb. Intensity of facebook use is associated with lower self-concept clarity: cross-sectional and longitudinal evidence. *Journal of Media Psychology*, 30(4):160–172, 2018.
- [122] Sanaz Talaifar and Brian S. Lowery. Freedom and constraint in digital environments: implications for the self. *Perspectives on Psychological Science*, 18(3):544–575, 2022.
- [123] Melissa West, Simon Rice, and Dianne Vella-Brodrick. Mid-adolescents social media use: supporting and suppressing autonomy. *Journal of Adolescent Research*, 2023.
- [124] Sherri Grasmuck, Jason Martin, and Shanyang Zhao. Ethno-racial identity displays on facebook. *Journal of Computer-Mediated Communication*, 15(1):158–188, 2009.
- [125] Michael A. DeVito, Ashley M. Walker, and Jeremy Birnholtz. Too Gay for Facebook: presenting LGBTQ+ identity throughout the personal social media ecosystem. *Proceedings of the ACM on Human-Computer Interaction*, 2(CSCW):1–23, 2018.
- [126] Nicole Ellison, Rebecca Heino, and Erica Gibbs. Managing impressions online: self-presentation processes in the online dating environment. *Journal of Computer-Mediated Communication*, 11(2), 2006.
- [127] Jeffrey T. Hancock. Interpersonal communication and social interaction in computer-mediated contexts. In Adam Joinson, Katelyn McKenna, Tom Postmes, and Ulf-Dietrich Reips, editors, *Oxford Handbook of Internet Psychology*, pages 287–301. Oxford University Press, Oxford, 2009.
- [128] Brian I. Davidson and Adam N. Joinson. Shape shifting across social media. *Social Media + Society*, 7(1):205630512199063, 2021.
- [129] Jenny L. Davis. Triangulating the self: identity processes in a connected era. *Symbolic Interaction*, 37(4):500–523, 2014.
- [130] Brittany J. Allen, Zachary E. Stratman, Brianna R. Kerr, Qianqian Zhao, and Megan A. Moreno. Associations between psychosocial measures and digital media use among transgender youth: cross-sectional study. *JMIR Pediatrics and Parenting*, 4(4):e25801, 2021.
- [131] Oliver L. Haimson. Mapping gender transition sentiment patterns via social media data: toward decreasing transgender mental health disparities. *Journal of the American Medical Informatics Association*, 26(8-9):749–758, 2019.
- [132] Susan Harter. *The Construction of the Self: Developmental and Sociocultural Foundations*. Guilford Press, New York, 2012.
- [133] Eveline A. Crone, Kirsten H. Green, Ilse H. van de Groep, and Ramon van der Cruysen. A neurocognitive model of self-concept development in adolescence. *Annual Review of Developmental Psychology*, 4:273–295, 2022.
- [134] Jennifer H. Pfeifer and Shelby J. Peake. Self-development: integrating cognitive, socioemotional, and neuroimaging perspectives. *Developmental Cognitive Neuroscience*, 2(1):55–69, 2012.
- [135] Catherine Sebastian, Stephanie Burnett, and Sarah-Jayne Blakemore. Development of the self-concept during adolescence. *Trends in Cognitive Sciences*, 12(11):441–446, 2008.
- [136] Elisabetta Crocetti, Monica Rubini, Koen Luyckx, and Wim Meeus. Identity formation in early and middle adolescents from various ethnic groups: from three dimensions to five statuses. *Journal of Youth and Adolescence*, 37(8):983–996, 2008.
- [137] Hironori Morita, Nathalie Griffioen, and Isabela Granic. Adolescents and social media: opportunities and challenges for development. In Jacqueline Nesi, Eva H. Telzer, and Mitchell J. Prinstein, editors, *Handbook of Adolescent Digital Media Use and Mental Health*, pages 63–84. Cambridge University Press, Cambridge, 2022.
- [138] Iroise Dumontheil, Ian A. Apperly, and Sarah-Jayne Blakemore. Online usage of theory of mind continues to develop in late adolescence. *Developmental Science*, 13(2):331–338, 2010.
- [139] Leah C. Weil, Stephen M. Fleming, Iroise Dumontheil, Emma J. Kilford, Ryan S. Weil, Geraint Rees, Raymond J. Dolan, and Sarah-Jayne Blakemore. The development of metacognitive ability in adolescence. *Consciousness and Cognition*, 22(1):264–271, 2013.
- [140] Mollie E. Moses-Payne, Gabriele Chierchia, and Sarah-Jayne Blakemore. Age-related changes in the impact of valence on self-referential processing in female adolescents and young adults. *Cognitive Development*, 61:101128, 2022.
- [141] Max Scheuplein, Laura Müller-Pinzler, Sören Krach, and Frieder M. Paulus. Perspective taking and memory for self- and town-related information in male adolescents and young adults. *Cognitive Development*, 67:101356, 2023.
- [142] Alexandra M. Rodman, Keely E. Powers, and Leah H. Somerville. Development of self-protective biases in response to social evaluative feedback. *Proceedings of the National Academy of Sciences of the United States of America*, 114(50):13158–13163, 2017.
- [143] Angie Y. Lee, Hanna Mieczkowski, Nicole B. Ellison, and Jeffrey T. Hancock. The algorithmic crystal: conceptualizing the self through algorithmic personalization on tiktok. *Proceedings of the ACM on Human-Computer Interaction*, 6(CSCW1):1–22, 2022.
- [144] Sander Thomaes, Albert Reijntjes, Bram Orobio de Castro, Brad J. Bushman, Astrid M. G. Poorthuis, and Michael J. Telch. I like me if you like me: on the interpersonal modulation and regulation of preadolescents state self-esteem. *Child Development*, 81(3):811–825, 2010.
- [145] Patti M. Valkenburg, Jochen Peter, and Alexander P. Schouten. Friend networking sites and their relationship to adolescents well-being and social self-esteem. *CyberPsychology & Behavior*, 9(5):584–590, 2006.
- [146] Izzy Kwan, Kelly Dickson, Marty Richardson, Wendy MacDowall, Helen Burchett, Claire Stansfield, and James Thomas. Cyberbullying and children and young peoples mental health: a systematic map of systematic reviews. *Cyberpsychology, Behavior, and Social Networking*, 23(2):72–82, 2020.
- [147] Andrew K. Przybylski and Lucy Bowes. Cyberbullying and adolescent well-being in england: a population-based cross-sectional study. *The Lancet Child & Adolescent Health*, 1(1):19–26, 2017.
- [148] Sabine Peters, Ramon van der Cruysen, Ilse van de Groep, Rosa Meuwese, and Eveline A. Crone. Social media use and the not-so-imaginary audience: behavioral and neural mechanisms underlying the influence on self-concept. *Developmental Cognitive Neuroscience*, 48:100921, 2021.
- [149] Joanne V. Wood. What is social comparison and how should we study it? *Personality and Social Psychology Bulletin*, 22(5):520–537, 1996.
- [150] Ronald E. Dahl, Nicholas B. Allen, Linda Wilbrecht, and Ahna B. Suleiman. Importance of investing in adolescence from a developmental science perspective. *Nature*, 554(7693):441–450, 2018.
- [151] Amy M. Ferguson, Gemma Turner, and Amy Orben. Social uncertainty in the digital world. *Trends in Cognitive Sciences*, 28(4):286–289, 2024.
- [152] Christopher R. Bleas. Too many friends, too few likes? evolutionary psychology and facebook depression. *Review of General Psychology*, 19(1):1–13, 2015.

