



Universiteit
Leiden
The Netherlands

Understanding the impact of misinformation on adolescents

Ma, I.; Mubashir, S.; Kozyreva, A.; Bos, W. van den

Citation

Ma, I., Mubashir, S., Kozyreva, A., & Bos, W. van den. (2025). Understanding the impact of misinformation on adolescents. *Nature Human Behaviour*, 10, 18-28.

doi:10.1038/s41562-025-02338-8

Version: Publisher's Version

License: [Licensed under Article 25fa Copyright Act/Law \(Amendment Taverne\)](#)

Downloaded from: <https://hdl.handle.net/1887/4291369>

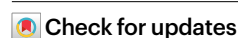
Note: To cite this publication please use the final published version (if applicable).

Understanding the impact of misinformation on adolescents

Received: 26 February 2025

Accepted: 6 October 2025

Published online: 14 November 2025



Ili Ma^{1,2}✉, Mubashir Sultan^{3,4}, Anastasia Kozyreva³ & Wouter van den Bos^{3,5}

There is an urgent need for targeted, evidence-based interventions to build resilience to misinformation among social media's most avid users: adolescents. Research on misinformation susceptibility is mostly focused on adults. However, adolescents encounter different types of (mis) information and undergo rapid social, emotional and cognitive changes. These changes can increase vulnerability to misinformation through social influence, emotional manipulation and cognitive biases, while also offering unique opportunities for resilience. Taking a developmental perspective, we outline how adolescents' susceptibility to misinformation differs from that of adults, propose a research agenda to systematically study these processes and introduce a Bayesian framework of belief updating tailored to social media contexts. Finally, we highlight how these insights inform age-appropriate interventions to promote resilience. This Perspective underscores the vital role that social sciences have in understanding and combating the harmful influence of misinformation on youth's beliefs and behaviours, while leveraging their strengths.

Adolescents grow up deeply immersed in the online world. The majority of adolescents worldwide spend several hours daily on social media¹. Many report feeling constantly online and rely on social media as their primary information source². Although being a 'digital native' has benefits, such as the ability to access information and connect with peers worldwide, it does not equate to being adept at navigating online information³. For instance, a study conducted in US schools revealed major deficiencies in high school students' ability to critically evaluate digital information⁴. This is concerning given the widespread problem of misinformation on social media^{5–7} (but see ref. 8). Much work has focused on misinformation susceptibility in adults^{9,10} and the effect of social media use on adolescents' mental well-being^{11,12}. Yet, there remains a critical gap in understanding adolescents' resilience to misinformation, their susceptibility to misinformation and their likelihood of sharing it. Addressing this gap is essential for designing age-appropriate interventions.

This Perspective highlights three areas that show the most prominent developmental changes during adolescence and how these

changes shape adolescents' susceptibility to misinformation: social, emotional and cognitive development. We propose a research agenda to understand developmental changes in adolescents' misinformation susceptibility, including in a social media context. This research agenda aims to guide the advancement of urgently needed and developmentally tailored interventions.

We focus on adolescence as this is a vital period for identity formation, characterized by heightened sensitivity to social information and substantial emotional and cognitive development^{13,14}. This comes with many opportunities as teenagers show an increasing motivation for autonomy and willingness to make positive contributions to societal issues^{15,16}. Nevertheless, exposure to false and misleading information may have disproportionately harmful consequences for adolescents compared with adults. Alarming, polarization among youth on political and ideological domains is increasing in various parts of the world¹⁷. Furthermore, recent European Union elections showed a rise in adolescents' support for far-right political parties^{18,19}, especially among young

¹Department of Developmental and Educational Psychology, Institute of Psychology, Leiden University, Leiden, the Netherlands. ²Leiden Institute for Brain and Cognition, Leiden, the Netherlands. ³Center for Adaptive Rationality, Max Planck Institute for Human Development, Berlin, Germany. ⁴Department of Psychology, Humboldt University of Berlin, Berlin, Germany. ⁵Department of Developmental Psychology, University of Amsterdam, Amsterdam, the Netherlands. ✉e-mail: i.ma@fsw.leidenuniv.nl

men²⁰. Moreover, in the USA, more adolescents than adults were found to endorse conspiracy theories²¹. These patterns can be exacerbated by misinformation on social media platforms, which amplify sensationalist and polarizing content^{22,23}. Moreover, adolescents increasingly use social media to gather information about personal and (mental) health-related issues, despite the high prevalence of misinformation on these topics²⁴. For example, 50% of social media content on attention deficit hyperactivity disorder is misleading²⁵. There is a need to better understand adolescents' susceptibility to misinformation; this is crucial for the development of targeted and evidence-based interventions that foster their resilience against misinformation.

Misinformation studies that focus on adults provide important insights within the social, emotional and cognitive domains^{9,10}. These insights can inform studies to identify vulnerabilities in adolescence, as well as areas in which adolescents may show more resilience than adults. In the social domain, social media has changed our sense of calibration, including our perception of consensus. Only a small minority of users actively post on social media, while the rest passively observe. This can lead to phenomena such as the majority illusion (that is, thinking that the majority holds a specific view due to a vocal minority), the bandwagon effect (that is, adopting majority views) and prestige bias (that is, trusting information from influential figures). For example, political elites undermined the threat of COVID-19 and the efficacy of interventions^{26,27}. Indeed, more active social media use was found to be associated with higher susceptibility to misinformation in early adulthood, according to a non-peer-reviewed preprint²⁸. Moreover, all of these phenomena can be manipulated through bots or the use of algorithms to bolster support for specific viewpoints. Social context can also motivate misinformation susceptibility. This includes motivated reasoning and partisan bias, where viewpoints that are aligned with social or political identity are accepted and those that are misaligned are rejected^{29–31}. In addition, social exclusion has been linked to increased conspiracy beliefs³². The adult misinformation literature also provides key insights within the emotional domain. Misinformation frequently exploits emotional appeal^{22,33,34}, where heightened emotionality is associated with greater susceptibility to misinformation, both at the level of veracity judgements and at that of sharing intentions^{22,35,36}. In the cognitive domain, rapid content consumption opens us up to the perils of cognitive failures. Intuitive thinking (that is, faster-paced deliberation) has been associated with poorer misinformation discernment, and slower deliberation and analytical thinking have been shown to increase accuracy discernment^{37,38}. This is also the rationale behind accuracy nudges, an intervention type that prompts individuals to deliberate on accuracy before sharing content³⁹. Similarly, ample evidence has shown that repetition increases beliefs through the cognitive mechanisms of familiarity and fluency⁴⁰. In addition, confirmation bias reinforces misinformation beliefs when the message is aligned with one's worldview^{29,41}.

Adult-focused research has advanced insights into misinformation susceptibility and interventions, but it remains unclear how adolescents' unique social, emotional and cognitive development shapes their vulnerabilities and how they may be particularly resilient. In the next sections, we first explore these developmental factors in the context of social media use. We then outline a research agenda that aims to map developmental differences in adolescents' misinformation exposure, vulnerability and resilience. These insights will further expose differences between adolescents and adults. Finally, we make recommendations for how understanding these developmental changes can inform educational interventions tailored to adolescents' needs while also leveraging their strengths.

Social, emotional and cognitive development

Social influence by peers and influencers

Adolescents are highly susceptible to social influence, particularly from early to mid-adolescence^{13,42–46}. Adolescents feel a strong need to belong

and further develop their personal identity and self-concept^{47–49}. Their uncertainty about the world and their developing identity can make them especially sensitive to social influence^{50–54}. Adolescents show strong sensitivity to peer norms (for example, the behaviours and attitudes of the majority) and to social validation from peers^{55–58}. Nuance is critical here, though, as peer influence can either foster resilience to misinformation or exacerbate vulnerability, depending on the peer group's norm. When peer norms emphasize veracity and accuracy, they can foster a social environment in which adolescents reinforce each other's digital literacy skills, such as discernment between trustworthy and untrustworthy sources. Supportive, close friendships can further facilitate psychological resilience to adversity^{59,60}, potentially serving as a buffer against the influence of misinformation. Conversely, social deprivation has especially pronounced negative effects on adolescents' mental health⁶¹, which may increase susceptibility to misleading or harmful content. For instance, adolescents who experience loneliness are more likely to endorse conspiracy beliefs later in life, possibly because online communities that spread such narratives can also offer a sense of belonging⁶².

Not all social information is treated equally. Information from certain individuals within adolescents' social network, such as popular peers, is more highly valued⁶³. Social media amplifies these tendencies by emphasizing popularity and validation. Indeed, half of adolescents' time on social media is spent on following the content posted by influencers⁶⁴. Influencers have the capacity to reach a large audience and sway opinions and behaviours due to their perceived authority, knowledge and/or status^{65–72}. Given influencers' large number of followers, such posts receive substantial engagement, which can create an illusion of majority support or consensus and amplify their reach. Moreover, adolescents are particularly drawn to relatable content that aligns with their personal interests⁶⁴. Influencers often capitalize on this tendency by sharing personal experiences, which enhances their perceived social connection and thus enhances perceived credibility⁷³. This emphasis on relatability may make adolescents especially susceptible to anecdotal reasoning, particularly in situations where concrete evidence may be lacking⁷⁴.

