Misinformation and its Correction:
Continued Influence and Successful Debiasing

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Abstract

The widespread prevalence and persistence of misinformation in contemporary societies, such as the false belief that there is a link between childhood vaccinations and autism, must be of public concern. For example, the myths surrounding vaccinations which led some parents to withhold immunization from their children have demonstrably led to a marked increase in vaccine-preventable disease, as well as unnecessary public expenditure on research and public information campaigns to rectify the situation.

We first examine the mechanisms by which such misinformation is disseminated in society, both inadvertently and purposely. Misinformation can originate from rumors but also works of fiction, from government and politicians, as well as vested interests. Moreover, changes in the media landscape and the arrival of the internet have fundamentally impacted the ways in which information is communicated and misinformation is spread.

We then move to the level of the individual, and review the cognitive factors that often render misinformation resistant to correction. We consider how people assess the truth of a statement and what makes people believe certain things but not others. We answer the question why retractions of misinformation are so ineffective and why efforts to retract misinformation can even backfire and ironically increase misbelief. While ideology and personal worldviews can be major obstacles for debiasing, there nonetheless are a number of effective techniques to reduce the impact of misinformation, and we pay special attention to these factors that aid in debiasing.

We conclude by providing specific recommendations for practitioners to aid in the debunking of misinformation. These recommendations pertain to the ways in which corrections should be designed, structured, and applied in order to maximise impact. Grounded in cognitive psychological theory, these recommendations may help practitioners—including journalists, health professionals, educators, and science communicators—design effective misinformation retractions, educational tools, and public information campaigns.

On August 4, 1961, a young woman gave birth to a healthy baby boy in a hospital at 1611 Bingham Street, Honolulu. That child, Barack Obama, later became the 44th President of the United States. Notwithstanding the incontrovertible evidence for this simple fact—from a Hawaiian birth certificate to birth announcements in the papers to the fact that a pregnant woman went into hospital and left it cradling a baby—a group known as "birthers" claimed during the first few years after Obama assumed office that the President was born outside the United States and therefore not eligible to assume the presidency. Even though the claims were met with skepticism by the media, polls at the time showed that a sizable proportion of the public believed these claims (Travis, 2010), including at one point a majority of Republican primary voters (Barr, 2011).

In the United Kingdom, a 1998 study suggesting a link between a common childhood vaccine and autism generated considerable fear in the general public concerning the safety of the vaccine. The UK Department of Health and several other health organizations immediately pointed to the lack of evidence for such claims, and urged parents not to reject the vaccine. The media subsequently widely reported the failures to substantiate any of the original claims. Nonetheless, in 2002, about 20-25% of the public continued to believe in the vaccine-autism link, and a further 39-53% continued to believe there was equal evidence on both sides of the debate (Hargreaves, Lewis, & Speers, 2003). More worryingly still, even a substantial number of health professionals continued to believe the unsubstantiated claims (Petrovic, Roberts, & Ramsay, 2001). Ultimately, a significant conflict-of-interest emerged involving the first author of the misleading study, whereupon most co-authors distanced themselves from the study, the journal officially retracted the article, and the first author was eventually found guilty of misconduct, losing his license to practice medicine (Colgrove & Bayer, 2005; Larson et al., 2011).

Another particularly well documented case of the persistence of mistaken beliefs despite extensive corrective efforts involves the decade-long deceptive advertising for Listerine mouthwash in the U.S. Advertising for Listerine had claimed for over 50 years that the product helped prevent or reduce the severity of colds and sore throats. After a long legal battle, this claim was found to be deceptive, and the U.S. Federal Trade Commission (FTC) mandated corrective advertising that explicitly withdrew the deceptive claims. The company ran a television ad campaign for 16 months during 1978-1980 retracting cold-related claims using a 5-second disclosure midway through 30-second TV spots. Notwithstanding a $10 million budget, the campaign was only moderately successful (Wilkie, McNeill, & Mazis, 1984). Using a cross-sectional comparison of representative samples at various points during the corrective campaign, a telephone survey by Armstrong, Gural, and Russ (1983) did find a

significant reduction in consumers' belief that Listerine could alleviate colds, but overall levels of acceptance of the false claim remained high. For example, 42% of Listerine users continued to believe that the product was still promoted as an effective cold remedy, and more than half of Listerine consumers (57%) rated the presumed medicinal effects of the product as a key attribute of their purchasing decision (compared to 15% of consumers of a competing product). In summarizing the results, Wilkie et al. (1984) suggested that the campaign was only partially effective, with important misperceptions persisting despite the corrective ad campaign.

