The Challenge of Misinformation and Ways to Reduce Its Impact

Chapter for "Handbook of Learning from Multiple Representations and Perspectives"

Jasmyne A. Sanderson and Ullrich K. H. Ecker

School of Psychological Science

University of Western Australia

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Contributor Bios:

Jasmyne A. Sanderson is a postgraduate researcher and a student in the combined Master of Clinical Neuropsychology and PhD program at the School of Psychological Science at the University of Western Australia. Her research investigates the role of information integration and updating in the continued influence of misinformation.

Ullrich K. H. Ecker is an Associate Professor and Director of Community and Engagement at the University of Western Australia's School of Psychological Science. He is a cognitive psychologist studying human memory and in particular misinformation processing and debunking. He has published more than 60 articles and book chapters on these topics, including papers in *Psychological Science in the Public Interest*, the *Journal of Experimental Psychology: General*, and *Political Psychology*. His research is funded mainly by the Australian Research Council. He teaches Cognitive Psychology and Research Communication Skills, and has received multiple awards for both his teaching and research.

Abstract

Misinformation can influence people's memory, reasoning, and decision making even after they have received a correction—this is known as the continued influence effect of misinformation (CIE). There are a number of factors that contribute to misinformation's influence, both cognitive—including failures in the integration/updating of information and its later retrieval—and motivational—including the impact of pre-existing attitudes and worldviews. With the rise of the internet and social media, exposure to misleading and/or inaccurate information has arguable become more common, and there is a lack of gatekeepers to ensure information's quality and veracity; further challenges lie in the formation of echo chambers and filter bubbles. In this information environment, it is difficult for individuals to evaluate information and identify misinformation. This chapter briefly reviews theoretical accounts of the CIE and the challenges associated with the impact of misinformation in the current information landscape. It also discusses how some people may be more susceptible to misinformation effects, and suggests some recommendations on how to reduce the impact of misinformation, touching on both the specifics of how corrections should be presented and broader systemic factors.

Keywords: misinformation; continued influence effect; memory updating; debunking; post-truth

The Challenge of Misinformation and Ways to Reduce Its Impact

People are exposed to large amounts of information on a daily basis, with constant and immediate access to information through both traditional news sources (i.e., radio, television) and social media and the internet. Unfortunately, a significant share of this information will be incomplete, contradictory, or even inaccurate and misleading—even if euphemisms such as "alternative facts" are being applied (Lewandowsky, Ecker, & Cook, 2017). This leaves individuals with the difficult task of appraising the quality and credibility of the information they receive. Given the sheer volume of information available to people at their fingertips, individuals' ability to assess veracity is hindered: People have limited resources (either cognitive, motivational, or temporal) and therefore need to rely on heuristics—mental shortcuts such as the superficial visual aspects of a website (Fogg et al., 2003; Metzger & Flanagin, 2013)—to evaluate credibility. Such reliance on heuristics can lead to bias (Metzger & Flanagin, 2013). Moreover, the task is further complicated by the rise of fake accounts and deepfakes (i.e., artificial intelligence-based technology used to produce or alter video content; Fogg et al., 2003). It is estimated that 48 million Twitter accounts and 66 million Facebook profiles may be fake accounts or bots (i.e., an account impersonating a human) designed to boost the prevalence and distribution of false information, as seen in the use of Russian bots during the 2016 U.S. Presidential Election (Chang, 2018; Lazer et al., 2018; Varol, Ferrara, Davis, Menczer, & Flammini, 2017). Therefore, people are faced with growing amounts of misinformation but they are not necessarily well-equipped to deal with it.