Unfortunately, influencers also have a prominent role in generating and endorsing misinformation. Even though this may happen unintentionally, many influencers promote opinions, products and activities without having the requisite expertise^{75,76}. A recent report by the United Nations Educational, Scientific and Cultural Organization showed that most influencers do not fact-check their content before posting it⁷⁷. A stark illustration of this phenomenon was the amplification of anti-vaccine scepticism during the COVID-19 pandemic, which was in part fuelled by celebrities' dissemination of anti-vaccine sentiments on social media⁷⁸. YouTube vloggers who were specifically popular with adolescents showed numerous violations of COVID-19 regulations; they also verbally dismissed rules and some of the dangers of getting infected. These violations were often supported in the comment sections. Such videos and the social validation in the comments were experimentally shown to reduce adolescents' beliefs about the severity of the virus, specifically if the adolescents identified with the vlogger⁷⁹.

Social motivations to believe and share misinformation

Social motivations may further shape adolescents' misinformation susceptibility, particularly as it intersects with their emerging political ideologies⁸⁰. Research shows that biases in truth discernment can stem from confirmation bias, such as partisan bias or motivated reasoning, where social or political goals override accuracy^{29,31,81,82}. Adolescents, who are more driven by peer approval and a strong sense of belonging⁸³, may be especially influenced by biases that foster in-group cohesion, making them prone to accepting misinformation that aligns with group preferences. Similarly, when adolescents were presented with an in-group member who shared misinformation, they remained positive

towards this individual, whereas if it was an out-group member, their evaluation was negative⁸⁴. Adolescents may share misinformation not because they believe it but because it aligns with their social motivations or social norms. Two recent studies have found that adolescents do not consider veracity when sharing content; instead, they share misinformation if it aligns with their interests or if their peers consider it newsworthy^{85,86}. This is further corroborated by research showing that adults were willing to share information they believed to be false⁴¹. The disconnect between information sharing and believing can be motivated by a desire to signal political identity^{87,88} or to increase social cohesion, or simply because of its entertainment value if the information were true⁸⁹ (and according to a non-peer-reviewed preprint⁹⁰). It is an important open question whether the motivations to share misinformation are similar for adults and adolescents. Addressing this is essential to mitigating the spread of misinformation among adolescents.

Peer approval gradually becomes more important during adolescence, and the influence of parents and other adults declines, aligning with adolescents' motivation for autonomy from adult control⁹¹. Research has shown that interventions that align with this need for autonomy can be highly effective in changing adolescent behaviour. For example, interventions that appeal to values of autonomy and motivation to pursue social justice can shift adolescents from junk food to healthier diets^{92,93}. Similarly, the growing social motivation for adolescents to make a meaningful contribution to society¹⁶ could be leveraged to motivate adolescents to reduce misinformation sharing and to make the online environment more prosocial. For example, in a study on young adults, participants were asked to write a letter to a less digitally competent relative, explaining six strategies to help them to recognize false news. This was found to improve the participants' own false news discernment in the long term⁹⁴. Such prosocial interventions might be promising for younger adolescents as well.

Intervention strategies that leverage adolescents' strengths are further discussed in the section 'Building effective educational interventions for adolescents'. This topic is introduced here because understanding adolescents' susceptibility to misinformation requires knowing from whom information is acquired and how this affects beliefs and sharing decisions in light of adolescents' social goals. Both shape perceptions in ways that can be misaligned with factual accuracy. However, adolescents' drive for autonomy from adults and increasing motivation to contribute to society can potentially be leveraged to increase their motivation to identify accurate information^{94,95} and reduce their motivation to share misinformation. In general, it is important to consider that finding social connection is one of adolescents' main motivations to seek and share information.

Emotional appeal and reactivity

Misinformation can strategically target the emotions of its audience. Emotional content is well documented to capture more attention than neutral stimuli⁹⁶. Adolescents show stronger responses to emotional stimuli than children and adults^{97–102}. This bias is consistent with adolescents' tendency to seek entertaining news rather than news from official sources that strike a more neutral tone^{85,103,104}. Moreover, adolescent resilience and susceptibility may further result from age differences in processing emotion valence. Content designed to provoke negativity such as moral outrage or outgroup animosity is more likely to go viral on media primarily used by adults, such as X/Twitter^{22,23,105–107} (but also see refs. 108,109). In this context, adolescents may differ from adults. Social media platforms that are more popular among adolescents show a greater prevalence of positive content than negative content¹¹⁰. Laboratory studies suggest that early to mid-adolescents indeed prefer to gather positive over negative social information⁵⁰, attend more to positive words than to negative words¹¹¹ and focus more on good news than on bad news¹¹².

Adolescents' preference for positive content can act as a filter, reducing misinformation exposure to emotionally negative or

manipulative misinformation that is often prevalent on platforms such as X/Twitter³³. For example, certain types of politically motivated rage bait may appeal less to adolescents, and they may therefore be less exposed to this common misinformation strategy, which is often generated by bots¹¹³. This mechanism may decline with age, as experiences of negative emotions increase in frequency from early to late adolescence¹¹⁴. Positively framed misinformation is also abundant on social media³⁵. For example, influencers and celebrities regularly use positive terms such as 'wellness routine' or 'life hacks' to promote diets or lifestyles that can be, in reality, unhealthy or even dangerous^{115,116}.

In addition to a positivity bias, adolescents experience emotions of higher intensity more frequently than adults¹¹⁴, resulting in increased emotional variability. From early to late adolescence, the frequency of positive emotions may decrease while the frequency of negative emotions may increase¹¹⁴, potentially resulting in age and valence differences in susceptibility to emotional appeal, which is common in misinformation. A recent study further showed that in the context of social media, adolescents show greater changes in mood in response to likes received¹⁴. Importantly, recent models suggest that mood or emotional states also affect their learning processes¹¹⁷ and that heightened emotionality can impair truth discernment³⁶. These findings emphasize the role of emotional appeal and emotionality in adolescents' susceptibility and resilience to misinformation.

Cognitive capabilities and knowledge

Cognitive capabilities and knowledge gradually develop throughout adolescence. Limitations in capabilities and knowledge can further shape misinformation susceptibility. Misinformation often exploits cognitive biases and intuitive reasoning. Rapid and overabundant content availability may further encourage intuitive rather than analytical thinking, especially during early adolescence, given the gradual development of self-control¹¹⁸. Moreover, online misinformation often aims to polarize issues by limiting the discussion to extreme viewpoints, suppressing nuanced perspectives or appealing to confirmation biases^{119,120}. Analytical thinking has been shown to be the strongest predictor of discrimination ability in a recent meta-analysis¹⁰. In addition, adults who believe in conspiracies rely more on intuition and engage less in analytical reasoning¹²¹. Studies on cognitive development have established that analytical reasoning skills (including critical thinking) and metacognition continue to develop during adolescence^{122–126}. Heuristic reasoning itself is also further refined during early adolescence, according to a non-peer-reviewed preprint¹²⁷. With age, adolescents gain a more developed capacity for abstract thinking and understanding of the need for more substantial and relevant evidence when making decisions¹²⁸. These cognitive developments may result in heightened misinformation susceptibility, especially in younger adolescents¹²⁹.

From a Bayesian perspective, limited knowledge can be reflected in increased uncertainty¹³⁰. When uncertainty is high, the same novel information will lead to greater belief updating than when uncertainty is low. Indeed, lower levels of knowledge, for example, about health or basic science, have been linked to higher belief in misinformation and reduced ability to discern truth, as observed during the COVID-19 pandemic^{131,132}. Similarly, knowledge about cancer (cancer literacy) was shown to have a key role in identifying misleading information about chemotherapy¹³³. Adolescence is a time of substantial knowledge acquisition¹³⁴ and, consequently, high uncertainty¹³⁵. Adolescence may therefore represent a time of increased susceptibility to misinformation, particularly in domains where foundational knowledge is limited. Adolescents are also less aware of their own (un)certainly. That is, their metacognitive skills are still developing¹²³. Discrepancies between a person's confidence in their knowledge and their actual understanding may help to explain why misinformed beliefs can persist despite contradictory evidence¹³⁶. Indeed, adolescents' increasing metacognitive abilities have also been associated with a decline in relying on misleading advice¹³⁷.

These cognitive developments highlight the importance of education and fostering skills that are adapted to the information environments in which adolescents operate (for example, critical thinking¹³⁸ and critical ignoring¹³⁹). At the same time, adolescents also possess cognitive strengths that can be leveraged as protective factors. For example, adolescents may benefit from heightened open-mindedness in social contexts^{140,141}, which can serve as a protective factor against confirmation bias¹⁴¹. Many adolescents are motivated to master emerging technologies and navigate social media platforms with considerable fluency. This may extend to a growing awareness of algorithmic personalization and the ability to tailor online environments to their interests¹⁴².

