Review

Pathways between digital activity and depressed mood in adolescence: outlining a developmental model integrating risk, reactivity, resilience and reciprocity☆

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Digital technology use (i.e. digital activity) has been proposed to contribute to a decline in adolescents' mental health. We present a new model of how risky digital activity may increase depressed mood via reciprocal pathways, creating negative developmental cycles. Specifically, we hypothesize that risky digital activity increases depressed mood by evoking frequent and persistent negative affective (e.g. anger) and cognitive reactions (e.g. "I feel stupid"). These effects, we postulate, are compounded when depressed mood further increases both risky digital activity and negative affective and cognitive reactions to it. The model also proposes that these negative impacts of risky digital activity can be mitigated by actively managing it and/or the reactions it evokes. All pathways are hypothesized to be moderated by nondigital factors.

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Adolescent mental health in the digital age

Depression is one of the most common and burdensome mental health conditions [1]. For many people, it emerges in adolescence and, once established, often persists across their lifespan [2], creating the risk for suicidal thoughts and behaviours [3]. Depression affects females more than males [3] and the socially disadvantaged more than the advantaged [4]. Finding ways to reduce adolescent depression is a top public health priority [5]. The urgency to intervene has been accentuated by evidence showing dramatic increases in adolescent depression rates over recent decades [6]. Although we do not know the long-term impact of the coronavirus disease 2019 pandemic, systematic reviews suggest it has exacerbated the decline in youth mental health [7,8].

Explanations for the increased prevalence of adolescent depression and related mental health problems point to the influence of societal changes [9], including the widespread claim that digital technology has impacted how adolescents spend their free time and interact with peers and the wider world [10]. Certainly, adolescent exposure to digitally mediated experiences is now nearly ubiquitous in most cultures [11]. In the United Kingdom, 97% of children have their own mobile phone by 12 years old, and a majority (88%) have a personal profile on an app or website [12]. Digital experiences can be both positive and negative. With regard to the latter, for example, about one-third of UK youth aged 8–17 years are exposed to hurtful treatment via digital technologies compared with two in 10 who experience this face to face [12].

Despite the dominant cultural narrative linking digital activity to poor mental health in general, and depression in particular, empirical studies give a mixed picture, and few are designed to assess causal pathways. Many report associations between high levels of digital activity and poor mental health, but the sizes of the effects are typically small (e.g. [10,13,14]). In contrast, some studies have identified protective benefits of digital activity on mental health; for instance, opportunities for social connection, support and entertainment have been suggested [15] and demonstrated [16].

The need for strong theory and robust methods

Interpreting research on digital activities and mental health in a way that could promote policy and practice innovation to reduce risks arising from harmful activity and promote or leverage positive activity in adolescence is hampered by the methodological limitations of many studies. *First,* many characterize digital activity simplistically, limiting it to a single quantitative measure of 'screen time' or 'social media use'. For a more detailed discussion of this, see Ref. [17]. This leads to an inability to distinguish high-/low-risk digital activities from neutral or protective activities [18]. *Second,* many studies fail to distinguish between different aspects of poor mental health [16]. Yet, risks may be different for different clinical presentations, for instance, anxiety versus depression [19]. Furthermore, factors that are instrumental in reducing poor mental health may be different from those that promote well-being [20]. *Third,* studies often rely on cross-sectional observation data when it is vital to clarify the direction of causality between digital activity and mental health if findings are to lead to improved practice and policy [21]. Also, relying on cross-sectional data limits developmental insights, even though we know that both digital activity and mental health show marked developmental changes across adolescence [21]. Longitudinal studies are vital for disentangling the likely reciprocal pathways between digital activity and mental health — how digital activity impacts mental health and how mental health shapes digital activity [22]. *Fourth,* few studies sufficiently control for nondigital confounding factors associated independently with both digital activity and mental health, such as pre-existing vulnerabilities, social disadvantage or neurodevelopmental problems. Controlling for these may change the statistical relationship between digital activity and mental health [23,24]. *Fifth,* there is a general lack of focus on understanding potential drivers of the relationship between digital activity and mental health [25]. Studies often make little attempt to identify moderating and mediating mechanisms, whether social, psychological and/or biological, which could represent future intervention targets. Overall, there is an urgent need for strong, clinically and developmentally informed theory to guide hypotheses development and further empirical research.