Misinformation is defined here as objectively false information that is presented as valid (and plausible enough to be initially believed by some) but is subsequently found to be incorrect (Johnson & Seifert, 1994; Wilkes & Leatherbarrow, 1988). While we assume the objective falsity of misinformation can be established at least in principle (e.g., by subject

matter experts or independent fact-checkers), the increasing prevalence of misinformation means that information consumers must increasingly make veracity judgments of their own. Misinformation has many forms, ranging from rumors to fully elaborated fake news stories, but it is currently unclear how these forms differ in terms of impact. Moreover, while some misinformation may be benign (e.g., the false belief that the Great Wall of China is visible from space), other misinformation can have serious and lasting negative implications. One of the most prevalent examples of impactful misinformation involves childhood vaccinations, specifically the claim in a now retracted paper published in the *Lancet* that there was a causal link between the MMR (mumps, measles, rubella) vaccine and autism (Murch et al., 2004; Wakefield et al., 1998). This demonstrably caused significant and long-lasting drops in vaccination rates in both the U.S. and U.K. (e.g., Smith, Ellenberg, Bell, & Rubin, 2008; Thompson, 2009), despite widespread, clear and credible retractions, and abundant evidence discrediting the false claim (Demicheli, Jefferson, Rivetti, & Price, 2005).

There have been a number of proposed ways of classifying different types of misinformation. Recently, McCright and Dunlap (2017) proposed a taxonomy of four main types of misinformation: (1) truthiness, (2) bullshit, (3) systemic lies, and (4) shock and chaos. Truthiness refers to misinformation that is considered valid based simply on a feeling that it might be true rather than evidence. Bullshit is purposely deceptive and self-serving misinformation spread solely to persuade without any concern for reason or veracity. Systemic lies refers to carefully crafted misinformation campaigns specifically designed as a means to further ideological interests. Finally, a shock and chaos approach is used to confuse and fatigue publics in order to derail societal institutions to gain power. These different types of misinformation vary with respect to the amount of effort required to produce and sustain the misinformation. For example, campaigns of systemic lies (e.g., climate change denial movement) require greater effort compared to bullshit, which is easily manufactured by

individuals (e.g., conspiracy theories). For information consumers, it is important to be aware of these nuances in order to recognize misinformation when it is encountered. However, it is currently unclear how best to counteract the various types of misinformation; thus, presenting specific solutions to deal with the different types of misinformation is beyond the scope of this chapter, although we will provide general suggestions in the recommendations section.

In the following, this chapter will discuss the impact misinformation can have on a person's memory, reasoning, and decision making. It will outline the cognitive mechanisms that contribute to misinformation's persistence as well as briefly touching on the role of motivational factors. We will then discuss some of the challenges posed by misinformation, before making recommendations on ways to reduce the impact of misinformation.

The Continued Influence Effect

In light of the increasing prevalence of misinformation, there is a need to be able to successfully correct it. Unfortunately, this is a challenging task as once a person has been exposed to misinformation, it cannot simply be removed from memory, and it is therefore difficult to completely eliminate its influence. This means that misinformation can have a measurable impact on individuals' inferential reasoning, decision making, and judgments, even after a clear correction is provided that explicitly refutes the misinformation. This is known as the *continued influence effect* of misinformation (CIE; Johnson & Seifert, 1994; Wilkes & Leatherbarrow, 1988; for review, see Lewandowsky, Ecker, Seifert, Schwarz, & Cook, 2012).

Psychological research has demonstrated the CIE in a wide variety of settings, both in the lab and online, and using common myths (e.g., playing Mozart to your baby will make it smarter [it will not]), real-world misinformation (e.g., climate change is a hoax [it is not]), or fictional event reports. Using fictional event reports not only allows tight experimental control, but can also help demonstrate that the effect is not purely motivational, but