The distinction between the social, emotional and cognitive domains offers a structure to conceptualize adolescents' resilience and susceptibilities to misinformation, while also taking into account developmental changes throughout adolescence. These domains are, however, deeply interconnected. For instance, emotionally charged or socially salient content can prompt adolescents to engage more with information, thereby fostering epistemic curiosity and the development of cognitive competencies¹⁴³, which may act as protective factors against misinformation. Conversely, heightened emotional arousal or peer influence can impair deliberative reasoning, increasing reliance on salient but irrelevant cues and reducing resistance to misleading content³⁶. How interacting developmental processes shape belief formation needs to be further understood. This calls for a formal framework. A Bayesian perspective emphasizes how different aspects of information, such as emotional appeal and peer influence, may be weighted in belief updating depending on age, while also incorporating prior knowledge and uncertainty. This framework offers a powerful model to test both strengths and vulnerabilities throughout adolescence.

Understanding misinformation beliefs and sharing decisions

Characterizing adolescents' susceptibility to misinformation will require addressing three key components across adolescent development: (1) identifying the types of information they consume and share; (2) identifying their beliefs about that information, including veracity judgements and motivations for sharing, such as entertainment value, informativeness or identity signalling; and (3) considering individual variation in resilience and vulnerability. The first component is critical for tracking developmental differences in misinformation exposure and dissemination, as these probably change from early adolescence to adulthood. Recent advances allow researchers to ethically access public social media data and facilitate data donations^{144–147}. This has opened opportunities to analyse digital trace data, which refers to the users' digital footprints (for example, posts, likes, shares and comments)^{147,148}. Such analyses provide valuable insights into the social, emotional and cognitive factors that are present in adolescents' online information ecosystem. For example, language analyses (such as large language models) can identify the emotional framing and cognitive biases in content adolescents engage with¹⁴⁹, and influencer interactions and comment section participation can offer clues into key social influences.

These insights can then be used to enhance the ecological validity of experimental studies on misinformation beliefs. Experiments informed by digital trace data analyses can systematically manipulate social, emotional and cognitive factors to examine their effects on veracity judgements and sharing behaviour while maintaining high ecological validity. Social media simulators, for instance, allow researchers to adjust likes and comment sentiments to investigate the influence of social feedback on misinformation beliefs¹⁵⁰ (and according to a non-peer-reviewed preprint¹⁵¹). Similarly, stimuli can be designed to elicit specific emotional responses or expose cognitive biases.

The behavioural data generated from such experiments and digital trace data can be analysed using Bayesian computational models, which offer a robust framework to quantify the relative influence of

social, emotional and cognitive factors. A key advantage of the Bayesian approach is that it tracks not only beliefs but also the uncertainty associated with those beliefs. This is especially important for understanding the effects of misinformation. For example, adolescents are most susceptible to social influence in domains where they are uncertain. Additionally, misinformation can strengthen a belief without necessarily changing the belief itself (for an overview, see Box 1).

Adopting a formal Bayesian framework across studies also enhances comparability. Such standardization is crucial given the broad range of psychological factors within the social, emotional and cognitive domains that can influence veracity judgements and sharing decisions. Improved comparability will help to assess the relative effects of these factors and support the development of comprehensive theories of misinformation susceptibility.

By combining social media trace data, controlled experiments and computational models, we can gain a deeper understanding of how adolescents engage with and evaluate online information. Longitudinal studies will reveal developmental patterns in information consumption and belief formation, and cross-sectional studies will uncover generational differences, which is critical for adapting interventions to the rapidly changing social media landscape.

Contextual factors shape the development of misinformation susceptibility

Individual differences in adolescents' susceptibility to misinformation do not arise solely from developmental processes. They can also be shaped by broader environmental contexts. Indeed, misinformation susceptibility is associated with increased polarization as well as a decline in trust in broader institutions, including democracy, news, governments and science. For example, only 40% of people worldwide trust news most of the time¹⁵². Furthermore, aspects such as unemployment, higher corruption and lower press freedom are all correlated with conspiratorial ideation^{153–155}. For adolescents, familial and educational backgrounds are particularly salient contexts that may influence susceptibility and resilience. These contexts can contribute to misinformation susceptibility, as they can influence adolescents' broader sense of trust and access to opportunities to acquire digital literacy skills, develop critical thinking and navigate online risks.

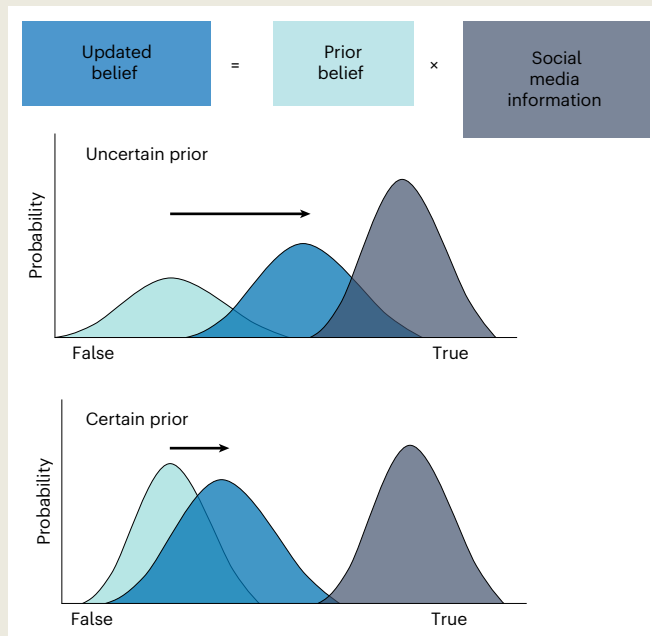
At the familial level, parental mediation practices, particularly active mediation involving discussion and guidance about digital content, might be associated with higher digital literacy and better-discerning information evaluation among adolescents^{156–159}. Importantly, the effectiveness of parental mediation may depend on parents' own attitudes and trust in reliable information sources¹⁶⁰, as well as their digital competence, including their awareness of algorithms and understanding of online risks^{161,162}. As digital environments become increasingly complex, disparities in parental digital skills may reinforce inequalities in adolescents' ability to critically evaluate online information.

The educational system is another key context. Access to high-quality media and information literacy education varies widely between schools and countries¹⁵², and not all adolescents receive formal training in digital literacy or source evaluation^{163,164}. Curricula that incorporate lateral reading strategies and epistemic reasoning, for example, have shown promise in improving students' ability to detect misinformation¹⁶⁵, but these are not yet widely implemented (also see ref. 166). Structural differences in educational access may therefore contribute to unequal levels of trust in reliable information sources and preparedness in resisting misinformation. Moreover, data from non-Western countries as well as low- or middle-income countries are scarce, and this is an important avenue for further research. As efforts to profile misinformation susceptibility grow¹⁶⁷, it is important to reflect deeply on and integrate these contextual factors when characterizing adolescents' strengths and vulnerabilities to misinformation. These insights also raise key information for discussions about

BOX 1

Bayesian framework of belief updates

Bayesian computational models of belief updating are a powerful formal framework for quantifying how adolescents update beliefs in response to new information⁵¹. The Bayesian approach is grounded in normative principles, where new beliefs (posteriors) are formed on the basis of the integration of an individual's preexisting beliefs (priors) and the incoming information (likelihood). In Bayesian terms, personal beliefs and (mis)information encountered on social media are probability distributions, where the variance of the prior distribution reflects the subjective uncertainty of the participant, and the variance of the likelihood represents the weight one puts on that information. Experimentally, social media posts can be designed to systematically vary in aspects that may make misinformation more persuasive, such as social validation (for example, comments, likes, shares and source credibility), use of emotions (for example, sentiment and intensity) and cognitive biases (for example, alignment with prior beliefs). For example, a low-engagement post (such as one with few likes, shares or comments) contradicting one's beliefs will have a lot of variance, thus leading to minimal belief change. Conversely, a widely endorsed post from a trusted source will exert greater influence, particularly among individuals with higher uncertainty in their prior beliefs (see Box Fig. 1). Bayesian computational models can be fitted at the level of the individual to precisely quantify the effects of social, emotional and cognitive factors and how those may change with age during adolescence. This approach identifies the factors that hold the most influence, thereby guiding the development of targeted, age-appropriate interventions to mitigate the spread and impact of misinformation.



Box Fig. 1 | Illustration of belief updates. Examples of belief updates for a highly uncertain prior belief (top) and a certain prior belief (bottom). Image adapted from ref. 51 under a Creative Commons license CC BY 4.0.

promoting adolescents' rights to digital inclusion, education and active online citizenship¹⁶⁸.

Building effective educational interventions for adolescents

Media and information literacy education is critical for equipping adolescents with the skills to critically evaluate online content. Educational, school-based information literacy interventions with adolescents show promising results. For example, strategies such as lateral reading train students to evaluate online information by consulting additional credible sources. Their effectiveness has been demonstrated primarily as part of the Civic Online Reasoning curriculum with high school and college students in the USA^{169–172}. Similarly, gamified interventions based on inoculation theory, such as the Bad News game¹⁷³, have proved to be effective in building resilience by teaching people to recognize common misinformation tactics in an active learning context. Other interventions focus on improving students' ability to verify online information¹⁷⁴.