Those results underscore the difficulties of correcting widespread misinformation in society. These difficulties arise from two distinct factors: First, there are cognitive variables within each person which render misinformation "sticky." We focus primarily on those variables in this article. The second factor is purely pragmatic, and relates to the ability to reach the target audience. The Listerine real-life quasi-experiment is particularly informative in this regard because its effectiveness remained limited despite the availability of a fairly large budget to disseminate corrective information.

What, then, causes the persistence of erroneous beliefs in sizable segments of the population? Assuming corrective information has been received, why does misinformation[1] continue to influence people's thinking despite clear retractions? The literature on these issues is extensive and complex, but it permits several reasonably clear conclusions which we present in the remainder of this article. Psychological science has much light to shed onto the cognitive processes with which individuals process, acquire, and update information.

To foreshadow, we focus primarily on individual-level cognitive processes as they relate to misinformation. However, a discussion of the continued influence of misinformation cannot be complete without addressing the societal mechanisms that give rise to the persistence of false beliefs in large segments of the population. Thus, it is a matter of individual cognition to understand why one might reject evidence about President Obama's place of birth; however, to understand why more than half of Republican primary voters expressed doubt about the President's birth place (Barr, 2011) requires a consideration not only of why an individual clings to misinformation, but also how information—and especially false information—is disseminated through society. We therefore begin our analysis at the societal level: First, we highlight the societal costs of widespread misinformation, and then turn to the societal processes that permit its spread.

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[1] We use the term "misinformation" here to refer to any piece of information that is initially processed as valid but which is subsequently retracted or corrected. This is in contrast to the literature on so-called "post-event misinformation", which has been reviewed extensively elsewhere (e.g., Ayers & Reder, 1998, Loftus, 2005) and has focused on the effects of suggestive and misleading information presented to event witnesses *after* the event.

The Societal Cost of Misinformation

It is a truism that a functioning democracy relies on an educated and well-informed populace (Kuklinski, Quirk, Jerit, Schwieder, & Rich, 2000). The processes by which people form their opinions and beliefs are thus of obvious public interest, in particular if major streams of beliefs persist that are in opposition to established facts. If a majority believes in something that is objectively incorrect, political and societal decisions will be made and accepted that may run counter to a society's best interest; if an individual is misinformed, they will likewise make decisions for themselves and their families that may not be in their best interest and can have serious consequences. For example, following the unsubstantiated claims of a vaccination-autism link, many parents decided not to immunize their children, which has had dire consequences both for individuals and societies, with a marked increase in vaccine-preventable disease and hence preventable hospitalizations, deaths, and unnecessary expenditure of large amounts of money for follow-up research and public information campaigns to rectify the situation (Larson, Cooper, Eskola, Katz, & Ratzan, 2011; Poland & Spier, 2010; Ratzan, 2010).

This reliance on misinformation differs from ignorance, defined here as the *absence* of relevant knowledge. Ignorance, too, can have obvious detrimental effects on decision making but, perhaps surprisingly, those effects may be less severe than those arising from reliance on misinformation. Ignorance may be a lesser evil because in the self-acknowledged absence of knowledge, people often turn to simple heuristics when making decisions. Those heuristics, in turn, can work surprisingly well, at least under favorable ecological conditions. For example, mere familiarity with an object often permits accurate guessing (Goldstein & Gigerenzer, 2002; Newell & Fernandez, 2006). Moreover, decisions based solely on such heuristics are typically associated with relatively low levels of decision confidence (De Neys, Cromheeke, & Osman, 2011; Glöckner & Bröder, 2011). In other words, ignorance will rarely lead to strong support of a cause, in contrast to false beliefs based on the continued influence of misinformation, which are often held strongly and with (perhaps infectious) conviction. For example, those who most vigorously reject the scientific evidence for climate change are also those who believe they are best informed about the subject (Leiserowitz, Maibach, Roser-Renouf, & Hmielowski, 2011).