essentially a cognitive phenomenon. In these studies, participants typically read a fictitious news report that contains a target piece of critical information—for example, that a warehouse fire was caused by negligent storage of volatile materials (Johnson & Seifert, 1994; Wilkes & Leatherbarrow, 1988). This information is either retracted (i.e., it is explained that there were no volatile materials) or not. Participants then answer a series of inferential reasoning questions that probe details of the report (e.g., "what may have caused the explosion?"). Such studies have found that *retractions*—merely stating that the critical information is incorrect—are relatively ineffective; that is, they reduce but do not eliminate the influence of the critical information on people's reasoning. Typically, a retraction is found to approximately halve the number of references to the critical information relative to a no-retraction control condition. Notably, this occurs even when people can remember and report the retraction (Ecker, Hogan, & Lewandowsky, 2017; Ecker, Lewandowsky, Fenton, & Martin, 2014; Ecker, Lewandowsky, & Tang, 2010; Johnson & Seifert, 1994; Wilkes & Leatherbarrow, 1988). This result is highly reliable and has been found even with subtle or implied misinformation (Chan, Jones, Hall Jamieson, & Albarracín, 2017; Ecker, Lewandowsky, Chang, & Pillai, 2014; Rich & Zaragoza, 2016; Walter & Murphy, 2018). For example, pairing a news article with a misleading (vs. accurate) headline can affect people's memory for the article and their inferential reasoning about the article's implications (Ecker, Lewandowsky, Chang et al., 2014). A more effective method, which will be discussed in the recommendations section, is to include an explanation with the retraction statement as to why the misinformation is incorrect.

It is important to note that a large proportion of CIE research has only examined the effect of corrections on individuals' reasoning, and there is less clear evidence of the *behavioral* effects. Some research has examined how corrections influence voting behaviors (Aird, Ecker, Swire, Berinsky, & Lewandowsky, 2018; Swire, Berinsky, Lewandowsky, &

Ecker, 2017), as well as health behaviors such as vaccinations (Nyhan, Reifler, Richey, & Freed, 2014) and the purchase of multivitamin supplements (MacFarlane, Hurlstone, & Ecker, 2018). These studies demonstrate that corrections do not necessarily translate to behavioral change—that is, corrections may have a larger effect on reasoning measures than behavioral measures. For example, it has been found that fact-checks of politicians' statements can change people's beliefs about those statements without, however, changing voting intentions (unless the number of false statements from a particular politician far outweighed the number of factual statements; Aird et al., 2018; Swire, Berinsky et al., 2017).

Cognitive Explanations for the CIE

There are two dominant cognitive explanations for the CIE. One position suggests that the CIE occurs due to a failure at *retrieval* (Ayers & Reder, 1998; Ecker et al., 2010; Swire, Ecker, & Lewandowsky, 2017). According to this view, misinformation and valid information (e.g., a retraction) are stored separately in different memory representations and compete for activation during retrieval; misinformation thus influences reasoning when it is selectively retrieved while the correction is not (Ayers & Reder, 1998; Ecker et al., 2010; Swire, Ecker et al., 2017). One particular version of this account assumes dual processes: automatic retrieval processes on the one hand and strategic retrieval and monitoring processes on the other. If misinformation is activated by cues and automatically retrieved, strategic processes are required to assess the validity of the information retrieved, and/or recollect any relevant correction. As these strategic processes are cognitively demanding, they often fail, resulting in the CIE (Ecker et al., 2010).

The retrieval failure account is supported by the finding that specific warnings reduce the influence of misinformation, presumably because warnings promote the use of strategic monitoring processes (Ecker et al., 2010). Additional evidence comes from work on familiarity effects: Swire, Ecker et al. (2017) found that longer retention intervals were

associated with increased misinformation reliance. They argued that as the retention interval increased, recollection of the retraction became more difficult, while familiarity-driven automatic retrieval of the misinformation remained relatively intact.

Alternatively, the mental-model account suggests that failures of *information integration and updating* drive the CIE. This account assumes that people create mental models of events or causalities that are used to reason and draw inferences (Bower & Morrow, 1990; Wilkes & Leatherbarrow, 1988). When relevant new information—such as a retraction or correction—is encountered, the mental model requires updating and revision (Bower & Morrow, 1990). However, retractions by nature disrupt the mental model by invalidating a piece of critical information; this disruption threatens model coherence and may thus lead to the retraction being discounted and poorly integrated into the model (Gordon, Brooks, Quadflieg, Ecker, & Lewandowsky, 2017). This lack of integration between retraction and misinformation may be due to people's preference for complete over incomplete mental models, even when the complete model may contain dubious elements (Johnson & Seifert, 1994; Lewandowsky et al., 2012). A failure to integrate a retraction and subsequently update the mental model will lead to misinformation reliance (Gordon et al., 2017; Kendeou, Walsh, Smith, & O'Brien, 2014).