An evidence-based toolbox of interventions against misinformation was recently developed¹⁶⁵. These interventions address different aspects of the misinformation problem and aim to affect key outcome variables: belief updating, sharing behaviour and competence in accuracy discernment. However, except for lateral reading and certain inoculation interventions, most existing interventions are primarily based on research on adults or tested in adults. As discussed in previous sections, adolescents' unique social, emotional and cognitive development can lead to exacerbated vulnerabilities to (mis)information in ways that may differ from adults, and importantly, they also possess distinct strengths. Adolescents even tend to favour different social media platforms than adults, yet most social media research is focused on platforms with primarily adult users, such as X/Twitter and Facebook, and these conclusions may not generalize to adolescents' online information ecosystems. Systematic characterization of the developmental differences in social media content and vulnerabilities to misinformation is needed for effective interventions, particularly because behavioural interventions designed for adults are generally less effective for adolescents as they do not account for adolescents' experiences and developmental characteristics⁹¹. Adult-focused research therefore should not be applied to adolescents without adaptation. As discussed, in some situations adolescents might show higher resilience than adults, and these strengths too can be leveraged in interventions. Here we provide recommendations for tailoring interventions to adolescents, informed by insights from developmental science and the research agenda outlined earlier.

Promoting awareness of misinformation tactics

Training individuals to recognize common misinformation tactics, a strategy also referred to as psychological inoculation, has been shown to reduce misinformation susceptibility^{89,175–179}. This approach, which draws an analogy between misinformation tactics and viral strains, equips individuals with the cognitive 'antibodies' to resist manipulation. Inoculation interventions have shown promise with adolescents, targeting common tactics such as emotional manipulation, scapegoating, conspiracy promotion and trolling^{166,173}. Yet, these interventions are based on studies on adults and might not inoculate against tactics that adolescents are particularly exposed or vulnerable to. The content of this type of intervention can straightforwardly be extended to a broad range of tactics that specifically adolescents are exposed and susceptible to. For example, if adolescents are particularly influenced by positive emotional appeals, influencer relatability or specific logical fallacies within a certain age range, then age-targeted inoculation interventions should be extended to focus on those vulnerabilities. Inoculation interventions help individuals to recognize popular persuasive tactics and are agnostic about objective truthfulness. Detecting such tactics can help individuals to identify potentially misleading

information and determine whether fact checking is warranted. It is therefore recommended to combine inoculation interventions with broader media literacy programmes to enhance their effectiveness.

Setting social norms to promote accuracy

Adolescents' heightened sensitivity to social influence, social goals and peer-group norms presents an opportunity for interventions. For instance, school-based interventions could integrate peer discussions to emphasize and promote the importance of accuracy on social media. This way, adolescents may become socially motivated to promote accuracy online, creating a new social norm. Similar suggestions have been made for public health campaigns to encourage adolescents to adhere to social distancing guidelines¹⁸⁰. While accuracy prompt interventions for adults often leverage existing preferences to share accurate information³⁹, adolescent-focused programmes may need to first cultivate these norms through collaborative learning and discussions on the societal value of accuracy.

Building media literacy and discernment competences

Accuracy and trustworthiness discernment are key outcome variables in interventions against misinformation¹⁸¹. Effective programmes must not only help adolescents to identify falsehoods (which can be achieved by increasing overall scepticism) but also foster trust in credible sources that adhere to journalistic standards. Trust in professional journalism is declining among individuals who are younger than 35 years old^{182,183}, with many perceiving news organizations as biased. For instance, a recent survey found that 35% of US adolescents expressed low trust in news media. Those low-trust individuals believed that news organizations do not take journalism standards such as accuracy and fairness seriously and that they do not produce more impartial information than other online content creators. In fact, they generally reported that they believe "journalists intentionally add bias to their coverage of events and issues"¹⁸⁴. Building competences to correctly identify trustworthy content is especially important in adolescence¹⁸⁵, and media literacy interventions should focus not only on cues for untrustworthy content¹⁸⁶ but also on tips that focus on trust and identifying reliable sources¹⁸⁷. Research on adolescents' knowledge gaps about professional journalism can further inform these efforts.

Increasing the effectiveness of misinformation interventions

Misinformation education should be integrated with broader digital media and information literacy programmes and policies^{166,188}. This equips adolescents with a more complete skill set to navigate online environments responsibly. Among other competencies, this framework should address critical competencies such as privacy, security concerns, self-regulation and screen time management strategies. These programmes could also help adolescents to understand the incentive structures that operate online, such as social media algorithms that aim to maximize engagement, and paid influencers. Programmes such as DIGYMATEX highlight the importance of integrating multiple dimensions of digital literacy into interventions¹⁸⁹. Notably, adolescents support such educational programmes: 94% of US adolescents say that schools should be required to teach media literacy¹⁸⁴. Age differences also need to be considered for the development of interventions, as the strengths and vulnerabilities that arise from developmental processes and the environment change during adolescence. Furthermore, trends will change with time, and social media use and technologies will also evolve over generations. Adolescents' own views and opinions need to be included to enhance the relevance and appeal of the interventions, thereby increasing their effectiveness. This can be achieved by involving adolescents in designing educational interventions together with professionals¹⁹⁰. Additionally, influencers and adolescents themselves can assist in delivering interventions, further increasing engagement with the educational content.

Interventions should also address complementary challenges, including attention management and competences that allow users to take control over how they spend time online and what sources they include in their information diets. Managing attention in the world of information overabundance is a difficult task irrespective of age, but the challenge is particularly salient in adolescence. Self-regulation strategies, such as critical ignoring, or the ability to resist low-quality or misleading information and focus attentional resources on credible sources, may be particularly helpful¹³⁹. One way of implementing this competence is by using insights from self-nudging strategies¹⁹¹. This includes designing one's information environments in ways that would inhibit encounters with certain (low quality) sources (that is, those peddling misinformation and conspiracy theories), reduce temptations by using greyscale mode on the smartphone, or set time limits and self-imposed obstacles on the use of certain platforms¹⁹².

Finally, digital media and misinformation tactics continue to evolve. New social media platforms will arise, and technological advancements such as deepfakes increase the challenge of distinguishing real from fabricated information. Education must adapt to these technological changes. Continuously monitoring adolescents' exposure to misinformation, their vulnerabilities and their digital literacy is necessary to refine interventions. Youth should not stand alone in their fight against misinformation. Policies and laws should offer protection—for example, by prohibiting profiling and microtargeting of minors for commercial purposes. Addressing these challenges demands interdisciplinary collaboration among policymakers and experts in developmental and educational sciences, communication, computer science and artificial intelligence. Ultimately, misinformation interventions transcend individual protection; they are integral to fostering a democratic society where evidence, not manipulation, guides decision-making.

References

1. Pew Research Center. *Teens and Social Media Fact Sheet* (PEW Research Center, 2024).
2. Howard, P. N., Neudert, L.-M., Prakash, N. & Vosloo, S. *Digital Misinformation/Disinformation and Children* (UNICEF, 2021).
3. Osborne, J. & Pimentel, D. Science education in an age of misinformation. *Sci. Educ.* **107**, 553–571 (2023).
4. Breakstone, J. et al. Students' civic online reasoning: a national portrait. *Educ. Res.* **50**, 505–515 (2021).
5. Elsner, M., Atkinson, G., & Zahidi, S. *Global Risks Report 2025* (World Economic Forum, 2025).
6. Ecker, U. K. H. et al. Why misinformation must not be ignored. *Am. Psychol.* **80**, 867–878 (2024).
7. Ecker, U. et al. Misinformation poses a bigger threat to democracy than you might think. *Nature* **630**, 29–32 (2024).
8. Allen, J., Howland, B., Mobius, M., Rothschild, D. & Watts, D. J. Evaluating the fake news problem at the scale of the information ecosystem. *Sci. Adv.* **6**, eaay3539 (2020).
9. Ecker, U. K. et al. The psychological drivers of misinformation belief and its resistance to correction. *Nat. Rev. Psychol.* **1**, 13–29 (2022).
10. Sultan, M. et al. Susceptibility to online misinformation: a systematic meta-analysis of demographic and psychological factors. *Proc. Natl Acad. Sci. USA* **121**, e2409329121 (2024).
11. Valkenburg, P. M., Meier, A. & Beyens, I. Social media use and its impact on adolescent mental health: an umbrella review of the evidence. *Curr. Opin. Psychol.* **44**, 58–68 (2022).
12. Orben, A., Meier, A., Dalgleish, T. & Blakemore, S.-J. Mechanisms linking social media use to adolescent mental health vulnerability. *Nat. Rev. Psychol.* **3**, 407–423 (2024).
13. Molleman, L., Ciranka, S. & van den Bos, W. Social influence in adolescence as a double-edged sword. *Proc. R. Soc. B* **289**, 20220045 (2022).