Towards a clinical–developmental framework for the scientific study of the link between digital activity and depressed mood in adolescence

Here, we set out a developmentally informed and process-oriented model designed to offer a new framework for the study of how digital activity may increase the risk of poor mental health in adolescence. Our aim is to help researchers overcome some of the limitations described above by providing a framework with a granularity that allows for careful empirical testing of whether specific mental health risks arise from some forms of digital activity. In this regard, the framework differs from, though is potentially complementary to, previous theoretical accounts of why digital activity may lead to poor mental health (e.g. offline activity displacement, sleep degradation, social contagion, fear of missing out; see Twenge [26] for a review) in its attempts to bring a degree of clinical specificity. That is, the framework does not propose that digital activity *per se* is problematic for mental health. Rather, it attempts to set out new hypotheses about why certain forms of digital activity may contribute to adolescent *depressed mood*. In turn, over time, together with nondigital factors, this may increase the risk of developing clinical depression. The proposed framework is grounded in more general scientific accounts of the specific mechanisms through which social environmental experiences (which may include digital activity) increase depressed mood during adolescence [27].

While seeking this specificity, we acknowledge that 'normal' depressed mood (i.e. feeling sad, low, down, irritable or lacking motivation and energy) is a common and frequently experienced phenomenon that, for most of the population, resolves before it escalates into full-

blown disorder [28]. Furthermore, depressed mood appears to be dimensional rather than categorical, where normal emotions may develop into 'pathological' states along the continuum of severity [29]. We also recognize that depressed mood overlaps with other conditions, such as anxiety [30], self-harm [31] and suicidality [32], with which it may share common risks linked to, for instance, low self-esteem [33] and sleep problems [34], and, potentially, risky digital activity. In future studies, it will be essential to test the specificity of the clinical mechanisms proposed in our model by controlling for the impact of these other clinical characteristics. The model's focus on adolescence also gives our framework a degree of developmental specificity. We chose to focus on adolescence because it is a period of both increasing risk for depression [35] and increasing exposure to potentially risky digital encounters and activities [36,37]. However, factors and processes similar to those in our model are likely to operate in both childhood and later adult life. Testing the generalizability of the model and/or adapting it to different developmental stages will be a valuable future direction.

The general proposition at the core of the framework is that the developmental pathways between digital activity and depressed mood are complex and reciprocal —

recognizing the likelihood that digital activity drives depression and vice versa. Furthermore, such processes must be considered in the context of the interplay between nondigital demographic, social risk, and protective factors — and biological and psychological traits linked to genetic factors (e.g. following a stress–diathesis process) — which are known from prior research to work together to create mental health vulnerability [38–40]. The core elements are described below and set out in Figure 1.

Pathway from digital activity to depressed mood

We postulate that the extent to which an individual's digital activity will increase depressed mood is determined by two separate, but interrelated, factors. First is the type (and amount) of their digital activity in terms of the balance between the mental health risks and benefits it confers. Specifically, it is not technology use *per se* that is detrimental (as implied by research on screen time), but rather that technology exposes adolescents to some types of digital activities that may be inherently more risky/beneficial for mental health than others. We recently identified separate 'content' (e.g. seeing violent or self-harm content) and 'conduct' (e.g. cyberbullying or being treated in a hurtful way,