- [153] Hye Youn Lee, Jacqueline P. Jamieson, Soo Hyun Lee, Christine Hill, and Hyun-Soo Kim. Getting fewer likes than others on social media elicits emotional distress among victimized adolescents. *Child Development*, 91(6):2141–2159, 2020.
- [154] Jacqueline Nesi and Mitchell J. Prinstein. In search of likes: longitudinal associations between adolescents digital status seeking and health-risk behaviors. *Journal of Clinical Child and Adolescent Psychology*, 48(5):740–748, 2019.
- [155] Caleb T. Carr, Rebecca A. Hayes, and Erin M. Sumner. Predicting a threshold of perceived facebook post success via likes and reactions: a test of explanatory mechanisms. *Communication Research Reports*, 35(2):141–151, 2018.
- [156] Elizabeth J. Noon and Adrian Meier. Inspired by friends: adolescents network homophily moderates the relationship between social comparison, envy, and inspiration on instagram. *Cyberpsychology, Behavior, and Social Networking*, 22(12):787–793, 2019.
- [157] Lore Schreurs, Adrian Meier, and Laura Vandenbosch. Exposure to the positivity bias and adolescents differential longitudinal links with social comparison, inspiration and envy depending on social media literacy. *Current Psychology*, 2022.
- [158] Adrian Meier and Helena-Verena Krause. Does passive social media use harm well-being? an adversarial review. *Journal of Media Psychology*, 35(4):169–180, 2023.
- [159] Jacqueline Nesi and Mitchell J. Prinstein. Using social media for social comparison and feedback-seeking: gender and popularity moderate associations with depressive symptoms. *Journal of Abnormal Child Psychology*, 43(8):1427–1438, 2015.
- [160] Björn Lindström et al. A computational reward learning account of social media engagement. *Nature Communications*, 12:1311, 2021.
- [161] Jasmine Fardouly, Philippa C. Diedrichs, Lenny R. Vartanian, and Emma Halliwell. Social comparisons on social media: the impact of facebook on young womens body image concerns and mood. *Body Image*, 13:38–45, 2015.
- [162] Maeve Scully, Liam Swords, and Elizabeth Nixon. Social comparisons on social media: online appearance-related activity and body dissatisfaction in adolescent girls. *Irish Journal of Psychological Medicine*, 40:31–42, 2023.
- [163] Hannah Appel, Alexander L. Gerlach, and Jule Crusius. The interplay between facebook use, social comparison, envy, and depression. *Current Opinion in Psychology*, 9:44–49, 2016.
- [164] A. Meier and B. K. Johnson. Social comparison and envy on social media: a critical review. *Current Opinion in Psychology*, 45:101302, 2022.
- [165] Philippe Verduyn, Natalia Gugushvili, Sander Massar, Kairi Täht, and Ethan Kross. Social comparison on social networking sites. *Current Opinion in Psychology*, 36:32–37, 2020.
- [166] A. Meier, A. Gilbert, S. Börner, and D. Possler. Instagram inspiration: how upward comparison on social network sites can contribute to well-being. *Journal of Communication*, 70:721–743, 2020.
- [167] J. M. Vaterlaus, E. V. Patten, C. Roche, and J. A. Young. gettinghealthy: the perceived influence of social media on young adult health behaviors. *Computers in Human Behavior*, 45:151–157, 2015.
- [168] P. M. Valkenburg, I. Beyens, J. L. Pouwels, I. I. Van Driel, and L. Keijsers. Social media browsing and adolescent well-being: challenging the passive social media use hypothesis. *Journal of Computer-Mediated Communication*, 2022.
- [169] R. W. Larson, M. H. Richards, G. Moneta, G. Holmbeck, and E. Duckett. Changes in adolescents daily interactions with their families from ages 10 to 18: disengagement and transformation. *Developmental Psychology*, 32:744–754, 1996.
- [170] C. Sebastian, E. Viding, K. D. Williams, and S.-J. Blakemore. Social brain development and the affective consequences of ostracism in adolescence. *Brain and Cognition*, 72:134–145, 2010.
- [171] C. et al. Sebastian. Developmental influences on the neural bases of responses to social rejection: implications of social neuroscience for education. *NeuroImage*, 57:686–694, 2011.
- [172] L. H. Somerville. The teenage brain: sensitivity to social evaluation. *Current Directions in Psychological Science*, 22:121–127, 2013.
- [173] R. W. Larson and U. S. How. Children and adolescents spend time: what it does (and doesnt) tell us about their development. *Current Directions in Psychological Science*, 10:160–164, 2001.
- [174] L. A. Thomas, M. D. De Bellis, R. Graham, and K. S. LaBar. Development of emotional facial recognition in late childhood and adolescence. *Developmental Science*, 10:547–558, 2007.
- [175] B. Gunther Moor, L. van Leijenhorst, S. A. R. B. Rombouts, E. A. Crone, and M. W. Van der Molen. Do you like me? neural correlates of social evaluation and developmental trajectories. *Social Neuroscience*, 5:461–482, 2010.
- [176] J. S. et al. Silk. Peer acceptance and rejection through the eyes of youth: pupillary, eyetracking and ecological data from the chatroom interact task. *Social Cognitive and Affective Neuroscience*, 7:93–105, 2012.
- [177] S. Gao, M. Assink, A. Cipriani, and K. Lin. Associations between rejection sensitivity and mental health outcomes: a meta-analytic review. *Clinical Psychology Review*, 57:59–74, 2017.
- [178] M. J. Prinstein, J. Nesi, and E. H. Telzer. Commentary: an updated agenda for the study of digital media use and adolescent developmentfuture directions following odgers jensen (2020). *Journal of Child Psychology and Psychiatry*, 61:349–352, 2020.
- [179] D. Meshi, C. Morawetz, and H. R. Heekeren. Nucleus accumbens response to gains in reputation for the self relative to gains for others predicts social media use. *Frontiers in Human Neuroscience*, 7:1–11, 2013.
- [180] E. A. Crone and R. E. Dahl. Understanding adolescence as a period of socialaffective engagement and goal flexibility. *Nature Reviews Neuroscience*, 13:636–650, 2012.
- [181] B. Platt, K. C. Kadosh, and J. Y. F. Lau. The role of peer rejection in adolescent depression. *Depression and Anxiety*, 30:809–821, 2013.
- [182] G.-J. Will, R. B. Rutledge, M. Moutoussis, and R. J. Dolan. Neural and computational processes underlying dynamic changes in self-esteem. *eLife*, 6:e28098, 2017.
- [183] N. Macrynika and R. Miranda. Active facebook use and mood: when digital interaction turns maladaptive. *Computers in Human Behavior*, 97:271–279, 2019.
- [184] K. Grunewald, J. Deng, J. Wertz, and S. Schweizer. The effect of online social evaluation on mood and cognition in young people. *Scientific Reports*, 12:20999, 2022.
- [185] J. L. Andrews, A. C. Khin, T. Crayn, K. Humphreys, and S. Schweizer. Measuring online and offline social rejection sensitivity in the digital age. *Psychological Assessment*, 34:742–751, 2022.
- [186] A. L. Forest and J. V. Wood. When social networking is not working: individuals with low self-esteem recognize but do not reap the benefits of self-disclosure on facebook. *Psychological Science*, 23:295–302, 2012.
- [187] P. M. Valkenburg, M. Koutamanis, and H. G. M. Vossen. The concurrent and longitudinal relationships between adolescents use of social network sites and their social self-esteem. *Computers in Human Behavior*, 76:35–41, 2017.
- [188] A. L. Burrow and N. Rainone. How many likes did i get? purpose moderates links between positive social media feedback and self-esteem. *Journal of Experimental Social Psychology*, 69:232–236, 2017.
- [189] M. Seo, J. Kim, and H. Yang. Frequent interaction and fast feedback predict perceived social support: using crawled and self-reported data of facebook users. *Journal of Computer-Mediated Communication*, 21:282–297, 2016.
- [190] D. Fuhrmann, C. S. Casey, M. Speekenbrink, and S.-J. Blakemore. Social exclusion affects working memory performance in young adolescent girls. *Developmental Cognitive Neuroscience*, 40:100718, 2019.
- [191] S.-J. Blakemore and S. Choudhury. Development of the adolescent brain: implications for executive function and social cognition. *Journal of Child Psychology and Psychiatry*, 47:296–312, 2006.
- [192] M. Dreyfuss et al. Teens impulsively react rather than retreat from threat. *Developmental Neuroscience*, 36:220–227, 2014.
- [193] A. E. Guyer, V. R. Choate, D. S. Pine, and E. E. Nelson. Neural circuitry underlying affective response to peer feedback in adolescence. *Social Cognitive and Affective Neuroscience*, 7:81–92, 2012.
- [194] L. E. Sherman, A. A. Payton, L. M. Hernandez, P. M. Greenfield, and M. Dapretto. The power of the like in adolescence: effects of peer influence on neural and behavioral responses to social media. *Psychological Science*, 27:1027–1035, 2016.
- [195] A.-L. van Harmelen et al. Adolescent friendships predict later resilient functioning across psychosocial domains in a healthy community cohort. *Psychological Medicine*, 47:2312–2322, 2017.
- [196] P. S. Chu, D. A. Saucier, and E. Hafner. Meta-analysis of the relationships between social support and well-being in children and adolescents. *Journal of Social and Clinical Psychology*, 29:624–645, 2010.
- [197] F. M. Schneider et al. Social media ostracism: the effects of being excluded online. *Computers in Human Behavior*, 73:385–393, 2017.
- [198] S. Reich, F. M. Schneider, and L. Heling. Zero likessymbolic interactions and need satisfaction online. *Computers in Human Behavior*, 80:97–102, 2018.
- [199] S. Lutz and F. M. Schneider. Is receiving dislikes in social media still better than being ignored? the effects of ostracism and rejection on need threat and coping responses online. *Media Psychology*, 24:741–765, 2021.
- [200] S. Lutz. Why dont you answer me? exploring the effects of (repeated exposure to) ostracism via messengers on users fundamental needs, well-being, and coping motivation. *Media Psychology*, 26:113–140, 2023.
- [201] C. T. Rodríguez-Hidalgo, E. S. H. Tan, P. W. J. Verlegh, I. Beyens, and R. Kühne. Dont stress me now: assessing the regulatory impact of face-to-face and online feedback prosociality on stress during an important life event. *Journal of Computer-Mediated Communication*, 25:307–327, 2020.
- [202] S. Trepte, T. Dienlin, and L. Reinecke. Influence of social support received in online and offline contexts on satisfaction with social support and satisfaction with life: a longitudinal study. *Media Psychology*, 18:74–105, 2015.
- [203] R. Dredge and L. Schreurs. Social media use and offline interpersonal outcomes during youth: a systematic literature review. *Mass Communication and Society*, 23:885–911, 2020.
- [204] T. Colasante, L. Lin, K. De France, and T. Hollenstein. Any time and place? digital emotional support for digital natives. *American Psychologist*, 77:186–195, 2022.
- [205] J. L. Pouwels, P. M. Valkenburg, I. Beyens, I. I. Van Driel, and L. Keijsers. Social media use and friendship closeness in adolescents daily lives: an experience sampling study. *Developmental Psychology*, 57:309–323, 2021.
- [206] K. L. Mills et al. Structural brain development between childhood and adulthood: convergence across four longitudinal samples. *NeuroImage*, 141:273–281, 2016.
- [207] C. K. Tamnes et al. Development of the cerebral cortex across adolescence: a multisample study of inter-related longitudinal changes in cortical volume, surface area, and thickness. *Journal of Neuroscience*, 37:3402–3412, 2017.
- [208] B. Larsen and B. Luna. Adolescence as a neurobiological critical period for the development of higher-order cognition. *Neuroscience & Biobehavioral Reviews*, 94:179–195, 2018.