14. Pinho, A. da S., Izquierdo, V. C., Lindström, B., & van den Bos, W. Youths' sensitivity to social media feedback: a computational account. *Sci. Adv.* **10**, eadp8775 (2024).
15. Do, K. T., van de Groep, S., Crone, E. A. & Tamnes, C. K. A developmental neuroscience perspective on youth contributions and challenges in a changing society. *Dev. Cogn. Neurosci.* **73**, 101558 (2025).
16. Dahl, R. E., Armstrong-Carter, E. & van den Bos, W. Wanting to matter and learning to care: a neurodevelopmental window of opportunity for (pro) social learning? *Dev. Cogn. Neurosci.* **69**, 101430 (2024).
17. Burn-Murdoch, J. A new global gender divide is emerging. *Financial Times* <https://www.ft.com/content/29fd9b5c-2f35-41bf-9d4c-994db4e12998> (2024).
18. Cokelaere, H. It's not just boomers, young people are voting far right too. *Politico* <https://www.politico.eu/article/europe-young-people-right-wing-voters-far-right-politics-eu-elections-parliament/> (2024).
19. Vinocur, N. & Goury-Laffont, V. Europe's 'foreigners out!' generation: why young people vote far right. *Politico* <https://www.politico.eu/article/far-right-europe-young-voters-election-2024-foreigners-out-generation-france-germany/> (2024).
20. Milosav, Đ. et al. The youth gender gap in support for the far right. *J. Eur. Public Policy* <https://doi.org/10.1080/13501763.2025.2481181> (2025).
21. Center for Countering Digital Hate. *Public Support for Social Media Reform: Assessing CCDH's STAR Framework for Social Media Regulation* (Center for Countering Digital Hate, 2023).
22. McLoughlin, K. L. et al. Misinformation exploits outrage to spread online. *Science* **386**, 991–996 (2024).
23. Robertson, C. E. et al. Negativity drives online news consumption. *Nat. Hum. Behav.* **7**, 812–822 (2023).
24. Basch, C. H., Donelle, L., Fera, J. & Jaime, C. Deconstructing TikTok videos on mental health: cross-sectional, descriptive content analysis. *JMIR Form. Res.* **6**, e38340 (2022).
25. Yeung, A., Ng, E. & Abi-Jaoude, E. TikTok and attention-deficit/hyperactivity disorder: a cross-sectional study of social media content quality. *Can. J. Psychiatry* **67**, 899–906 (2022).
26. Chung, M. & Jones-Jang, S. M. Red media, blue media, Trump briefings, and COVID-19: examining how information sources predict risk preventive behaviors via threat and efficacy. *Health Commun.* **37**, 1707–1714 (2022).
27. Arceneaux, K. & Truex, R. Donald Trump and the lie. *Perspect. Polit.* **21**, 863–879 (2023).
28. Snijders, A. et al. Understanding susceptibility to misinformation in young adulthood. Preprint at PsyArXiv https://doi.org/10.31234/osf.io/b2f6m_v1 (2025).
29. Pereira, A., Harris, E. & Van Bavel, J. J. Identity concerns drive belief: the impact of partisan identity on the belief and dissemination of true and false news. *Group Process. Intergroup Relat.* **26**, 24–47 (2023).
30. Doell, K. C., Pärnamets, P., Harris, E. A., Hackel, L. M. & Van Bavel, J. J. Understanding the effects of partisan identity on climate change. *Curr. Opin. Behav. Sci.* **42**, 54–59 (2021).
31. Van Bavel, J. J., Rathje, S., Vlasceanu, M. & Pretus, C. Updating the identity-based model of belief: from false belief to the spread of misinformation. *Curr. Opin. Psychol.* **56**, 101787 (2024).
32. Poon, K.-T., Chen, Z. & Wong, W.-Y. Beliefs in conspiracy theories following ostracism. *Pers. Soc. Psychol. Bull.* **46**, 1234–1246 (2020).
33. Vosoughi, S., Roy, D. & Aral, S. The spread of true and false news online. *Science* **359**, 1146–1151 (2018).
34. Carrasco-Farré, C. The fingerprints of misinformation: how deceptive content differs from reliable sources in terms of cognitive effort and appeal to emotions. *Humanit. Soc. Sci. Commun.* **9**, 162 (2022).
35. Bago, B., Rosenzweig, L. R., Berinsky, A. J. & Rand, D. G. Emotion may predict susceptibility to fake news but emotion regulation does not seem to help. *Cogn. Emot.* **36**, 1166–1180 (2022).
36. Martel, C., Pennycook, G. & Rand, D. G. Reliance on emotion promotes belief in fake news. *Cogn. Res. Princ. Implic.* **5**, 1–20 (2020).
37. Bago, B., Rand, D. G. & Pennycook, G. Fake news, fast and slow: deliberation reduces belief in false (but not true) news headlines. *J. Exp. Psychol. Gen.* **149**, 1608–1613 (2020).
38. Sultan, M. et al. Time pressure reduces misinformation discrimination ability but does not alter response bias. *Sci. Rep.* **12**, 22416 (2022).
39. Pennycook, G. & Rand, D. G. Accuracy prompts are a replicable and generalizable approach for reducing the spread of misinformation. *Nat. Commun.* **13**, 2333 (2022).
40. Udry, J. & Barber, S. J. The illusory truth effect: a review of how repetition increases belief in misinformation. *Curr. Opin. Psychol.* **56**, 101736 (2024).
41. Pennycook, G. & Rand, D. G. The psychology of fake news. *Trends Cogn. Sci.* **25**, 388–402 (2021).
42. Smetana, J. G., Campione-Barr, N. & Metzger, A. Adolescent development in interpersonal and societal contexts. *Annu. Rev. Psychol.* **57**, 255–284 (2006).
43. Knoll, L. J., Magis-Weinberg, L., Speekenbrink, M. & Blakemore, S.-J. Social influence on risk perception during adolescence. *Psychol. Sci.* **26**, 583–592 (2015).
44. Van Hoorn, J., van Dijk, E., Meuwese, R., Rieffe, C. & Crone, E. A. Peer influence on prosocial behavior in adolescence. *J. Res. Adolesc.* **26**, 90–100 (2016).
45. Van Hoorn, J., Crone, E. A. & Van Leijenhorst, L. Hanging out with the right crowd: peer influence on risk-taking behavior in adolescence. *J. Res. Adolesc.* **27**, 189–200 (2017).
46. van Hoorn, J., Shaback, H., Lindquist, K. A. & Telzer, E. H. Incorporating the social context into neurocognitive models of adolescent decision-making: a neuroimaging meta-analysis. *Neurosci. Biobehav. Rev.* **101**, 129–142 (2019).
47. Granic, I., Morita, H. & Scholten, H. Beyond screen time: identity development in the digital age. *Psychol. Inq.* **31**, 195–223 (2020).
48. Pérez-Torres, V. Social media: a digital social mirror for identity development during adolescence. *Curr. Psychol.* **43**, 22170–22180 (2024).
49. Crone, E. A., Green, K. H., Van De, G. I. H. & Renske van der, C. A neurocognitive model of self-concept development in adolescence. *Annu. Rev. Dev. Psychol.* **4**, 273–295 (2022).
50. Ma, I., Westhoff, B. & van Duijvenvoorde, A. C. K. Uncertainty about others' trustworthiness increases during adolescence and guides social information sampling. *Sci. Rep.* **12**, 7634 (2022).
51. Hofmans, L. & van den Bos, W. Social learning across adolescence: a Bayesian neurocognitive perspective. *Dev. Cogn. Neurosci.* **58**, 101151 (2022).
52. Reiter, A. M. et al. Preference uncertainty accounts for developmental effects on susceptibility to peer influence in adolescence. *Nat. Commun.* **12**, 3823 (2021).
53. Reiter, A. M., Suzuki, S., O'Doherty, J. P., Li, S.-C. & Eppinger, B. Risk contagion by peers affects learning and decision-making in adolescents. *J. Exp. Psychol. Gen.* **148**, 1494–1504 (2019).
54. Topel, S. et al. Expecting the unexpected: a review of learning under uncertainty across development. *Cogn. Affect. Behav. Neurosci.* **23**, 718–738 (2023).
55. Crone, E. A. & Dahl, R. E. Understanding adolescence as a period of social-affective engagement and goal flexibility. *Nat. Rev. Neurosci.* **13**, 636–650 (2012).
56. Nelson, E. E., Jarcho, J. M. & Guyer, A. E. Social re-orientation and brain development: an expanded and updated view. *Dev. Cogn. Neurosci.* **17**, 118–127 (2016).