Figure 1
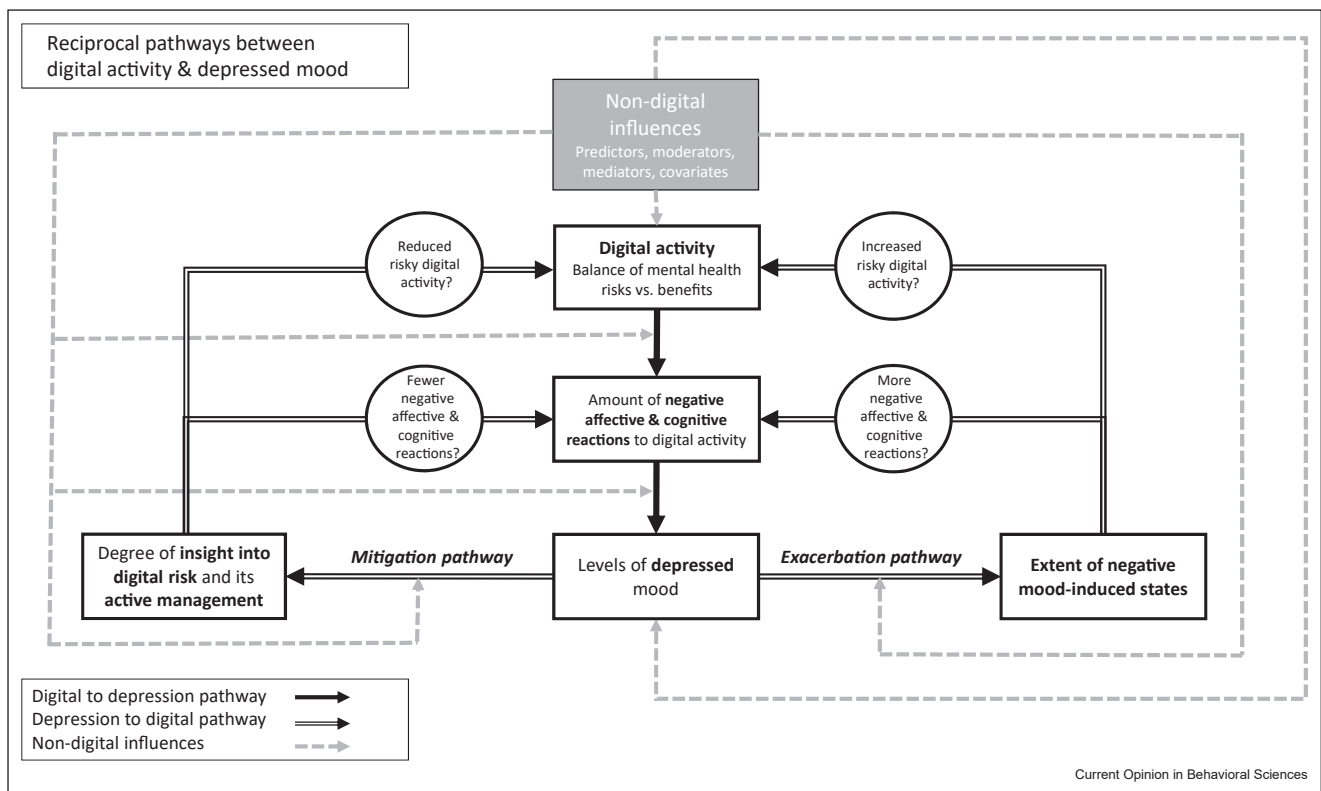
Reciprocal pathways between digital activity and depressed mood.

comparing oneself adversely to others) risk constructs, which were distinguished from more beneficial aspects, such as entertainment (e.g. playing a game or having fun with other people online). The risk constructs mapped onto specific elements in the 4C's (contact, content, conduct and commerce) model of digital risk [41]. This is important because these different types of risky digital activity may be linked to different outcomes; so too, more obviously, research shows that risky digital activities are linked to more negative outcomes than are entertainment and other positive digital activities (learning, finding information or social support) [15,42]. However, in much of the existing literature, the factors shaping different types of digital activity and their distinct impacts are obscured by the use of reductive measures of screen time and/or global or ill-defined outcome measures [43].

The second factor determining the link between digital activity and depressed mood is the extent to which such activity evokes negative reactions in an individual and the frequency, intensity and persistence of those reactions. This formulation builds on existing distinctions in the clinical literature, suggesting that negative experiences can lead to depressed mood via both/either affective and/or cognitive pathways. First, digital activity can affect an individual through the negative emotions (e.g. anger, annoyance, etc.) it evokes. We conceptualize this as a form of digital 'stress' reactivity. Second, digital activity can affect an individual through the negative inferences that they draw about themselves after engaging in it (e.g. I am stupid, unattractive, inadequate, etc.). This is likely to occur especially following social comparisons or interactions online. Our proposed model does not specify the secondary psychological processes that follow on from these evoked negative reactions to further mediate the pathway to depressed mood, although we suggest that emotional agitation, low self-worth and rumination represent important candidates, as they have each been identified in the scientific literature as being important mediators of depression risk.