- [209] Z. Petanjek et al. Extraordinary neoteny of synaptic spines in the human prefrontal cortex. *Proceedings of the National Academy of Sciences of the USA*, 108:13281–13286, 2011.
- [210] J. R. Cohen et al. A unique adolescent response to reward prediction errors. *Nature Neuroscience*, 13:669–671, 2010.
- [211] M. Ernst et al. Amygdala and nucleus accumbens in responses to receipt and omission of gains in adults and adolescents. *NeuroImage*, 25:1279–1291, 2005.
- [212] A. Galván and K. M. McGlennen. Enhanced striatal sensitivity to aversive reinforcement in adolescents versus adults. *Journal of Cognitive Neuroscience*, 25:284–296, 2013.
- [213] B. R. Braams, A. C. K. Van Duijvenvoorde, J. S. Peper, and E. A. Crone. Longitudinal changes in adolescent risk-taking: a comprehensive study of neural responses to rewards, pubertal development, and risk-taking behavior. *Journal of Neuroscience*, 35:7226–7238, 2015.
- [214] E. Schreuders et al. Contributions of reward sensitivity to ventral striatum activity across adolescence and early adulthood. *Child Development*, 89:797–810, 2018.
- [215] M. T. Maza et al. Association of habitual checking behaviors on social media with longitudinal functional brain development. *JAMA Pediatrics*, 177:160–167, 2023.
- [216] J. Miller, K. L. Mills, M. Vuorre, A. Orben, and A. K. Przybylski. Impact of digital screen media activity on functional brain organization in late childhood: evidence from the abcd study. *Cortex*, 169:290–308, 2023.
- [217] M. Flayelle et al. A taxonomy of technology design features that promote potentially addictive online behaviours. *Nature Reviews Psychology*, 2:136–150, 2023.
- [218] S. J. Lupien, B. S. McEwen, M. R. Gunnar, and C. Heim. Effects of stress throughout the lifespan on the brain, behaviour and cognition. *Nature Reviews Neuroscience*, 10:434–445, 2009.
- [219] M. R. Gunnar, S. Wewerka, K. Frenn, J. D. Long, and C. Griggs. Developmental changes in hypothalamuspituitaryadrenal activity over the transition to adolescence: normative changes and associations with puberty. *Development and Psychopathology*, 21:69–85, 2009.
- [220] L. H. Somerville et al. The medial prefrontal cortex and the emergence of self-conscious emotion in adolescence. *Psychological Science*, 24:1554–1562, 2013.
- [221] L. R. Stroud et al. Stress response and the adolescent transition: performance versus peer rejection stressors. *Development and Psychopathology*, 21:47–68, 2009.
- [222] A. Avital and G. Richter-Levin. Exposure to juvenile stress exacerbates the behavioural consequences of exposure to stress in the adult rat. *International Journal of Neuropsychopharmacology*, 8:163–173, 2005.
- [223] C. M. McCormick, I. Z. Mathews, C. Thomas, and P. Waters. Investigations of hpa function and the enduring consequences of stressors in adolescence in animal models. *Brain and Cognition*, 72:73–85, 2010.
- [224] L. Eiland and R. D. Romeo. Stress and the developing adolescent brain. *Neuroscience*, 249:162–171, 2013.
- [225] R. D. Romeo. The teenage brain. *Current Directions in Psychological Science*, 22:140.
- [226] T. D. Afifi, N. Zamanzadeh, K. Harrison, and M. Acevedo Callejas. Wired: The impact of media and technology use on stress (cortisol) and inflammation (interleukin il-6) in fast paced families. *Computers in Human Behavior*, 81:265–273, 2018.
- [227] J. K. Morin-Major et al. Facebook behaviors associated with diurnal cortisol in adolescents: is befriending stressful? *Psychoneuroendocrinology*, 63:238–246, 2016.
- [228] S. Ghai. Its time to reimagine sample diversity and retire the weird dichotomy. *Nature Human Behaviour*, 5:971–972, 2021.
- [229] M. R. Munafò and G. Davey Smith. Robust research needs many lines of evidence. *Nature*, 553:399–401, 2018.
- [230] R. Dale, A. S. Warlaumont, and K. L. Johnson. The fundamental importance of method to theory. *Nature Reviews Psychology*, 2:55–66, 2022.
- [231] D. A. Parry, J. T. Fisher, H. Mieczkowski, C. J. R. Sewall, and B. I. Davidson. Social media and well-being: a methodological perspective. *Current Opinion in Psychology*, 45:101285, 2022.
- [232] G.-J. Will et al. Neurocomputational mechanisms underpinning aberrant social learning in young adults with low self-esteem. *Translational Psychiatry*, 10:96, 2020.
- [233] J. B. Walther. Affordances, effects, and technology errors. *Annals of the International Communication Association*, 36:190–193, 2013.
- [234] P. Piray and N. D. Daw. A model for learning based on the joint estimation of stochasticity and volatility. *Nature Communications*, 12:6587, 2021.
- [235] U. Bronfenbrenner. *The Ecology of Human Development: Experiments by Nature and Design*. Harvard University Press, 1979.
- [236] M. D. Slater. Reinforcing spirals: the mutual influence of media selectivity and media effects and their impact on individual behavior and social identity. *Communication Theory*, 17:281–303, 2007.
- [237] P. M. Valkenburg, J. Peter, and J. B. Walther. Media effects: theory and research. *Annual Review of Psychology*, 67:315–338, 2016.
- [238] G. Aalbers, R. J. McNally, A. Heeren, S. De Wit, and E. I. Fried. Social media and depression symptoms: a network perspective. *Journal of Experimental Psychology: General*, 148:1454–1462, 2019.
- [239] S. Ghai, L. Fassi, F. Awadh, and A. Orben. Lack of sample diversity in research on adolescent depression and social media use: a scoping review and meta-analysis. *Clinical Psychological Science*, 11:759–772, 2023.
- [240] A. O. J. Cramer et al. Major depression as a complex dynamic system. *PLoS ONE*, 11:e0167490, 2016.
- [241] K. S. Kendler, P. Zachar, and C. Craver. What kinds of things are psychiatric disorders? *Psychological Medicine*, 41:1143–1150, 2011.
- [242] I. A. van de Leemput et al. Critical slowing down as early warning for the onset and termination of depression. *Proceedings of the National Academy of Sciences USA*, 111:87–92, 2014.
- [243] S. Trepte. The social media privacy model: privacy and communication in the light of social media affordances. *Communication Theory*, 31:549–570, 2021.