Behavioral and neuropsychological evidence has supported the mental-model account. At a basic level, this includes the finding that provision of a causal alternative explanation boosts the efficacy of a retraction (e.g., in the fictitious warehouse fire example, a statement that "there were no volatile materials present, but arson materials have been found"; see Chan et al., 2017; Ecker, O'Reilly, Reid, & Chang, 2019; Swire, Ecker et al., 2017; Walter & Murphy, 2018). This is easily explained by the mental-model account: if an alternative is provided that can replace the retracted element of the mental model, then there is no reason to discount the retraction because there is no threat to model coherence.

Behaviorally, the finding that working memory capacity predicts people's susceptibility to the CIE (Brydges, Gignac, & Ecker, 2018) supports the mental-model account because information integration and model updating require working memory resources. Furthermore, a neuroimaging study using functional magnetic resonance imaging found neural activity differed for the encoding of retractions compared to non-retractions in regions associated with information integration, suggesting that a failure of memory integration/updating may contribute to the CIE (Gordon et al., 2017). Research has suggested that integration is more likely to fail if individuals do not use full cognitive resources (e.g., when under cognitive load during retraction encoding; Ecker, Lewandowsky, Swire, & Chang, 2011), or if the initial mental model is highly plausible, based on stereotypical information, and/or in line with individuals' expectations and worldview, which we will discuss below (Ecker, Lewandowsky, Fenton et al., 2014).

To summarize, the retrieval-failure account suggests that the CIE arises when there is a failure in information selection and suppression occurring at the retrieval stage, whereas the mental-model account suggests a failure at the earlier integration/updating stage. It is important to note that these two views are not mutually exclusive; it is likely that failures with both integration/updating and retrieval contribute to the continued influence of misinformation.

The Role of Motivational Factors

Cognitive factors alone cannot explain reliance on misinformation entirely; motivational factors such as pre-existing attitudes, differing perspectives, and worldviews—fundamental beliefs about how society should operate (e.g., political worldviews; Cook, Lewandowsky, & Ecker, 2017)—also need to be considered. Individuals are motivated to maintain their view of the world and often attend to and interpret information in light of this view through attitude-driven processing (Kunda, 1990). For example, one study had left and

right-wing participants read fictitious articles about political misconduct (Ecker & Ang, 2019). Both participant groups mentioned worldview-consistent information more (i.e., mentioned misconduct by a politician of the opposing party more than their own party). This means correcting misinformation can be particularly challenging when the misinformation is congruent with people's attitudes and worldview. Worldview-incongruent corrections can be ineffective (Ecker & Ang, 2019), and under certain conditions, may even "backfire", that is, ironically increase belief in the misinformation being corrected (Lewandowsky et al., 2012; Nyhan & Reifler, 2010). Such backfire effects have been reported in the domains of climate change, vaccinations, and the presence of weapons of mass destruction in Iraq (Hart & Nisbet, 2012; Nyhan & Reifler, 2010; Nyhan et al., 2014). However, other research has failed to produce these effects despite using similarly contentious topics (Ecker, Lewandowsky, Fenton et al., 2014; Wood & Porter, 2019). More fully explaining the impact of motivational factors thus remains a target for future research. Suggestions to counter motivational factors include framing the correction in line with individuals' worldview (Feinberg & Willer, 2013), having an in-group member present the correction (Benegal & Scruggs, 2018; Berinsky, 2017), or bolstering people's feelings of self-worth (e.g., through self-affirmations) before presenting the correction (Nyhan & Reifler, 2018).