Individual differences in negative emotional reactivity to daily stressors have been shown to be associated with increased depressed mood, though the scale and direction of effects are disputed. Some find that negative emotional reactivity to stressors drives depression risk [44]. Such a finding is consistent with Beck's [45] claim that such reactions lead to depression in the longer term by sensitizing individuals to future depressing experiences. However, others have argued that a dampened emotional reactivity is linked to depression [46]. This is consistent with *emotional context insensitivity theory*, which argues that depression is associated with a blunted emotional response to daily events [47]. On balance, longitudinal studies provide more support for a prospective link between general negative emotional reactivity and depression [44,48], but see Ref. [49] for a

more complex characterization. Specifically in relation to digital activities, Nesi et al. [50] found that negative emotional reactions linked to social media engagement predicted depressed mood over time.

Research also suggests that negative socially relevant experiences can impact how an individual thinks or feels about themselves over time, impacting their sense of self-concept and self-esteem [51]. There is significant variation in the way individuals attribute self-related negative meanings to daily experiences. Those more prone to negative interpretation are more likely to develop habits of negative rumination [52] and strengthened negative cognitive schema [53], leading to a downward spiral of low self-esteem and then depressed mood [54]. Longitudinal studies support such links in the context of nondigital experiences [55]. Whether these associations exist in the digital context requires careful empirical testing.

Pathway from depressed mood to digital activity

Depressed mood, linked to either prior digital activity or nondigital experiences or factors, may shape digital activity and its cognitive and emotional framing. However, because we are focused on developing hypotheses about the potential role of digital activity as a risk for depressed mood, we characterize this as a reciprocal process involving either an *exacerbation* or *mitigation* of digital risk by depressed mood (Figure 1). The former builds on the concept of 'stress generation' [56]. Specifically, we hypothesize that depressed mood caused by digital activity and the negative reactions it evokes exacerbate digital risk further by producing self-defeating and negatively biased ways of thinking [57] and disrupting interactions with the world [58]. This leads to more risky digital activity and to more negative emotional and cognitive framing. Consistent with this, longitudinal studies highlight how poor mental health increases exposure to negative events and experiences [56], including online [59,60]. We envisage several possible risk-exacerbation mechanisms operating. First, depressed mood could make an individual seek out more negative content that aligns with their mood or that acts as a form of maladaptive coping through distraction. Digital algorithms may reinforce and amplify these depression-related search preferences by presenting ever riskier and depressed mood-inducing content. Second, depressed mood could reinforce cognitive biases, so one interprets content more negatively. Third, it could increase rumination about negative content or interactions. Fourth, it could create an excessive need for reassurance or approval, which could push one to engage in riskier social encounters.

Regarding the digital risk mitigation pathway, we hypothesize that individuals who become (or are made aware) of the deleterious effects of digital activity on

their mental health can act consciously to either alter digital activity itself or to reframe reactions it evokes less negatively. The concept of personal self-efficacy may be useful in understanding this positive response to a difficult situation. Self-efficacy is a personal sense of agency and control motivating attempts to improve health and well-being [61]. Self-efficacy can be conceptualized as a personal resilience characteristic, which can be promoted through cognitive behavioural therapies. Studies support the protective value of self-efficacy in reducing the mental health risks of exposure to negative online experiences [62] and suggest that increasing self-efficacy represents potential targets for interventions to promote good mental health online [63].

Nondigital factors

Our framework postulates that both the digital activity-to-depressed mood and the reciprocal depressed mood-to-digital activity pathway will be impacted through the interaction with nondigital factors. First, both digital activity and depressed mood will be affected by various factors, including demographic (e.g. socioeconomic status, gender), personal (e.g. genetic vulnerability, temperament, neuro-divergence, lifestyle, mental health), and wider sociocultural characteristics. Some of these will have unique associations with either digital activity or depressed mood and some (e.g. presence of attention deficit hyperactivity disorder and/or anxiety) will be shared across both. Therefore, it is vital to control for these factors when analyzing the associations between digital activity and depressed mood. Other nondigital factors can also moderate these pathways. General psychological *resilience* (including positive coping, cognitive reappraisal and emotional regulation) may mitigate the negative effects of digital mental health risks. In other words, some individuals with high levels of digital risk exposure are less likely to become depressed than others. There is considerable evidence that such personal qualities interact with exposure to negative events to reduce mental health risk [64]. There is some cross-sectional evidence that resilience has been successfully applied to the digital life of young people [42]. However, further longitudinal research is needed.