- [244] L. Reinecke et al. Permanently online and permanently connected: development and validation of the online vigilance scale. *PLoS ONE*, 13:e0205384, 2018.
- [245] P. Trieu, J. B. Bayer, N. B. Ellison, S. Schoenebeck, and E. Falk. Who likes to be reachable? availability preferences, weak ties, and bridging social capital. *Information, Communication & Society*, 22:1096–1111, 2019.
- [246] R. L. Daft and R. H. Lengel. Organizational information requirements, media richness and structural design. *Management Science*, 32:554–571, 1986.
- [247] L. Rhee, J. B. Bayer, D. S. Lee, and O. Kuru. Social by definition: how users define social platforms and why it matters. *Telematics and Informatics*, 59:101538, 2021.
- [248] P. M. Valkenburg. Understanding self-effects in social media: self-effects in social media. *Human Communication Research*, 43:477–490, 2017.
- [249] K. Thorson and C. Wells. Curated flows: a framework for mapping media exposure in the digital age: curated flows. *Communication Theory*, 26:309–328, 2016.
- [250] H. Zhao and C. Wagner. How tiktok leads users to flow experience: investigating the effects of technology affordances with user experience level and video length as moderators. *International Journal of Human-Computer Interaction*, 33:820–849, 2023.
- [251] C. T. Carr, D. Y. Wohn, and R. A. Hayes. As social support: relational closeness, automaticity, and interpreting social support from paralinguistic digital affordances in social media. *Computers in Human Behavior*, 62:385–393, 2016.
- [252] R. E. Rice et al. Organizational media affordances: operationalization and associations with media use: organizational media affordances. *Journal of Communication*, 67:106–130, 2017.
- [253] L. Scissors, M. Burke, and S. Wengrovitz. In *Proceedings of the 19th ACM Conference on Computer-Supported Cooperative Work & Social Computing (CSCW)*, pages 1499–1508. ACM Press, 2016.
- [254] D. M. Boyd. In Z. Papacharissi, editor, *A Networked Self: Identity, Community and Culture in Social Networking Sites*, pages 35–58. Routledge, 2011.
- [255] P. M. Valkenburg. In J. Nesi, E. H. Telzer, and M. J. Prinstein, editors, *Handbook of Adolescent Digital Media Use and Mental Health*, pages 39–60. Cambridge University Press, 2022.
- [256] A. R. Dennis, R. M. Fuller, and J. S. Valacich. Media tasks, and communication processes: a theory of media synchronicity. *MIS Quarterly*, 32:575–600, 2008.
- [257] D. C. DeAndrea. Advancing warranting theory: advancing warranting theory. *Communication Theory*, 24:186–204, 2014.
- [258] Peter J. Uhlhaas et al. Towards a youth mental health paradigm: a perspective and roadmap. *Molecular Psychiatry*, 28:3171–3181, 2023.
- [259] Linda Kachuri et al. Principles and methods for transferring polygenic risk scores across global populations. *Nature Reviews Genetics*, 25:8–25, 2024.
- [260] Emily C. Weinstein and Robert L. Selman. Digital stress: adolescents personal accounts. *New Media & Society*, 18:391–409, 2016.
- [261] Ric G. Steele, Jeffrey A. Hall, and J. L. Christofferson. Conceptualizing digital stress in adolescents and young adults: toward the development of an empirically based model. *Clinical Child and Family Psychology Review*, 23:15–26, 2020.
- [262] Emma A. Nick et al. Adolescent digital stress: frequencies, correlates, and longitudinal association with depressive symptoms. *Journal of Adolescent Health*, 70:336–339, 2022.
- [263] W. A. Van Der Schuur, S. E. Baumgartner, and S. R. Sumter. Social media use, social media stress, and sleep: examining cross-sectional and longitudinal relationships in adolescents. *Health Communication*, 34:552–559, 2019.
- [264] S. Fabio and P. Sonja. Is cyberbullying worse than traditional bullying? examining the differential roles of medium, publicity, and anonymity for the perceived severity of bullying. *Journal of Youth and Adolescence*, 42:739–750, 2013.
- [265] Robert S. Tokunaga. Following you home from school: a critical review and synthesis of research on cyberbullying victimization. *Computers in Human Behavior*, 26:277–287, 2010.
- [266] D. Khetawat and R. G. Steele. Examining the association between digital stress components and psychological wellbeing: a meta-analysis. *Clinical Child and Family Psychology Review*, 26:957–974, 2023.
- [267] Ine Beyens, Eline Frison, and Steven Eggermont. I don't want to miss a thing: adolescents fear of missing out and its relationship to adolescents social needs, facebook use, and facebook related stress. *Computers in Human Behavior*, 64:1–8, 2016.
- [268] L. Wartberg, R. Thomasius, and K. Paschke. The relevance of emotion regulation, procrastination, and perceived stress for problematic social media use in a representative sample of children and adolescents. *Computers in Human Behavior*, 121:106788, 2021.
- [269] Louise Winstone, Becky Mars, Claire M. A. Haworth, and Judi Kidger. Types of social media use and digital stress in early adolescence. *Journal of Early Adolescence*, 43:294–319, 2023.
- [270] M. West, S. Rice, and D. Vella-Brodick. Exploring the social in social media: adolescent relatedness thwarted and supported. *Journal of Adolescence Research*, 2021.
- [271] A. Gilbert, S. E. Baumgartner, and L. Reinecke. Situational boundary conditions of digital stress: goal conflict and autonomy frustration make smartphone use more stressful. *Mobile Media & Communication*, 2022.
- [272] A. Freytag et al. Permanently online always stressed out? the effects of permanent connectedness on stress experiences. *Human Communication Research*, 47:132–165, 2021.
- [273] Niklas Johannes et al. The relationship between online vigilance and affective well-being in everyday life: combining smartphone logging with experience sampling. *Media Psychology*, 24:581–605, 2021.
- [274] Leonard Reinecke et al. Digital stress over the life span: the effects of communication load and internet multitasking on perceived stress and psychological health impairments in a german probability sample. *Media Psychology*, 20:90–115, 2017.