Challenges of Misinformation

Apart from the fact that misinformation is generally difficult to correct, there are particular challenges. One challenge is that some people are particularly susceptible to misinformation and its effects (Bensley, Lilienfeld, & Powell, 2014; Lewandowsky et al., 2013; Pennycook & Rand, 2018, 2019a). Generally, older adults are more likely to share misinformation online due to unfamiliarity with the internet and limited knowledge of how to evaluate online information (Grimes, Hough, Mazur, & Singnorella, 2010; Guess, Nagler, & Tucker, 2019). Older adults are also more vulnerable to the CIE, being more likely to

incorrectly remember a corrected false claim as being true, particularly over longer intervals (Skurnik, Yoon, Park, & Schwarz, 2005; Swire, Ecker et al., 2017). These age-related differences are thought to arise from the general decline in cognitive functions, and more specifically less efficient strategic memory processes (Swire, Ecker et al., 2017). Additionally, cognitive abilities including working memory capacity and verbal intelligence have been found to predict susceptibility to misinformation effects (Byrdges et al., 2017; De keersmaeker & Roets, 2017). That is, even with no difference in initial misinformation belief, individuals with lower cognitive ability (i.e., WMC and verbal intelligence) tend to display less belief adjustment following the correction of false information compared to those with higher ability. Efforts to reduce the impact of misinformation should therefore be particularly geared towards groups that are most vulnerable to it.

Other challenges arise from the shape of the contemporary media landscape. This can be seen in the formation of echo chambers and filter bubbles—personalized information environments (e.g., social media feeds) where specific information is circulated based on user preferences and behavior (Lewandowsky, Ecker et al., 2017; Pariser, 2011; Sunstein, 2002; Zollo et al., 2017). This personalization—driven by both active personal decisions and preference-based algorithms—permits selective exposure to information that is consistent with one's attitudes and worldview, consequently limiting exposure to and learning from divergent views (Kahne & Bowyer, 2017; Lewandowsky, Cook, & Ecker, 2017). Selective exposure can foster attitude polarization and research has found that the degree of homogeneity and polarization within social networks is associated with increased acceptance of misinformation (Dylko et al., 2017; Garrett, Weeks, & Neo, 2016). Attempts to address this personalization include adapting algorithms to "burst" filter bubbles (Resnick, Garrett, Kriplean, Munson, & Stroud, 2013), or simply informing people of how filter bubble algorithms work, with many unaware that algorithms use data on online consumer behaviors

and preferences to shape people's information diet (Eslami et al., 2015). Moreover, in contrast to traditional news media—at least some of which have ethics and integrity guidelines and responsible editors who act as gatekeepers—there are few such regulatory mechanisms on the internet, and algorithms largely determine how news is distributed and to whom, thus fostering the creation and distribution of misinformation. There are obvious issues with the practicality of internet regulation that does not encroach on people's democratic rights; however, given the issues arising from misinformation, some argue that regulation may be an important tool to reduce the spread of misinformation (e.g., Nechushtai & Lewis, 2019).

Finally, societal factors such as the decline of social capital, social inequality and the associated broad discontent and political polarization, as well as either press monopolies or an information environment that allows anyone to publish information without gatekeeping mechanisms present more fundamental challenges relating to misinformation. For example, discontent arising from social inequality fosters vulnerability to targeted misinformation campaigns (e.g., ideological political polarization between parties tends to increase during periods of high income inequality; Garand, 2010; McCarty, Poole, & Rosenthal, 2006). Furthermore, combating misinformation is difficult when either one agency or platform has near exclusive control over media content or it is completely unregulated (see Lewandowsky, Cook et al., 2017; Lewandowsky, Ecker et al., 2017; also Garand, 2010; Iyengar & Westwood, 2015; Wilkinson & Pickett, 2009). These are important factors to consider in the fight against misinformation, even though they are largely beyond the scope of this chapter.