The costs of misinformation to society are thus difficult to ignore, and its widespread persistence calls for an analysis of its origins.

Origins of Misinformation

Misinformation can be disseminated in a number of ways, often without any intent to mislead. For example, the timely news coverage of unfolding events is by its very nature piecemeal and will

require corrections of earlier statements. As a case in point, the death toll after a major natural disaster—such as the 2011 Tsunami in Japan—is necessarily repeatedly updated until a final estimate becomes available. Similarly, a piece of information that is considered "correct" at any given stage can later turn out to have been mistaken.

Indeed, this piecemeal approach to knowledge construction is the very essence of the scientific process, where isolated initial findings are sometimes refuted or found not to be replicable. It is for this reason that scientific conclusions are usually only made and accepted after some form of consensus has been reached based on multiple lines of converging evidence. Misinformation arising during an evolving event or during knowledge updating is unavoidable as well as unintentional; however, there are other sources of misinformation that are arguably less benign. The particular sources that we discuss in the following are:

- Rumors and fiction. Societies have struggled with the effects of rumors for decades if not centuries; what is perhaps less obvious is that even works of fiction can give rise to lasting misconceptions of the facts.

- Governments and politicians can be powerful sources of misinformation, either inadvertently or in some cases by design.

- Vested and corporate interests have a long and well-documented history of seeking to influence public debate by promulgating incorrect information. Those systematic campaigns are not limited to corporate interests but, at least on some recent occasions, can also be directed against corporate interests by non-governmental interest groups.

- Although the media are by definition seeking to inform the public, it is notable that they are particularly prone to spreading misinformation for systemic reasons that are worthy of analysis and exposure.

- The internet has put immense quantities of information at our fingertips, but it has also contributed to the spread of misinformation. The growing use of social networks may contribute to the quick and wide dissemination of misinformation. The fractionation of the information landscape by new media is an important contributor to rendering misinformation particularly resilient to correction.

Rumors and fiction

Rumors and urban myths constitute important sources of misinformation. For example, in 2006, a majority of Democrats believed that the Bush administration either assisted in the 9/11 terror attacks

or took no action to stop them (Nyhan, 2010). This widespread belief is all the more remarkable because this conspiracy theory has found virtually no traction in the mainstream media.

Human culture strongly depends on people passing on information. While believability has been identified as a factor determining which information is propagated (Cotter, 2008), people seem to mainly pass on information that will evoke an emotional response in the recipient, irrespective of its truth value. Emotional arousal in general leads to a higher willingness to pass on information (Berger, 2011). Thus, stories containing disgust, fear, or happiness-evoking content are spread more readily from person to person and more widely through social media than neutral stories (Cotter, 2008; Heath, Bell, & Sternberg, 2001; K. Peters, Kashima, & Clark, 2009).

Accordingly, the most effective "misinformers" about vaccines are parents who truly believe that their child has been injured by a vaccine. Presented as fact by prominent individuals, those claims may be featured in the media, discussed on popular TV and radio talk shows, and made the subject of TV dramas and docudramas (Myers & Pineda, 2009).

A related but perhaps more surprising source of misinformation is literary fiction. People extract knowledge even from sources that are explicitly identified as fictional. This is often adaptive because fiction frequently contains valid world knowledge. For example, non-Americans' knowledge of U.S. traditions, sports, climate, and geography will partly stem from movies and novels, and many Americans will know from movies that Britain and Australia have left-hand traffic. By definition, however, fiction writers are not obliged to stick to the facts, thus creating an avenue for the spreading of misinformation even by stories that are explicitly identified as fictional. In a study by Marsh, Meade, and Roediger (2003), people relied on misinformation acquired from clearly fictitious stories to respond to later knowledge quiz questions, even when these pieces of misinformation contradicted common world knowledge. In most cases, source attribution was intact, so people were aware that they were taking their quiz answers from the stories, but reading the stories also increased people's illusory belief of prior knowledge. In other words, encountering misinformation in a fictional context leads people to assume they had known it all along, and misinformation is integrated with prior knowledge (Marsh et al., 2003; Marsh & Fazio, 2006).