57. Foulkes, L. & Blakemore, S.-J. Is there heightened sensitivity to social reward in adolescence? *Curr. Opin. Neurobiol.* **40**, 81–85 (2016).
58. Blakemore, S.-J. The social brain in adolescence. *Nat. Rev. Neurosci.* **9**, 267–277 (2008).
59. Graber, R., Turner, R. & Madill, A. Best friends and better coping: facilitating psychological resilience through boys' and girls' closest friendships. *Br. J. Psychol.* **107**, 338–358 (2016).
60. van Harmelen, A.-L., Blakemore, S. J., Goodyer, I. M. & Kievit, R. A. The interplay between adolescent friendship quality and resilient functioning following childhood and adolescent adversity. *Advers. Resil. Sci.* **2**, 37–50 (2021).
61. Orben, A., Tomova, L. & Blakemore, S.-J. The effects of social deprivation on adolescent development and mental health. *Lancet Child Adolesc. Health* **4**, 634–640 (2020).
62. Bierwaczon, K., Fluit, S., von Soest, T., Hornsey, M. J. & Kunst, J. R. Loneliness trajectories over three decades are associated with conspiracist worldviews in midlife. *Nat. Commun.* **15**, 3629 (2024).
63. Pinho, A., da, S., Molleman, L., Braams, B. R. & van den Bos, W. Majority and popularity effects on norm formation in adolescence. *Sci. Rep.* **11**, 12884 (2021).
64. Croes, E. & Bartels, J. Young adults' motivations for following social influencers and their relationship to identification and buying behavior. *Comput. Hum. Behav.* **124**, 106910 (2021).
65. Freberg, K., Graham, K., McGaughey, K. & Freberg, L. A. Who are the social media influencers? A study of public perceptions of personality. *Public Relat. Rev.* **37**, 90–92 (2011).
66. Turcotte, J., York, C., Irving, J., Scholl, R. M. & Pingree, R. J. News recommendations from social media opinion leaders: effects on media trust and information seeking. *J. Comput. Mediat. Commun.* **20**, 520–535 (2015).
67. Watts, D. J. & Dodds, P. S. Influentials, networks, and public opinion formation. *J. Consum. Res.* **34**, 441–458 (2007).
68. Hudders, L., De Jans, S. & De Veirman, M. The commercialization of social media stars: a literature review and conceptual framework on the strategic use of social media influencers. *Int. J. Advert.* **40**, 327–375 (2021).
69. Zhang, Y., Moe, W. W. & Schweidel, D. A. Modeling the role of message content and influencers in social media rebroadcasting. *Int. J. Res. Mark.* **34**, 100–119 (2017).
70. Lim, X. J., Radzol, A., Cheah, J. & Wong, M. W. The impact of social media influencers on purchase intention and the mediation effect of customer attitude. *Asian J. Bus. Res.* **7**, 19–36 (2017).
71. Ki, C. W. C. & Kim, Y. K. The mechanism by which social media influencers persuade consumers: the role of consumers' desire to mimic. *Psychol. Mark.* **36**, 905–922 (2019).
72. Weeks, B. E., Ardèvol-Abreu, A. & Gil de Zúñiga, H. Online influence? Social media use, opinion leadership, and political persuasion. *Int. J. Public Opin. Res.* **29**, 214–239 (2017).
73. Djafarova, E. & Rushworth, C. Exploring the credibility of online celebrities' Instagram profiles in influencing the purchase decisions of young female users. *Comput. Hum. Behav.* **68**, 1–7 (2017).
74. Freling, T. H., Yang, Z., Saini, R., Itani, O. S. & Abualsamh, R. R. When poignant stories outweigh cold hard facts: a meta-analysis of the anecdotal bias. *Organ. Behav. Hum. Decis. Process.* **160**, 51–67 (2020).
75. Lofft, Z. When social media met nutrition: how influencers spread misinformation, and why we believe them. *Health Sci. Inq.* **11**, 56–61 (2020).
76. Vasconcelos, C., Costa, R. L. D., Dias, ÁL., Pereira, L. & Santos, J. P. Online influencers: healthy food or fake news. *Int. J. Internet Mark. Advert.* **15**, 149–175 (2021).
77. Ha, L. *Behind the Screens: Insights from Digital Content Creators; Understanding Their Intentions, Practices and Challenges* (UNESCO, 2024).
78. White, B. M. et al. Exploring celebrity influence on public attitude towards the COVID-19 pandemic: social media shared sentiment analysis. *BMJ Health Care Inform.* **30**, e100665 (2023).
79. Hensums, M., van den Bos, W., Overbeek, G. & Larsen, H. YouTube vloggers set the stage: how public (non)compliance with COVID-19 regulations affects adolescents. *J. Adolesc.* **96**, 429–442 (2024).
80. Adelson, J. The political imagination of the young adolescent. *Daedalus* **100**, 1013–1050 (1971).
81. Groenendyk, E. Competing motives in a polarized electorate: political responsiveness, identity defensiveness, and the rise of partisan antipathy. *Polit. Psychol.* **39**, 159–171 (2018).
82. Roozenbeek, J. et al. Susceptibility to misinformation is consistent across question framings and response modes and better explained by myside bias and partisanship than analytical thinking. *Judgm. Decis. Mak.* **17**, 547–573 (2022).
83. Brechwald, W. A. & Prinstein, M. J. Beyond homophily: a decade of advances in understanding peer influence processes. *J. Res. Adolesc.* **21**, 166–179 (2011).
84. Farooq, A., Ketzitidou Argyri, E., Adlam, A. & Rutland, A. Children and adolescents' ingroup biases and developmental differences in evaluations of peers who misinform. *Front. Psychol.* **13**, 835695 (2022).
85. Herrero-Diz, P., Conde-Jiménez, J. & Reyes de Cózar, S. Teens' motivations to spread fake news on WhatsApp. *Soc. Media Soc.* **6**, 2056305120942879 (2020).
86. Zozaya-Durazo, L. D., Sádaba-Chalezquer, C. & Feijoo-Fernández, B. "Fake or not, I'm sharing it": teen perception about disinformation in social networks. *Young Consum.* **25**, 425–438 (2023).
87. Van Bavel, J. J. & Pereira, A. The partisan brain: an identity-based model of political belief. *Trends Cogn. Sci.* **22**, 213–224 (2018).
88. Jordan, J. J. & Rand, D. G. Signaling when no one is watching: a reputation heuristics account of outrage and punishment in one-shot anonymous interactions. *J. Pers. Soc. Psychol.* **118**, 57–88 (2020).
89. Altay, S., Berriche, M., Heuer, H., Farkas, J. & Rathje, S. A survey of expert views on misinformation: definitions, determinants, solutions, and future of the field. *Harv. Kennedy Sch. Misinformation Rev.* **4**, 1–34 (2023).
90. Lorenz-Spreen, P. et al. Real-time assessment of motives for sharing and creating content among highly active Twitter users. Preprint at PsyArXiv <https://doi.org/10.31234/osf.io/jf8w9> (2024).
91. Yeager, D. S., Dahl, R. E. & Dweck, C. S. Why interventions to influence adolescent behavior often fail but could succeed. *Perspect. Psychol. Sci.* **13**, 101–122 (2018).
92. Bryan, C. J., Yeager, D. S. & Hinojosa, C. P. A values-alignment intervention protects adolescents from the effects of food marketing. *Nat. Hum. Behav.* **3**, 596–603 (2019).
93. Bryan, C. J. et al. Harnessing adolescent values to motivate healthier eating. *Proc. Natl Acad. Sci. USA* **113**, 10830–10835 (2016).
94. Orosz, G., Paskuj, B., Faragó, L. & Krekó, P. A prosocial fake news intervention with durable effects. *Sci. Rep.* **13**, 3958 (2023).
95. Rathje, S., Roozenbeek, J., Van Bavel, J. J. & van der Linden, S. Accuracy and social motivations shape judgements of (mis) information. *Nat. Hum. Behav.* **7**, 892–903 (2023).
96. Vuilleumier, P. How brains beware: neural mechanisms of emotional attention. *Trends Cogn. Sci.* **9**, 585–594 (2005).
97. Schweizer, S., Gotlib, I. H. & Blakemore, S.-J. The role of affective control in emotion regulation during adolescence. *Emotion* **20**, 80–86 (2020).
98. Steinberg, L. et al. Around the world, adolescence is a time of heightened sensation seeking and immature self-regulation. *Dev. Sci.* **21**, e12532 (2018).