- [275] Klaus Schönbach. The international encyclopedia of media effects. In Patrick Rössler, Cynthia A. Hoffner, and Liesbet van Zoonen, editors, *The International Encyclopedia of Media Effects*, pages 1–11. Wiley, 2017.
- [276] John D. Mayer, Yvonne N. Gaschke, Donald L. Braverman, and Thomas W. Evans. Mood-congruent judgment is a general effect. *Journal of Personality and Social Psychology*, 63:119–132, 1992.
- [277] Charles B. Ferster. A functional analysis of depression. *American Psychologist*, 28:857–870, 1973.
- [278] John P. Carvalho and Derek R. Hopko. Behavioral theory of depression: reinforcement as a mediating variable between avoidance and depression. *Journal of Behavior Therapy and Experimental Psychiatry*, 42:154–162, 2011.
- [279] S. Helbig-Lang and F. Petermann. Tolerate or eliminate? a systematic review on the effects of safety behavior across anxiety disorders. *Clinical Psychology: Science and Practice*, 17:218–233, 2010.
- [280] L. Marciano, C. C. Driver, P. J. Schulz, and A.-L. Camerini. Dynamics of adolescents smartphone use and well-being are positive but ephemeral. *Scientific Reports*, 12:1316, 2022.
- [281] P. A. Rao et al. Social anxiety disorder in childhood and adolescence: descriptive psychopathology. *Behaviour Research and Therapy*, 45:1181–1191, 2007.
- [282] Amy F. Corning, Amy J. Krumm, and L. A. Smitham. Differential social comparison processes in women with and without eating disorder symptoms. *Journal of Counseling Psychology*, 53:338–349, 2006.
- [283] Ana Radovic, Theresa Gmelin, Bradley D. Stein, and Elizabeth Miller. Depressed adolescents positive and negative use of social media. *Journal of Adolescence*, 55:5–15, 2017.