Recommendations

We will now discuss some recommendations to combat misinformation and the CIE. These recommendations are broken down into suggestions for (1) presenting the correction, (2) helping individuals to detect misinformation and, (3) broader systemic changes.

Correction Design

Recommendation 1: Refutations. One of the most effective methods for reducing reliance on misinformation is a refutation. In comparison to a retraction, which simply states that a piece of information is incorrect, a *refutation* explains *why* the information is incorrect (and/or why people assumed it to be correct) and provides some factual information (Tippett, 2010). Multiple studies including several meta-analyses have supported the effectiveness of refutations for both constructed and real-world misinformation (Chan et al., 2017; Ecker, O'Reilly et al., 2019; Paynter et al., 2019; Swire, Ecker et al., 2017; Walter & Murphy, 2018). Refutations have been found particularly useful in situations characterized by mutual trust and availability of sufficient motivational and temporal resources, such as correcting scientific misconceptions in educational settings (Guzzetti, Snyder, Glass, & Gamas, 1993; Kowalski & Taylor, 2009; Tippett, 2010).

There are three reasons for a refutation's effectiveness. Firstly, refutations promote the co-activation of misinformation and retraction. Models of conceptual change argue that in order for knowledge revision to occur both the misconception and correction need to be co-activated and a discrepancy noticed (Kendeou et al., 2014). Accordingly, refutations that make the discrepancy between the valid and invalid information salient have been found to facilitate integration/updating and reduce the CIE (Ecker et al., 2017).

Secondly, as briefly mentioned before, to the extent that a refutation includes factual information, it can serve to fill the gap created in a person's mental model by a retraction (Johnson & Seifert, 1994). For example, in the warehouse fire scenario people rely on misinformation less when they are given the alternative arson explanation (Johnson & Seifert, 1994). Naturally, utilizing this mechanism is not possible if no clear factual alternative is readily available. One explanation for the difficulty dispelling the vaccine-autism myth is that the causes of (the various types of) autism are not yet fully understood (Leonard et al., 2010).

Thirdly, refutations provide additional recollectable detail. In terms of the retrieval failure account sketched earlier, strategic recollection processes will easily fail if only scarce corrective information (e.g., "X is not true") is available in memory. A richer, more elaborate representation of corrective information will be better able to compete with the misinformation at retrieval (Ecker, Lewandowsky, Jayawardana, & Mladenovic, 2018; Kendeou et al., 2014).

Although refutations are demonstrably effective, there has been debate within the literature as to whether the misconception should be repeated in the correction. It is argued that repetition of the misinformation may inadvertently increase its familiarity and subsequent acceptance (Lewandowsky et al., 2012; Schwarz, Newman, & Leach, 2016; Schwarz, Sanna, Skurnik, & Yoon, 2007). However, research has not found much evidence for the existence of this so-called familiarity backfire effect (Ecker et al., 2017; Ecker, O'Reilly et al., 2019; Pashler, Kang, & Mozer, 2013; Swire, Ecker et al., 2017). Pashler et al. (2013) found that reviewing previous incorrect information actually improved memory for new correct information. In line with this, the reconsolidation literature argues that retrieving information puts it in a labile and malleable state; this allows the memory representation to be updated and revised before again being stabilized by a reconsolidation process (Elsey & Kindt, 2017). Therefore, repeating the misinformation in a correction may induce the labilization process and better allow the correction to be incorporated into the original memory representation.

Recommendation 2: Warnings. Where possible, before people are exposed to misinformation the publisher or content platform should provide explicit warnings stating that the information people are going to receive may not be true. Warnings put people cognitively on guard, therefore reducing the depth of information encoding and increasing strategic monitoring processes at retrieval (Cook et al., 2017; Ecker et al., 2010). Social

media platforms have trialed the use of warnings, although its effectiveness is unclear (Blair et al., 2017; Pennycook & Rand, 2019b). Blair et al. (2017) found that a "disputed" flag warning about false news stories—as per Facebook's original strategy against misinformation (Lyons, 2017)—modestly reduced the perceived accuracy of flagged stories; however, another study found that warnings also increased the perceived accuracy of non-flagged stories regardless of their veracity (Pennycook & Rand, 2019b). Additionally, researchers are developing fake news detection systems which may predict misinformation surges by identifying polarizing topics on social media, which may be used to optimize warnings about misinformation (Del Vicario, Quattrociocchi, Scala, & Zollo, 2018).