99. Greene, K., Krmar, M., Walters, L. H., Rubin, D. L. & Hale, L. Targeting adolescent risk-taking behaviors: the contributions of egocentrism and sensation-seeking. *J. Adolesc.* **23**, 439–461 (2000).
100. Hare, T. A. et al. Biological substrates of emotional reactivity and regulation in adolescence during an emotional go-nogo task. *Biol. Psychiatry* **63**, 927–934 (2008).
101. Somerville, L. H., Jones, R. M. & Casey, B. A time of change: behavioral and neural correlates of adolescent sensitivity to appetitive and aversive environmental cues. *Brain Cogn.* **72**, 124–133 (2010).
102. Somerville, L. H., Hare, T. & Casey, B. J. Frontostriatal maturation predicts cognitive control failure to appetitive cues in adolescents. *J. Cogn. Neurosci.* **23**, 2123–2134 (2011).
103. Marchi, R. With Facebook, blogs, and fake news, teens reject journalistic ‘objectivity’. *J. Commun. Inq.* **36**, 246–262 (2012).
104. Balakrishnan, V., Ng, K. S. & Rahim, H. A. To share or not to share—the underlying motives of sharing fake news amidst the COVID-19 pandemic in Malaysia. *Technol. Soc.* **66**, 101676 (2021).
105. Carpenter, J., Brady, W., Crockett, M., Weber, R. & Sinnott-Armstrong, W. Political polarization and moral outrage on social media. *Conn. Law Rev.* **52**, 1107–1120 (2020).
106. Brady, W. J., McLoughlin, K., Doan, T. N. & Crockett, M. J. How social learning amplifies moral outrage expression in online social networks. *Sci. Adv.* **7**, eabe5641 (2021).
107. Rathje, S., Van Bavel, J. J. & Van Der Linden, S. Out-group animosity drives engagement on social media. *Proc. Natl Acad. Sci. USA* **118**, e2024292118 (2021).
108. Kyrychenko, Y., Brik, T., van der Linden, S. & Roozenbeek, J. Social identity correlates of social media engagement before and after the 2022 Russian invasion of Ukraine. *Nat. Commun.* **15**, 8127 (2024).
109. Eck, C. W. V., Roozenbeek, J., Stevens, T. M. & Dewulf, A. Platform cultures and emotional communication about climate change: a comparison of affective language in the climate change blogo- and Twittersphere. *Int. J. Commun.* **19**, 26–46 (2025).
110. Waterloo, S. F., Baumgartner, S. E., Peter, J. & Valkenburg, P. M. Norms of online expressions of emotion: comparing Facebook, Twitter, Instagram, and WhatsApp. *N. Media Soc.* **20**, 1813–1831 (2018).
111. Ma, I. et al. Does an attention bias to appetitive and aversive words modulate interference control in youth with ADHD? *Child Neuropsychol.* **24**, 541–557 (2018).
112. Moutsiana, C. et al. Human development of the ability to learn from bad news. *Proc. Natl Acad. Sci. USA* **110**, 16396–16401 (2013).
113. Shao, C. et al. The spread of low-credibility content by social bots. *Nat. Commun.* **9**, 4787 (2018).
114. Bailen, N. H., Green, L. M. & Thompson, R. J. Understanding emotion in adolescents: a review of emotional frequency, intensity, instability, and clarity. *Emot. Rev.* **11**, 63–73 (2019).
115. Swire-Thompson, B. & Lazer, D. Public health and online misinformation: challenges and recommendations. *Annu. Rev. Public Health* **41**, 433–451 (2020).
116. Myrick, J. G. & Erlichman, S. How audience involvement and social norms foster vulnerability to celebrity-based dietary misinformation. *Psychol. Pop. Media* **9**, 367–379 (2020).
117. Gregorová, K., Eldar, E., Deserno, L. & Reiter, A. M. F. A cognitive-computational account of mood swings in adolescence. *Trends Cogn. Sci.* **28**, 290–303 (2024).
118. Edelson, S. M., Reyna, V. F., Singh, A. & Roue, J. E. The psychology of misinformation across the lifespan. *Annu. Rev. Dev. Psychol.* **6**, 425–454 (2024).
119. Levy, R. Social media, news consumption, and polarization: evidence from a field experiment. *Am. Econ. Rev.* **111**, 831–870 (2021).
120. Huszár, F. et al. Algorithmic amplification of politics on Twitter. *Proc. Natl Acad. Sci. USA* **119**, e2025334119 (2022).
121. Binnendyk, J. & Pennycook, G. Intuition, reason, and conspiracy beliefs. *Curr. Opin. Psychol.* **47**, 101387 (2022).
122. Ku, K. Y. et al. What predicts adolescents’ critical thinking about real-life news? The roles of social media news consumption and news media literacy. *Think. Skills Creat.* **33**, 100570 (2019).
123. Weil, L. G. et al. The development of metacognitive ability in adolescence. *Conscious. Cogn.* **22**, 264–271 (2013).
124. Klaczynski, P. A. Analytic and heuristic processing influences on adolescent reasoning and decision-making. *Child Dev.* **72**, 844–861 (2001).
125. Kokis, J. V., Macpherson, R., Toplak, M. E., West, R. F. & Stanovich, K. E. Heuristic and analytic processing: age trends and associations with cognitive ability and cognitive styles. *J. Exp. Child Psychol.* **83**, 26–52 (2002).
126. Klaczynski, P. A. in *The Development of Judgment and Decision Making in Children and Adolescents* (eds Jacobs, J. E. & Klaczynski, P. A.) 39–76 (Lawrence Erlbaum Associates, 2005).
127. Ma, I., Phaneuf, C., van Opheusden, B., Ma, W. J. & Hartley, C. The component processes of complex planning follow distinct developmental trajectories. Preprint at PsyArXiv <https://doi.org/10.31234/osf.io/d62rw> (2022).
128. Steinberg, L. Cognitive and affective development in adolescence. *Trends Cogn. Sci.* **9**, 69–74 (2005).
129. Lemaire, M., Ye, S., Le Stanc, L., Borst, G. & Cassotti, M. The development of media truth discernment and fake news detection is related to the development of reasoning during adolescence. *Sci. Rep.* **15**, 6854 (2025).
130. Sutton, R. S. & Barto, A. G. *Reinforcement Learning: An Introduction* (MIT Press, 2018).
131. Lee, J. J. et al. Associations between COVID-19 misinformation exposure and belief with COVID-19 knowledge and preventive behaviors: cross-sectional online study. *J. Med. Internet Res.* **22**, e22205 (2020).
132. Pennycook, G., McPhetres, J., Bago, B. & Rand, D. G. Beliefs about COVID-19 in Canada, the United Kingdom, and the United States: a novel test of political polarization and motivated reasoning. *Pers. Soc. Psychol. Bull.* **48**, 750–765 (2022).
133. Wang, W. & Jacobson, S. Effects of health misinformation on misbeliefs: understanding the moderating roles of different types of knowledge. *J. Inf. Commun. Ethics Soc.* **21**, 76–93 (2022).
134. Romer, D., Reyna, V. F. & Satterthwaite, T. D. Beyond stereotypes of adolescent risk taking: placing the adolescent brain in developmental context. *Dev. Cogn. Neurosci.* **27**, 19–34 (2017).
135. Ciranka, S. & van den Bos, W. Adolescent risk-taking in the context of exploration and social influence. *Dev. Rev.* **61**, 100979 (2021).
136. Rapp, D. N. & Withall, M. M. Confidence as a metacognitive contributor to and consequence of misinformation experiences. *Curr. Opin. Psychol.* **55**, 101735 (2024).
137. Moses-Payne, M. E., Habicht, J., Bowler, A., Steinbeis, N. & Hauser, T. U. I know better! Emerging metacognition allows adolescents to ignore false advice. *Dev. Sci.* **24**, e13101 (2021).
138. Pennycook, G. & Rand, D. G. Lazy, not biased: susceptibility to partisan fake news is better explained by lack of reasoning than by motivated reasoning. *Cognition* **188**, 39–50 (2019).
139. Kozyreva, A., Wineburg, S., Lewandowsky, S. & Hertwig, R. Critical ignoring as a core competence for digital citizens. *Curr. Dir. Psychol. Sci.* **32**, 81–88 (2023).
140. Gopnik, A. et al. Changes in cognitive flexibility and hypothesis search across human life history from childhood to adolescence to adulthood. *Proc. Natl Acad. Sci. USA* **114**, 7892–7899 (2017).
141. Mirhoseini, M., Early, S., El Shamy, N. & Hassanein, K. Actively open-minded thinking is key to combating fake news: a multimethod study. *Inf. Manage.* **60**, 103761 (2023).