Table 1: Affordances of social media that are relevant to the relationship between adolescent development and mental health

Affordance	Description	Example of Affordance	Example Associated Mechanism	Example Relationship with Mental Health	Refs.
Anonymity	The difficulty with which other social media agents (users, institutions or companies) can identify the source or sender of a message	Anonymity can easily be achieved in social media through fake accounts or using platforms that do not require sharing of identity	Behaviour: risky posting behaviour	High anonymity can disinhibit interactions and make behaviours or reactions more extreme	79,243
Association	The degree with which links between people, between people and content or between a presenter and their audience can be articulated	Friends lists facilitate the association between people; Comments or reposts facilitate the association between a person and content or ideas	Cognitive: social comparison	The ability to understand who is associated with whom can make it easier to judge social status or friendship ties, boosting comparison with others	84
Availability	How easily a user can reach and access the technology as well as how easily the user can be reached through the technology (also termed permanence or perpetual contact)	Mobile use of social media enables high availability	Neurobiological: reward and stress	Heightened availability of peers via mobile media can support increased checking behaviours, which might have long-term consequences for reward processing	244,245
Bandwidth	The breadth of socio-emotional cues that messages transmit; partially determined by the modality of channels (such as video chat or email), but also by users adaption to channel limitations (for example, different language use, timing or interpunctuation), which can all influence a sense of social presence	Few social cues makes it difficult to judge what people think of a behaviour or posts on social media	Behaviour: risky posting behaviour	Low bandwidth can potentially disinhibit interactions and make behaviours or reactions more extreme	81,246,247
Editability	The degree to which messages can be carefully crafted, refined and edited; also called rehearsability, which emphasizes the ability to not only edit but also consider material before posting	Posts can be drafted and re-drafted many times before sharing on social media	Behaviour: self-presentation and identity	The editability of profiles enables users to curate and present their online identity, potentially facilitating identity development	35,84,248
Persistence	The degree to which messages remain accessible to receivers in the same form as originally crafted and displayed by the sender	Auto-deletion features enable ephemeral messages with low persistence	Behaviour: self-presentation and identity	The persistence of social media posts (for example, after screenshotting) could limit adolescents ability to freely explore their identity	79,80,82,84
Personalisation	The degree to which messages are tailored (by senders or by recommendation algorithms) to fit the identity, preferences or expectations of the receiver	TikTok algorithms enable users to consume content that is highly relevant to them	Cognitive: self-concept development	The personalization of content can change what young people see on social media feeds, influencing self-concept development	81,143,249,250
Quantifiability	How countable information is, especially if it formally quantifies aspects of social life that were previously not as clearly labelled with quantitative values	Numbers of friends or followers, and social feedback and content popularity, which are quantified through the like button or similar one-click reactions	Cognitive: social inclusion and exclusion	The quantifiability of social feedback could make it easier to feel excluded or unpopular (for example, when not receiving likes)	35,152,194,251-253