Summary

By building on existing clinical–developmental models of the link between experience, emotion, cognition and depressed mood, we have been able to specify a framework to guide future research on the developmental relationship between digital activity and depressed mood in the context of other nondigital risks, personal traits, and characteristics. Currently, a series of hypotheses derived from this model are being tested within a longitudinal study, the *Dynamic Interplay of Online Risk and Resilience in Adolescence* project [65], as part of the UKRI Digital Youth Research programme

(https://digitalyouth.ac.uk/). The aim is to identify critical mechanisms underpinning the link between digital activity (including possible specific forms of risky digital activity and depressed mood) and, by doing so, identify new treatment targets. Finally, the model has the potential to be extended to other mental health or well-being outcomes and could be applied to formulate and test hypotheses about the effects of potentially positive digital activities (e.g. learning, finding information or social support).

Data Availability

No data were used for the research described in the article.

Declaration of Competing Interest

The co-authors have no conflict of interest to declare in relation to this article submission.

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References and recommended reading

Papers of particular interest, published within the period of review, have been highlighted as:

- of special interest
- •• of outstanding interest

1. Liu Q, He H, Yang J, Feng X, Zhao F, Lyu J: **Changes in the global burden of depression from 1990 to 2017: findings from the Global Burden of Disease study**. *J Psychiatr Res* 2020, **126**:134-140.

2. Weavers B, Heron J, Thapar AK, Stephens A, Lennon J, Jones RB,
•• Eyre O, Anney RJ, Collishaw S, Thapar A: **The antecedents and outcomes of persistent and remitting adolescent depressive symptom trajectories: a longitudinal, population-based English study**. *Lancet Psychiatry* 2021, **8**:1053-1061.
An important methodologically strong study using longitudinal data and sophisticated analysis to identify which factors are associated with changes in depression symptoms in adolescence. The most important factors were adolescent age at onset, academic attainment, early and persistent adversity, and genetic risk.

3. Li S, Xu Y, Zheng L, Pang H, Zhang Q, Lou L, Huang X: **Sex difference in global burden of major depressive disorder: findings from the Global Burden of Disease Study 2019**. *Front Psychiatry* 2022, **13**:789305.

4. Lund J, Andersen AJW, Haugland SH: **The Social Gradient in Stress and Depressive Symptoms Among Adolescent Girls: A Systematic Review and Narrative Synthesis**; 2019.

5. Thapar A, Eyre O, Patel V, Brent D: **Depression in young people**. *Lancet* 2022, **400**:617-631.

6. Wilson S, Dumornay NM: **Rising rates of adolescent depression in the United States: challenges and opportunities in the 2020s**. *J Adolesc Health* 2022, **70**:354-355.

7. Hawes MT, Szenczy AK, Klein DN, Hajcak G, Nelson BD: **Increases in depression and anxiety symptoms in adolescents and young adults during the COVID-19 pandemic**. *Psychol Med* 2022, **52**:3222-3230.

8. Newlove-Delgado T, Russell AE, Mathews F, Cross L, Bryant E, Gudka R, Ukoumunne OC, Ford TJ: **Annual research review: the impact of Covid-19 on psychopathology in children and young people worldwide: systematic review of studies with pre- and within-pandemic data**. *J Child Psychol Psychiatry* 2023, **64**:611-640.

9. Office of the Surgeon G: **Publications and reports of the surgeon general** (Edited by), Protecting Youth Mental Health: The U.S. Surgeon General's Advisory. US Department of Health and Human Services; 2021.

10. Odgers CL, Jensen MR: **Annual research review: adolescent mental health in the digital age: facts, fears, and future directions**. *J Child Psychol Psychiatry* 2020, **61**:336-348.

11. Winther DK, Livingstone S, Saeed M, and Office of Research - Innocenti, (2019), *Growing up in a connected world, Innocenti Research Report*, https://EconPapers.repec.org/RePEc:ucf:inorer:inorer1060.

12. Ofcom. *Children and parents: media use and attitudes report 2023*. https://www.ofcom.org.uk/__data/assets/pdf_file/0027/255852/childrens-media-use-and-attitudes-report-2023.pdf.

13. Orben A: **Teenagers, screens and social media: a narrative review of reviews and key studies**. *Soc Psychiatry Psychiatr Epidemiol* 2020, **55**:407-414.

14. Keles B, McCrae N, Grealish A: **A systematic review: the influence of social media on depression, anxiety and psychological distress in adolescents**. *Int J Adolesc Youth* 2020, **25**:79-93.