Recommendation 3: Graphical displays. Information is often encountered across multiple representations including texts, graphs, or visual images. Corrections should be presented in a simple format that facilitates comprehension and retention. Graphical representations are choice formats because they achieve this goal, while quantifying and specifying the corrective information, which can prevent motivational counter-arguing (e.g., a graph showing data from several independent sources that quantify the exact amount of temperature rise over time is more difficult to counter-argue than a verbal statement that temperatures have increased; Nyhan & Reifler, 2018; also see Ecker, O'Reilly et al., 2019; Paynter et al., 2019; van der Linden, Leiserowitz, Feinberg, & Maibach, 2014; but see Pluviano, Watt, & Della Sala, 2017). While visual representations are effective, it is important to note that they can easily be distorted and become misleading. For example, deceptive data visualizations (i.e., truncated or inverted axes) can lead to misinterpretation of data even if they are accompanied by accurate text explanations (O'Brien & Lauer, 2018; Vargas-Restrepo, Yang, Stanley, & Marsh, 2019). Furthermore, the credibility of misinformation itself may be bolstered by visual representations, as people perceive graphs as "scientific" and visuals as a direct index of reality that are less easily manipulated than text,

which is particularly concerning given the advent of deepfakes (Hameleers, Powell, Van der Meer, & Bos, 2019; Messaris & Abraham, 2001; Smith, Best, Stubbs, Archibald, & Roberson-Nay, 2002). Thus, while corrections are likely to benefit from the use of multiple representations, individuals must also be aware of potentially deceitful use.

Educational Approaches

Recommendation 4: Information and media literacy training. General training in information and media literacy is a pre-emptive step to provide individuals with the skills and resources necessary to evaluate and recognize misinformation (Bensley et al., 2014; Lewandowsky et al., 2013; Lewandowsky, Ecker et al., 2017; Pennycook & Rand, 2019a). This involves fostering healthy skepticism and teaching individuals critical thinking skills, which are important for the recognition and rejection of misinformation (Bensley et al., 2014; Lewandowsky et al., 2013; Pennycook & Rand, 2019a). An important aspect of information literacy is source evaluation. People use trustworthiness over expertise as a heuristic for evaluating information (in the misinformation context, see Guillory & Geraci, 2013); however, people are not good at determining whether a source is trustworthy and therefore interventions must teach individuals source evaluation skills (McGrew, Breakstone, Ortega, Smith, & Wineburg, 2018). Interventions must also utilize available technologies (e.g., debunking sites, fake-news detection) to be able to rival the progression of misinformation on the internet. There is preliminary evidence supporting the effectiveness of literacy interventions with improvements in students' abilities to identify inaccurate political information (Craft, Ashley, & Maksl, 2017; Kahne & Bowyer, 2017; Walton & Hepworth, 2011). These effects are found even when the information aligned with partisan ideology, suggesting such training has the potential to overcome personal motivational biases (Kahne & Bowyer, 2017). Some have argued, however, that these interventions could backfire by making people hyper-skeptical of information sources and well-established facts (Mihailidis,

2009). It is important to note that critical thinking should not be thought of as an abstract skill entirely independent of factual knowledge, as one often needs subject-relevant knowledge in order to appraise new information critically. Obtaining subject-relevant knowledge is a challenge given the inherent difficulty in reading scientific texts and individuals' low levels of understanding of scientific processes (Britt, Richter, & Rouet, 2014; Ozuru, Dempsey, & McNamara, 2009).