Continued on next page

Affordance	Description	Example of Affordance	Example Associated Mechanism	Example Relationship with Mental Health	Refs.
Replicability	The ease with which messages can be duplicated and shared with others, via the same or other digital channels	Features that enable forwarding content across platforms; if this is not built into the system, users might find other means (for example, through screenshots)	Behaviour: risky posting behaviour	Replicability can amplify the risk of activities such as sexting	254
Synchronicity	The degree to which an interaction is perceived as happening simultaneously, in real time	Feed posts are classically more strongly associated with asynchronous communication, and instant messengers with synchronous communication	Cognitive: social feedback	Asynchronicity of communication makes it more likely that adolescents have time to ruminate about potential social feedback, especially when presumed negative	35,81,255
Variability of Social Rewards	The degree to which social interaction and feedback occur on variable time schedules	The time lag between sending a message or posting and the responses and reactions to these actions is unknown	Neurobiological: reward	Quantified social feedback from peers can support increased checking behaviours, which might have long-term consequences on reward processing	160,217,256
Verifiability	How easily a messages truthfulness can be cross-examined and authenticated by others	Verifiability is implicated in inauthentic self-presentations (such as using visual filters), scams (such as catfishing) and other forms of deception (such as misinformation or fake news)	Cognitive: social comparison	If the verifiability of individuals or their posts is low, it is difficult to gauge the authenticity of their self-presentations that form the basis for social comparisons	33,143,249,250,252,257
Visibility	The relative ease with which messages can be located and seen by others; sometimes also termed publicness (or scalability if approached from the senders perspective)	Visibility enables users to choose the size and nature of their audiences and influences whether information is considered private, semi-public or public	Cognitive: self-presentation and identity	Profile visibility enables users to curate and try out different private and public online identities, potentially facilitating identity development	83,84,255

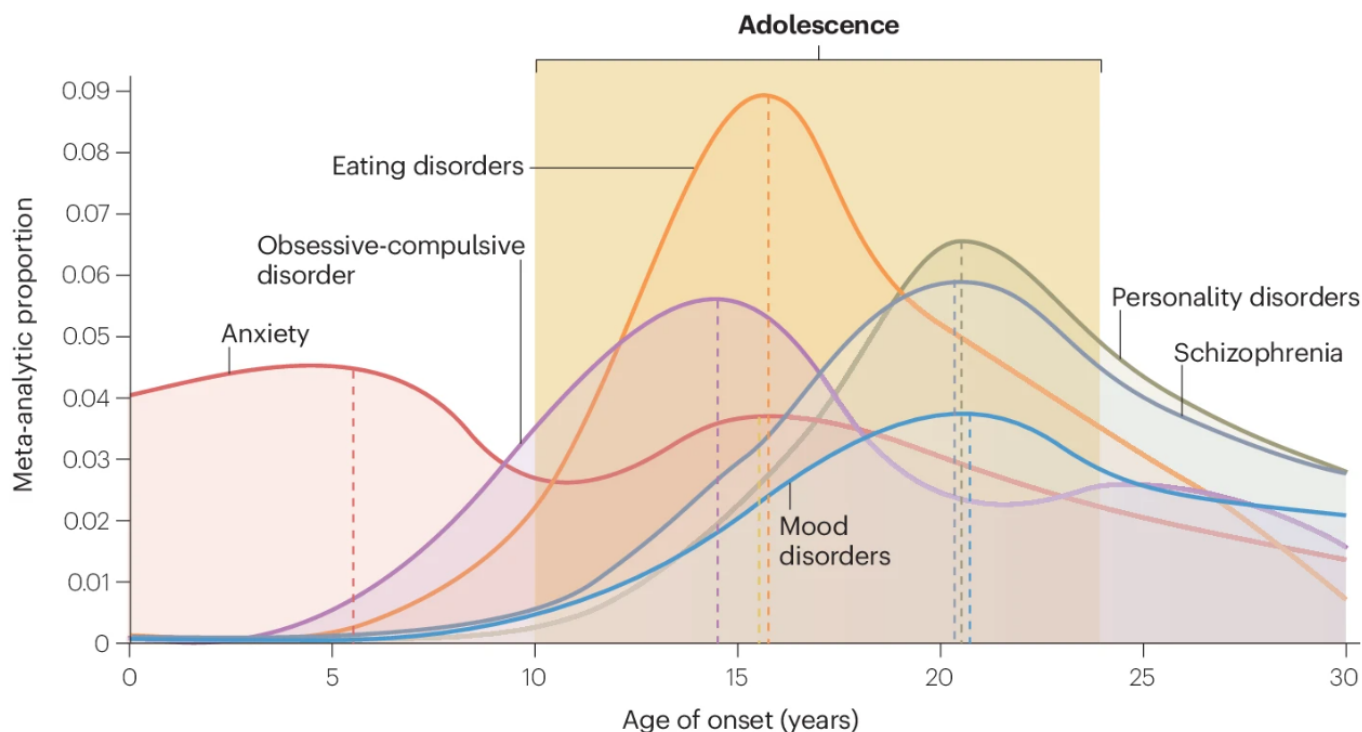


Fig. 1: Age of onset for different mental disorders.

Meta-analytic proportion of age of onset of anxiety (red), obsessive-compulsive disorder (purple), eating disorders (orange), personality disorders (green), schizophrenia (grey) and mood disorders (blue). The peak age of onset (dotted lines) is 5.5 and 15.5 years for anxiety, 14.5 years for obsessive-compulsive disorder, 15.5 years for eating disorders and 20.5 years for personality disorders, schizophrenia and mood disorders. Adapted from ref. ²⁵⁸, CC BY 4.0. (<https://creativecommons.org/licenses/by/4.0/>).

[FIG 2 CANNOT BE REPRODUCED AS IT WAS CREATED WITH THE JOURNAL IMAGE EDITORS AFTER ACCEPTANCE. SEE ORIGINAL CITATION FOR FIGURE]

Fig. 2: Factors contributing to adolescent mental health vulnerability.