15. Hollis C, Livingstone S, Sonuga-Barke E: **The Role of Digital Technology in Children and Young People's Mental Health — a triple-edged sword?** ; Edited by: Wiley Online Library. 2020:837–841. vol 61.

16. Kostyrka-Allchorne K, Stoilova M, Bourgaize J, Rahali M,
•• Livingstone S, Sonuga-Barke E: **Digital experiences and their impact on the lives of adolescents with pre-existing anxiety, depression, eating and nonsuicidal self-injury conditions — a systematic review**. *Child Adolesc Ment Health* 2023, **28**:22-32.
A high-quality systematic review exploring the relationship between digital activity and a range of mental health conditions. The take-home message was that there were common elements of digital activity of clinical relevance across different mental health conditions. Key themes were (a) social connectivity; (b) distraction/escape; (c) social comparison; (d) accessing/creation of potentially harmful content; (e) cyberbullying; and (f) difficulties with self-regulation. By and large the literature was considered too limited to identify condition-specific effects — although these were considered likely.

17. Browne DT, May SS, Colucci L, Hurst-Della Pietra P, Christakis D, Asamoah T, Hale L, Delrahim-Howlett K, Emond JA, Fiks AG: **From screen time to the digital level of analysis: a scoping review of measures for digital media use in children and adolescents**. *BMJ Open* 2021, **11**:e046367.

18. Tang S, Werner-Seidler A, Torok M, Mackinnon AJ, Christensen H: **The relationship between screen time and mental health in young people: a systematic review of longitudinal studies**. *Clin Psychol Rev* 2021, **86**:102021.

19. Kim S, Favotto L, Halladay J, Wang L, Boyle MH, Georgiades K: **Differential associations between passive and active forms of screen time and adolescent mood and anxiety disorders**. *Soc Psychiatry Psychiatr Epidemiol* 2020, **55**:1469-1478.

20. Stiglic N, Viner RM: **Effects of screentime on the health and well-being of children and adolescents: a systematic review of reviews**. *BMJ Open* 2019, **9**:e023191.

21. Zhu X, Griffiths H, Xiao Z, Ribeaud D, Eisner M, Yang Y, Murray AL:
•• **Trajectories of screen time across adolescence and their associations with adulthood mental health and behavioral outcomes**. *J Youth Adolesc* 2023, **52**:1433-1447.
A paper using a sophisticated analysis of longitudinal data to identify groups with different trajectories of digital usage over adolescent

development and then link the different trajectories with adult mental health problems. Five trajectory classes were identified (1) low-screen use; (2) increasing chatting/surfing; (3) moderate-screen use; (4) early-adolescence screen use; and (5) increasing videogame and chatting/surfing. The study provided preliminary evidence of links between trajectories and adult outcomes — though the direction of effect was uncertain.

22. Boer M, Stevens GW, Finkenauer C, de Looze ME, van den Eijnden
•• RJ: **Social media use intensity, social media use problems, and mental health among adolescents: investigating directionality and mediating processes**. *Comput Hum Behav* 2021, **116**:106645.
One of the first studies to explore the direction of the effect in the digital – mental health relationship found using sophisticated statistical models. It also attempted to examine the drivers of the association in terms of mediators — although the effects did not persist over time. No mediators were identified.

23. Jensen M, George MJ, Russell MR, Odgers CL: **Young adolescents' digital technology use and mental health symptoms: little evidence of longitudinal or daily linkages**. *Clin Psychol Sci* 2019, **7**:1416-1433.

24. Schemer C, Masur PK, Geiß S, Müller P, Schäfer S: **The impact of internet and social media use on well-being: a longitudinal analysis of adolescents across nine years**. *J Comput Mediat Commun* 2021, **26**:1-21.

25. Granic I, Morita H, Scholten H: **Beyond screen time: identity development in the digital age**. *Psychol Inq* 2020, **31**:195-223.

26. Twenge JM: **Increases in depression, self-harm, and suicide among US adolescents after 2012 and links to technology use: possible mechanisms**. *Psychiatr Res Clin Pract* 2020, **2**:19-25.

27. Panchal P, Kaltenboeck A, Harmer CJ: **Cognitive emotional processing across mood disorders**. *CNS Spectr* 2019, **24**:54-63.