The effects of fictional misinformation have proven stable and difficult to eliminate. Marsh and Fazio (2006) reported that prior warnings were ineffective in reducing the acquisition of misinformation from fiction, and that acquisition was only reduced (but not eliminated) under conditions of active on-line monitoring—when participants were instructed to actively monitor the contents while reading and press a key every time a piece of misinformation was identified (see also Eslick, Fazio, & Marsh,

2011). Few people would be so alert and mindful when reading fiction for their enjoyment. These links from fiction to incorrect knowledge are particularly concerning when popular fictional content pretends to accurately portray science but fails to do so, as was the case with Michael Crichton's novel "State of Fear." The novel misrepresented the science of global climate change but was nevertheless introduced as "scientific" evidence into a U.S. Senate committee (Allen, 2005; Leggett, 2005).

While writers of fiction are expected to depart from reality, in other instances misinformation is manufactured intentionally. There is considerable peer-reviewed evidence pointing to the fact that misinformation can be intentionally or carelessly disseminated, often for political ends or in the service of vested interests, but also through routine processes employed by the media in an open society.

Government and politicians

In the lead-up to the U.S.-led invasion of Iraq in 2003, U.S. government officials proclaimed there was "no doubt" that Saddam Hussein had weapons of mass destruction (WMD's) and was ready to use them against his enemies. The Bush administration also juxtaposed Iraq and the 9/11 terrorist attacks, identifying Iraq as the frontline in the "War on Terror" (Reese & Lewis, 2009) and implying it had intelligence linking Iraq to Al Qaeda. Although no WMD's were ever found in Iraq and although the link to Al Qaeda turned out to be unsubstantiated, large segments of the U.S. public continued to believe the administration's earlier claims, with some 20-30% of Americans believing that WMD's had actually been discovered in Iraq years after the invasion (Kull, Ramsay, & Lewis, 2003; Kull et al., 2006) and around half the public endorsing links between Iraq and Al Qaeda (Kull et al., 2006). These mistaken beliefs persisted even though all tentative media reports about possible WMD sightings during the invasion were followed by published corrections, and even though the non-existence of WMD's in Iraq and the absence of links between Iraq and Al Qaeda eventually became official and widely reported bipartisan U.S. policy through the Duelfer report.

Politicians were also a primary source of misinformation during the U.S. health care debate in 2010. Misinformation about the Obama health plan peaked when Sarah Palin posted a comment about "death panels" on her Facebook page. Within 5 weeks, 86% of Americans had heard of the death panel claims. Of those who heard the myth, fully half either believed it or were not sure of its veracity. *Time* magazine reported that the single phrase "death panels" nearly derailed Obama's health care plan (Nyhan, 2010).

Although Sarah Palin's turn of phrase may have been spontaneous and its consequences unplanned, other analyses reveal programmatic efforts to misinform the public, for example on climate

change (McCright & Dunlap, 2010). During the administration of George W. Bush, political appointees demonstrably interfered with scientific assessments of climate change (e.g., Mooney, 2007), and NASA's Inspector General found in 2008 that in previous years, the agency's "… Office of Public Affairs managed the topic of climate change in a manner that reduced, marginalized, or mischaracterized climate change science made available to the general public …" (Winters, 2008, p. 1).

The public seems to have some awareness of the presence of politically-motivated misinformation in society, especially during an election campaign (Ramsay, Kull, Lewis, & Subias, 2010). However, when asked to point to specific instances of such misinformation, people are often unable to differentiate between information that is false and other information that is correct (Ramsay et al., 2010). Thus, public awareness of the problem is no barrier to widespread and lasting confusion.

Vested interests and non-government organizations (NGOs)

There is also evidence of concerted efforts by vested interests to disseminate misinformation, especially when it comes to environmental (e.g., Jacques, Dunlap, & Freeman, 2008) and public-health issues (e.g., Oreskes & Conway, 2010; Proctor, 2008) that have the potential to impose a regulatory burden on certain industries (e.g., tobacco manufacturers or the fossil fuel industry). This process of willful manufacture of mistaken beliefs has been described as "agnogenesis" (Bedford, 2010). There is considerable legal and scientific evidence for this process in at least two arenas; namely, industry's response to the health consequences of tobacco smoke and to climate change.