Recommendation 5: Inoculation. Inoculation is a pre-bunking strategy aimed to stop the spread and aid the detection of misinformation (Cook et al., 2017; Lewandowsky, Ecker et al., 2017; van der Linden, Leiserowitz, Rosenthal, & Maibach, 2017). Inoculation involves a warning about potential false information that attempts to challenge beliefs, followed by a specific, weakened example of such an attempt that highlights the techniques used and the logical flaw in the argument made. It thus acts like a "psychological vaccination" that helps to develop resistance against stronger, more persuasive attempts in the future (Cook et al., 2017). For example, such strategies have been found effective in the domain of climate change (Cook et al., 2017; van der Linden et al., 2017). Inoculation strategies may be incorporated as part of broader interventions against misinformation including literacy training programs and technology-based interventions. For example, Roozenbeek and van der Linden (2019) have had preliminary success with a "fake news game", which teaches players about misleading techniques by having them take on the role of a news editor whose only objective is to build a media empire using false news articles.

Broader Systemic Changes

Recommendation 6: Technocognition approach. Technology is progressing at a rapid rate and technological techniques to identify misinformation are developing just as quickly; for example, fact-checking is becoming automated and machine-learning algorithms are being built to automatically detect misinformation online (Del Vicario et al., 2018; Pérez-

Rosas, Kleinberg, Lefevre, & Mihalcea, 2018). However, technological approaches alone will not be able to tackle the problem of misinformation. Instead, Lewandowsky, Ecker et al. (2017) proposed a "technocognition" approach which combines psychological principles including insights from behavioral economics with technological innovation in an attempt to reduce the impact of misinformation. An example of this is broadening of filter bubbles and diversification of information sources. Psychological research has shown that exposure to alternative perspectives can increase understanding and acceptance of those perspectives, or reduce polarization of one's own attitudes (Grönlund, Herne, & Setala, 2015; Lord, Lepper, & Preston, 1984). For example, deliberation between people who were either restrictive or permissive in their attitudes towards immigration has been found to result in lowered anti-immigration attitudes for those who were initially restrictive (Grönlund et al., 2015). Websites can incorporate this idea by changing their algorithms to promote content that is different to individuals' views and may reduce the acceptance of misinformation in line with them. However, some have questioned the utility of this approach (Bail et al., 2018; Haim, Graefe, & Brosius, 2018).

Recommendation 7: Social change. As mentioned briefly before, societal factors can play an important role in misinformation susceptibility and thus in efforts to reduce misinformation's impact. Interventions may include the passing of anti-misinformation laws, with many countries having already introduced legislation governing the distribution of misinformation on social media; however, with government regulation a balance must be maintained between freedom of speech and distribution of misinformation (Goldzweig, Wachinger, Stockmann, & Römmele, 2018). Additionally, vulnerability to misinformation effects will be lowered by efforts to reduce social inequality and political polarization: the former leads to marginalization and discontent, which are breeding grounds for misinformation that serves to ostensibly explain the unjust state of affairs; the latter creates

social division and can thus increase belief in misinformation about outgroups (see Deb, Donohue, & Glaisyer, 2017; Garand, 2010; Lewandowsky, Cook et al., 2017; Tucker et al., 2018). Finally, interventions could involve improved communication and reinforcement of existing social norms—socially accepted rules that govern worldviews and behaviors—in order to build a culture that values and promotes truth, particularly regarding the creation and sharing of information online (Lazer et al., 2018; Pankoke-Babatz & Jeffery, 2002).

Future Directions

Misinformation is a growing problem in current society and research continues to grow with it. Currently, research is beginning to go beyond just survey approaches, assessing the impact of misinformation and corrections on actual behaviors, and using neuroimaging techniques to gain a better understanding of the neural basis of the CIE. Further research is needed to investigate and create specific strategies to target the different types of misinformation. It is also becoming apparent with misinformation in the "post truth" era that this is an interdisciplinary problem that will require interdisciplinary solutions (Lewandowsky, Ecker et al., 2017). As such, research from different disciplines must join forces to find effective ways forward.

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