During adolescence, the interaction between genetic programming (yellow), social determinants (red) and environmental factors (blue), as well as the developmental changes discussed in this Review, increases the risk for onset of mental health conditions. Digital environments, mediated behaviours and experiences, and the impact that this technology has on society and economy more generally, are one aspect of the complex forces that might lead to the declines in adolescent mental health observed in the last decade. Adapted from ref. ²⁵⁹, Springer Nature Limited.

[FIG 2 CANNOT BE REPRODUCED AS IT WAS CREATED WITH THE JOURNAL IMAGE EDITORS AFTER ACCEPTANCE. SEE ORIGINAL CITATION FOR FIGURE.]

Fig. 3: Examples of social media affordances in adolescence.

Social media affordances can amplify the impact that common adolescent developmental mechanisms (behavioural, cognitive and neurobiological) have on mental health. At the behavioural level (top), affordances such as permanence and publicness lead to an increased impact of risk-taking behaviour on mental health compared with similar behaviours in non-mediated environments. At the cognitive level (middle), high quantifiability influences the effects of social comparison. At the neurobiological level (bottom), low synchronicity can amplify the effects of stress on the developing brain.

Box 1: Digital Stress

Digital stress is not a unified construct. Thematic content analyses have categorized digital stress into type I stressors (for example, mean attacks, cyberbullying or shaming) and type II stressors (for example, interpersonal stress due to pressure to stay available)²⁶⁰. Other reviews have noted its complexity, and categorized digital stress into availability stress (stress that results from having to be constantly available), approval anxiety (anxiety regarding others reaction to their own profile, posts or activities online), fear of missing out (stress about being absent from or not experiencing others rewarding experiences) and communication overload (stress due to the scale, intensity and frequency of online communication)²⁶¹.

Digital stress has been systematically linked to negative mental health outcomes. Higher digital stress was longitudinally associated with higher depressive symptoms in a questionnaire study²⁶². Higher social media stress was also longitudinally related to poorer sleep outcomes in girls (but not boys)²⁶³. Studies and reviews have linked cyberbullying victimization (a highly stressful experience) to decreased mental health outcomes such as depression, and psychosocial outcomes such as self-esteem^{103,146,147,264,265}. A systematic review of both adolescents and adults found a medium association ($r=0.26-0.34$) between different components of digital stress and psychological distress outcomes such as anxiety, depression or loneliness, which was not moderated by age or sex (except for connection overload)²⁶⁶. However, the causal structure giving rise to such results is still far from clear. For example, surveys have linked higher stress levels to more problematic social media use and fear of missing out^{267,268}.

Thus, the impact of digital stress on mental health is probably complex and influenced by the type of digital stressor and various affordances. For example, visibility and availability increase fear of negative public evaluation²⁶⁹ and high availability and a social norm of responding quickly to messages drive constant monitoring in adolescents due to a persistent fear of upsetting friends²⁷⁰.

A range of relevant evidence from qualitative and quantitative studies documents that adolescents often ruminate about online interactions and messages. For example, online salience (constantly thinking about communication, content or events happening online) was positively associated with stress on both between-person and within-person levels in a cross-sectional quota sample of adults and three diary studies of young adults^{271,272}. Online salience has also been associated with lower well-being in a pre-registered study of momentary self-reports from young adults with logged online behaviours. However, this study also noted that positive thoughts were related to higher well-being²⁷³. Furthermore, although some studies found no associations between the amount of communication and digital stress²⁷², a cross-sectional study found that younger users (age 14-34 years and 35-49 years) perception of social pressure to be constantly available was related to communication load (measured by questions about the amount of use, as well as the urge to check email and social media) and Internet multitasking, whereas this was not the case for older users aged 50-85 years²⁷⁴. By contrast, communication load and perceived stress were associated only among older users.

Box 2: Effects of Mental Health on Social Media

Although a lot of scientific discussion has focused on the impact of social media use on mental health, cross-sectional studies cannot differentiate between whether social media use is influencing mental health or mental health is influencing social media use, or a third factor is influencing both⁵¹. It is likely that mental health status influences social media use creating reinforcing cycles of behaviour, something that has been considered in the communication sciences literature under the term transactional media effects^{58,236,237}. According to communication science models, media use and its consequences are components of reciprocal processes²⁷⁵.

There are similar models in mental health research. For example, people's moods influence their judgements of events, which can lead to self-perpetuating cycles of negativity (or positivity); a mechanism called mood congruency²⁷⁶. Behavioural studies have also shown that people experiencing poor mental health behave in ways that decrease their opportunity to experience environmental reward such as social activities, maintaining poor mental health^{277,278}. Although for many people these behaviours are a form of coping (for example, by avoiding stressful circumstances), they often worsen symptoms of mental health conditions²⁷⁹.

Some longitudinal studies found that a decrease in adolescent well-being predicted an increase in social media use 1 year later^{47,59}. However, other studies have found no relationships between well-being and social media use over long-term or daily time windows^{45,46}. One reason behind the heterogeneity of the results could be that how mental health impacts social media use is highly individual^{45,280}.

Knowledge on the impact of mental health on social media use is still in its infancy and studies struggle to reach coherent conclusions. However, findings from the mental health literature can be used to generate hypotheses about how aspects of mental health might impact social media use. For example, it has been repeatedly found that young people with anxiety or eating disorders engage in more social comparisons than individuals without these disorders^{281,282}, and adolescents with depression report more unfavourable social comparisons on social media than adolescents without depression²⁸³. Similar results have been found for social feedback seeking (for example, reassurance), including in social media environments¹⁵⁹. Specifically, depressive symptoms were more associated with social comparison and feedback seeking, and these associations were stronger in women and in adolescents who were less popular. Individuals from the general population with lower self-esteem post more negative and less positive content than individuals with higher self-esteem, which in turn is associated with receiving less positive feedback from others¹⁸⁵. There are therefore a wide range of possible ways in which diverse aspects of mental health might influence specific facets of how social media is used and, in turn, how it ends up impacting the user.