28. Parker G, Wilhelm K, Asghari A: **Depressed mood states and their inter-relationship with clinical depression**. *Soc Psychiatry Psychiatr Epidemiol* 1997, **33**:10-15.

29. Ruscio AM: **Normal versus pathological mood: implications for diagnosis**. *Annu Rev Clin Psychol* 2019, **15**:179-205.

30. Saha S, Lim CC, Cannon DL, Burton L, Bremner M, Cosgrove P, Huo Y, McGrath JJ: **Co-morbidity between mood and anxiety disorders: a systematic review and meta-analysis**. *Depress Anxiety* 2021, **38**:286-306.

31. Niu S, Yin X, Pan B, Chen H, Dai C, Tong C, Chen F, Feng X: **Understanding comorbidity between non-suicidal self-injury and depressive symptoms in a clinical sample of adolescents: a network analysis**. *Neuropsychiatr Dis Treat* 2024, **20**:1-17.

32. Moitra M, Santomauro D, Degenhardt L, Collins PY, Whiteford H, Vos T, Ferrari A: **Estimating the risk of suicide associated with mental disorders: a systematic review and meta-regression analysis**. *J Psychiatr Res* 2021, **137**:242-249.

33. Meng L, Qu D, Bu H, Huo L, Qi L, Yang J, Zheng T, Du X, He K, Wang Y: **The psychosocial correlates of non-suicidal self-injury within a sample of adolescents with mood disorder**. *Front Public Health* 2022, **10**:768400.

34. Asarnow LD, Mirchandaney R: **Sleep and mood disorders among youth**. *Child Adolesc Psychiatr Clin* 2021, **30**:251-268.

35. Wiederhold BK: **The Escalating Crisis in Adolescent Mental Health**. Mary Ann Liebert, Inc.; 2022:81-82.

36. Anderson M., Jiang J.: **Teens, social media and technology 2018**; 2018.

37. Thomas G, Bennie JA, De Cocker K, Castro O, Biddle SJ: **A descriptive epidemiology of screen-based devices by children and adolescents: a scoping review of 130 surveillance studies since 2000**. *Child Indic Res* 2020, **13**:935-950.

38. Broerman R: **Diathesis-Stress Model**. In *Encyclopedia of Personality and Individual Differences*. Edited by Zeigler-Hill V, Shackelford TK. Springer; 2020:1107-1109.

39. Van Aswegen T, Seedat S, Van Straten A, Goossens L, Bosmans G: **Depression in middle childhood: secure base script as a**

cognitive diathesis in the relationship between daily stress and depressive symptoms. *Attach Hum Dev* 2023, **25**:353-367.

40. Thomas-Odenthal F, Ringwald K, Teutenberg L, Stein F, Alexander N, Bonnekoh LM, Brosch K, Dohm K, Flinkenflügel K, Grotegerd D: **Neural foundation of the diathesis-stress model: longitudinal gray matter volume changes in response to stressful life events in major depressive disorder and healthy controls**. *Mol Psychiatry* 2024,1-9.

41. Livingstone S, Stoilova M: **The 4Cs: Classifying Online Risk to Children**. 2021.

42. Santos D, Mateos-Pérez E, Cantero M, Gámez-Guadix M: **Cyberbullying in adolescents: resilience as a protective factor of mental health outcomes**. *Cyber Behav Soc Netw* 2021, **24**:414-420.

43. Livingstone S, Mascheroni G, Stoilova M: **The outcomes of gaining digital skills for young people's lives and wellbeing: a systematic evidence review**. *N Media Soc* 2023, **25**:1176-1202.

44. Herres J, Ewing ESK, Kobak R: **Emotional reactivity to negative adult and peer events and the maintenance of adolescent depressive symptoms: a daily diary design**. *J Abnorm Child Psychol* 2016, **44**:471-481.

45. Beck AT: **Cognitive Therapy and the Emotional Disorders**. Penguin; 1979.

46. Peeters F, Berkhof J, Rottenberg J, Nicolson NA: **Ambulatory emotional reactivity to negative daily life events predicts remission from major depressive disorder**. *Behav Res Ther* 2010, **48**:754-760.

47. Rottenberg J, Hindash AC: **Emerging evidence for emotion context insensitivity in depression**. *Curr Opin Psychol* 2015, **4**:1-5.