142. Brites, M. J., Castro, T. S., Müller, M. S. & Maneta, M. Young people learning about algorithms: five profiles spanning from ineptitude to enchantment. *Media Commun.* **12**, Article 8272 (2024).
143. Immordino-Yang, M. H. & Damasio, A. We feel, therefore we learn: the relevance of affective and social neuroscience to education. *Mind Brain Educ.* **1**, 3–10 (2007).
144. van Driel, I. I. et al. Promises and pitfalls of social media data donations. *Commun. Methods Meas.* **16**, 266–282 (2022).
145. Fitzgerald, K., Vandenbosch, L. & Tabruyn, T. Adolescent emotional expression on social media: a data donation study across three European countries. *Affect. Sci.* **5**, 436–448 (2024).
146. Boeschoten, L. et al. Port: a software tool for digital data donation. *J. Open Source Softw.* **8**, 5596 (2023).
147. Ohme, J., et al. Digital trace data collection for social media effects research: APIs, data donation, and (screen) tracking. *Commun. Methods Meas.* **18**, 124–141 (2024).
148. Sultan, M., Scholz, C. & van den Bos, W. Leaving traces behind: using social media digital trace data to study adolescent wellbeing. *Comput. Hum. Behav. Rep.* **10**, 100281 (2023).
149. Feuerriegel, S. et al. Using natural language processing to analyse text data in behavioural science. *Nat. Rev. Psychol.* **4**, 96–111 (2025).
150. Butler, L. H., et al. The (Mis) Information Game: a social media simulator. *Behav. Res. Methods* **56**, 2376–2397 (2024).
151. Epstein, Z. & Lin, H. Yourfeed: towards open science and interoperable systems for social media. Preprint at <https://doi.org/10.48550/arXiv.2207.07478> (2022).
152. Newman, N., Arguedas, A. R., Robertson, C. T., Nielsen, R. K. & Fletcher, R. *Reuters Institute Digital News Report 2025* (Reuters Institute for the Study of Journalism, 2025).
153. Cordonier, L. & Caffiero, F. Public sector corruption is fertile ground for conspiracy beliefs: a comparison between 26 Western and non-Western countries. *Soc. Sci. Q.* **105**, 843–861 (2024).
154. Cordonier, L., Cafiero, F. & Bronner, G. Why are conspiracy theories more successful in some countries than in others? An exploratory study on Internet users from 22 Western and non-Western countries. *Soc. Sci. Inf.* **60**, 436–456 (2021).
155. Alper, S. There are higher levels of conspiracy beliefs in more corrupt countries. *Eur. J. Soc. Psychol.* **53**, 503–517 (2023).
156. Buijzen, M. & Valkenburg, P. M. Parental mediation of undesired advertising effects. *J. Broadcast. Electron. Media* **49**, 153–165 (2005).
157. Rodríguez-de-Dios, I., van Oosten, J. M. & Igartua, J.-J. A study of the relationship between parental mediation and adolescents' digital skills, online risks and online opportunities. *Comput. Hum. Behav.* **82**, 186–198 (2018).
158. Livingstone, S., Mascheroni, G. & Staksrud, E. European research on children's Internet use: assessing the past and anticipating the future. *N. Media Soc.* **20**, 1103–1122 (2018).
159. Livingstone, S. & Helsper, E. J. Parental mediation of children's Internet use. *J. Broadcast. Electron. Media* **52**, 581–599 (2008).
160. Dohmen, T., Falk, A., Huffman, D. & Sunde, U. The intergenerational transmission of risk and trust attitudes. *Rev. Econ. Stud.* **79**, 645–677 (2012).
161. Taylor, S. H. & Brisini, K. S. C. Parenting the TikTok algorithm: an algorithm awareness as process approach to online risks and opportunities. *Comput. Hum. Behav.* **150**, 107975 (2024).
162. Livingstone, S. & Byrne, J. in *Digital Parenting: The Challenges for Families in the Digital Age, Yearbook 2018* (eds Mascheroni, G. et al.) 19–30 (Nordicom, Univ. Gothenburg, 2018).
163. McDougall, J., Zezulkova, M., Van Driel, B. & Sternadel, D. *Teaching Media Literacy in Europe: Evidence of Effective School Practices in Primary and Secondary Education* (European Commission, Directorate-General for Education, Youth, Sport and Culture, Public Policy and Management Institute, 2018).
164. McGrew, S., Breakstone, J., Ortega, T., Smith, M. & Wineburg, S. Can students evaluate online sources? Learning from assessments of civic online reasoning. *Theory Res. Soc. Educ.* **46**, 165–193 (2018).
165. Kozyreva, A. et al. Toolbox of individual-level interventions against online misinformation. *Nat. Hum. Behav.* **8**, 1044–1052 (2024).
166. Nygren, T. & Ecker, U. *Education as a Countermeasure against Disinformation* (Lund Univ. Psychological Defence Research Institute, 2024).
167. Kyrychenko, Y. et al. Profiling misinformation susceptibility. *Pers. Individ. Differ.* **241**, 113177 (2025).
168. Livingstone, S. & Third, A. Children and young people's rights in the digital age: an emerging agenda. *N. Media Soc.* **19**, 657–670 (2017).
169. McGrew, S. Learning to evaluate: an intervention in civic online reasoning. *Comput. Educ.* **145**, 103711 (2020).
170. Wineburg, S., Breakstone, J., McGrew, S., Smith, M. D. & Ortega, T. Lateral reading on the open Internet: a district-wide field study in high school government classes. *J. Educ. Psychol.* **114**, 893–909 (2022).
171. Breakstone, J. et al. Lateral reading: college students learn to critically evaluate Internet sources in an online course. *Harv. Kennedy Sch. Misinformation Rev.* <https://doi.org/10.37016/mr-2020-56> (2021).
172. McGrew, S. & Breakstone, J. Civic online reasoning across the curriculum: developing and testing the efficacy of digital literacy lessons. *AERA Open* <https://doi.org/10.1177/23328584231176451> (2023).
173. Axelsson, C.-A. W., Nygren, T., Roozenbeek, J. & Linden, S. van der. Bad News in the civics classroom: how serious gameplay fosters teenagers' ability to discern misinformation techniques. *J. Res. Technol. Educ.* **57**, 992–1018 (2024).
174. Barzilai, S. et al. Misinformation Is Contagious: middle school students learn how to evaluate and share information responsibly through a digital game. *Comput. Educ.* **202**, 104832 (2023).
175. Lewandowsky, S. & Van Der Linden, S. Countering misinformation and fake news through inoculation and prebunking. *Eur. Rev. Soc. Psychol.* **32**, 348–384 (2021).
176. Roozenbeek, J. & van der Linden, S. Breaking Harmony Square: a game that 'inoculates' against political misinformation. *Harv. Kennedy Sch. Misinformation Rev.* <https://doi.org/10.37016/mr-2020-47> (2020).
177. Traberg, C. S., Roozenbeek, J. & van der Linden, S. Psychological inoculation against misinformation: current evidence and future directions. *Ann. Am. Acad. Polit. Soc. Sci.* **700**, 136–151 (2022).
178. Basol, M., Roozenbeek, J. & Van der Linden, S. Good news about bad news: gamified inoculation boosts confidence and cognitive immunity against fake news. *J. Cogn.* **3**, 2 (2020).
179. Yeo, S. K. & McKasy, M. Emotion and humor as misinformation antidotes. *Proc. Natl Acad. Sci. USA* **118**, e2002484118 (2021).
180. Andrews, J. L., Foulkes, L. & Blakemore, S.-J. Peer influence in adolescence: public-health implications for COVID-19. *Trends Cogn. Sci.* **24**, 585–587 (2020).
181. Guay, B., Berinsky, A. J., Pennycook, G. & Rand, D. How to think about whether misinformation interventions work. *Nat. Hum. Behav.* **7**, 1231–1233 (2023).
182. Eddy, K. *The Changing News Habits and Attitudes of Younger Audiences* (Reuters Institute, 2022).
183. Nielsen, R. K. & Fletcher, R. *Public Perspectives on Trust in News* (Reuters Institute, 2024).
184. News Literacy Project. *News Literacy in America* (News Literacy Project, 2024).
185. Huang, G., Jia, W. & Yu, W. Media literacy interventions improve resilience to misinformation: a meta-analytic investigation of overall effect and moderating factors. *Commun. Res.* <https://doi.org/10.1177/00936502241288103> (2024).

186. Guess, A. M. et al. A digital media literacy intervention increases discernment between mainstream and false news in the United States and India. *Proc. Natl Acad. Sci. USA* **117**, 15536–15545 (2020).
187. Altay, S., De Angelis, A. & Hoes, E. Media literacy tips promoting reliable news improve discernment and enhance trust in traditional media. *Commun. Psychol.* **2**, 1–9 (2024).
188. Kozyreva, A., Lewandowsky, S. & Hertwig, R. Citizens versus the Internet: confronting digital challenges with cognitive tools. *Psychol. Sci. Public Interest* **21**, 103–156 (2020).
189. Laaber, F., Florack, A., Koch, T. & Hubert, M. Digital maturity: development and validation of the Digital Maturity Inventory (DIMI). *Comput. Hum. Behav.* **143**, 107709 (2023).
190. Hopkins, K. L. et al. Co-designing a mobile-based game to improve misinformation resistance and vaccine knowledge in Uganda, Kenya, and Rwanda. *J. Health Commun.* **28**, 49–60 (2023).
191. Reijula, S. & Hertwig, R. Self-nudging and the citizen choice architect. *Behav. Public Policy* **6**, 119–149 (2022).
192. Grüning, D. J., Riedel, F. & Lorenz-Spreen, P. Directing smartphone use through the self-nudge app one sec. *Proc. Natl Acad. Sci. USA* **120**, e2213114120 (2023).

Acknowledgements

This work was supported by the European Union: ERC StG 101164150-DISINFORMED TEENS awarded to I.M. and ERC Consolidator 803338-MEDIA MINDS to W.v.d.B.

Author contributions

I.M. conceived the idea and wrote the initial draft of the manuscript. All authors wrote the final draft.

Competing interests

The authors declare no competing interests.

Additional information

Correspondence should be addressed to Ili Ma.

Peer review information *Nature Human Behaviour* thanks Gregory Trevors and Rolando Pérez Sánchez for their contribution to the peer review of this work.

Reprints and permissions information is available at www.nature.com/reprints.

Publisher's note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Springer Nature or its licensor (e.g. a society or other partner) holds exclusive rights to this article under a publishing agreement with the author(s) or other rightsholder(s); author self-archiving of the accepted manuscript version of this article is solely governed by the terms of such publishing agreement and applicable law.

© Springer Nature Limited 2025