48. Wichers M, Geschwind N, Jacobs N, Kenis G, Peeters F, Derom C, Thiery E, Delespaul P, van Os J: **Transition from stress sensitivity to a depressive state: longitudinal twin study**. *Br J Psychiatry* 2009, **195**:498-503.

49. Santee AC, Starr LR: **Examining linear and nonlinear associations between negative emotional reactivity to daily events and depression among adolescents**. *Clin Psychol Sci* 2022, **10**:675-689.

50. Nesi J, Rothenberg WA, Bettis AH, Massing-Schaffer M, Fox KA, Telzer EH, Lindquist KA, Prinstein MJ: **Emotional responses to social media experiences among adolescents: longitudinal associations with depressive symptoms**. *J Clin Child Adolesc Psychol* 2022, **51**:907-922.
An important study focusing on the complex and sometimes surprising relationships between depressive symptoms, positive and negative emotional responses and digital activity. The results played a formative role in the ideas included in the current model.

51. Beck AT: **The current state of cognitive therapy: a 40-year retrospective**. *Arch Gen Psychiatry* 2005, **62**:953-959.

52. Moberly NJ, Watkins ER: **Ruminative self-focus, negative life events, and negative affect**. *Behav Res Ther* 2008, **46**:1034-1039.

53. Dozois DJ, Beck AT: **Cognitive schemas, beliefs and assumptions**. *Risk Factors Depress* 2008, **46**:119-143.

54. Hammen C, Marks T, Mayol A, DeMayo R: **Depressive self-schemas, life stress, and vulnerability to depression**. *J Abnorm Psychol* 1985, **94**:308.

55. Bishop A, Younan R, Low J, Pilkington PD: **Early maladaptive schemas and depression in adulthood: a systematic review and meta-analysis**. *Clin Psychol Psychother* 2022, **29**:111-130.

56. Rnic K, Santee AC, Hoffmeister J-A, Liu H, Chang KK, Chen RX, Neufeld RW, Machado DA, Starr LR, Dozois DJ: **The vicious cycle of psychopathology and stressful life events: a meta-analytic review testing the stress generation model**. *Psychol Bull* 2023, **149**:330-339.

57. Teasdale JD: **Negative thinking in depression: cause, effect, or reciprocal relationship?** *Adv Behav Res Ther* 1983, **5**:3-25.

58. Kim KJ, Conger RD, Elder GH Jr, Lorenz FO: **Reciprocal influences between stressful life events and adolescent internalizing and externalizing problems**. *Child Dev* 2003, **74**:127-143.

59. Verduyn P, Lee DS, Park J, Shablack H, Orvell A, Bayer J, Ybarra O, Jonides J, Kross E: **Passive Facebook usage undermines affective well-being: experimental and longitudinal evidence**. *J Exp Psychol Gen* 2015, **144**:480.

60. Choi BY, Huh S, Kim D-J, Suh SW, Lee S-K, Potenza MN: **Transitions in problematic internet use: a one-year longitudinal study of boys**. *Psychiatry Investig* 2019, **16**:433.

61. Jhang F-H: **Uncontrollable and controllable negative life events and changes in mental health problems: exploring the moderation effects of family support and self-efficacy in economically disadvantaged adolescents**. *Child Youth Serv Rev* 2020, **118**:105417.

62. Calandri E, Graziano F, Rollé L: **Social media, depressive symptoms and well-being in early adolescence. The moderating role of emotional self-efficacy and gender**. *Front Psychol* 2021, **12**:660740.
One of the first studies exploring the role of self-efficacy as potential resilience factor moderating the link between digital activity and depression.

63. Calvete E, Orue I, Echezarraga A, Cortazar N, Fernández-González L: **A growth mindset intervention to promote resilience against online peer victimization: a randomized controlled trial**. *Comput Hum Behav* 2022, **135**:107373.

64. Mesman E, Vreeker A, Hillegers M: **Resilience and mental health in children and adolescents: an update of the recent literature and future directions**. *Curr Opin Psychiatry* 2021, **34**:586.

65. ostyrka-Allchorne K, Stoilova M, Bourgaize J, Murray AL, Azeri E, Naeche N, Hollis C, Townsend E, Livingstone S, Sonuga-Barke E, Youth TD: **Dynamic Interplay of Online Risk and Resilience in Adolescence (DIORA): Protocol for a 12-Month Longitudinal Study of the Interplay Between Digital Activity, Emotional Reactions and Depression During Adolescence. Under review**.