In 2006, a U.S. Federal Court ruled that the major domestic cigarette manufacturers were guilty of conspiring to deny, distort, and minimize the hazards of cigarette smoking to the public (Smith et al., 2011). Similarly, starting in the early 1990s, the American Petroleum Institute, the Western Fuels Association (a coal-fired electrical industry consortium) and a Philip Morris-sponsored anti-science group called TASSC drafted and promoted campaigns to cast doubt on the science of climate change (Hoggan, Littlemore, & Littlemore, 2009). The industry has also formed an alliance with conservative think tanks, using a handful of respected scientists (typically experts from a different domain) as spokespersons (Oreskes & Conway, 2010). Accordingly, over 90% of environmentally skeptical books published between 1972 and 2005 have been linked to conservative think tanks (Jacques et al., 2008).

However, the spreading of misinformation is by no means always based on concerted efforts by vested interests. On the contrary, there are instances in which industry has been harmed by misinformation: For example, the vaccination-autism myth discussed earlier has led to decreased vaccination rates (Owens, 2002; Poland & Jacobsen, 2011) and hence arguably decreased the revenue

and profits of pharmaceutical companies. A similar case can be made for genetically-modified (GM) foods, which are strongly opposed by segments of the public, in particular in Europe (e.g., Gaskell et al., 2003; Mielby, Sandøe, & Lassen, 2012). The magnitude of opposition seems disproportionate to the actual risks of GM foods as portrayed by expert bodies (e.g., WHO, 2005), and it appears that people often rely on NGOs, such as Greenpeace, that are critical of peer-reviewed science to form their opinions about GM foods (Einsele, 2007). Those alternative sources have been resoundly criticized as spreading misinformation (e.g., Parrott, 2010).

Media

Given that people largely obtain their information from the media, broadly defined to include print newspapers and magazines, radio, TV, and the internet, its role in the dissemination of misinformation deserves to be explored. We have already mentioned that the media sometimes unavoidably reports incorrect information based on its need for timely news coverage. There are however several other systemic reasons for why the media might get things wrong.

First, the media can inadvertently oversimplify, misrepresent, or over-dramatize scientific results. Science is complex, and for the lay-person the details of many scientific studies are difficult to understand or of marginal interest. Science communication thus necessarily requires simplification in order to be effective. Any oversimplification, however, can lead to misunderstanding. For example, one study published in *Nature*, forecasting future global extinctions as a result of climate change, was widely misrepresented in the news media to make the consequences seem more catastrophic and the timescale shorter than actually projected (Ladle, Jepson, & Whittaker, 2005). This also implies that scientists need to take care to communicate their results clearly and unambiguously and that press releases need to be meticulously constructed to avoid media misunderstandings (e.g., Riesch & Spiegelhalter, 2011).

Second, in all arenas of reporting, journalists often aim to present a "balanced" story. In many instances, it is indeed appropriate to listen to "both sides of a story;" however, when media stick to journalistic norms of "balance" even when it is not warranted, the outcome can be highly misleading (Clarke, 2008). For example, if the national meteorological service issues a severe weather warning, no one would—or should—be interested in their neighbor Jimmy's opinion that it will be a fine day. For good reasons, a newspaper's weather forecast thus relies on expert assessment and excludes a layman's opinion.

On certain hotly contested issues, there is evidence that the media have systematically over-extended the "balance" frame. For example, the overwhelming majority (more than 95%; Anderegg, Prall, Harold, & Schneider, 2010; Doran & Zimmerman, 2009) of actively publishing climate scientists agree on the fundamental facts that the globe is warming and that this warming is due to human greenhouse gas emissions; yet, the contrarian opinions of non-experts are featured prominently in the media (Boykoff & Boykoff, 2004). A major Australian TV channel recently featured a self-styled "expert" on climate whose diverse qualifications included authorship of a book on cat palmistry (Readfearn, 2011). This asymmetric choice of "experts" leads to the perception of a debate about fundamentals which were in fact resolved in the relevant scientific literature long ago.

Although those systemic problems are shared to varying extents by most media outlets, there is also considerable variation both across time and between outlets. In the U.S., expert voices have repeatedly expressed alarm at the decline in "hard" news coverage since the 1990's and the growth of sensationalist coverage devoid of critical analysis or in-depth investigation (e.g., Bennett, 2003). After the invasion of Iraq in 2003, the American media attracted much critique for their often uncritical endorsement of pre-war claims by the Bush administration about Iraqi WMD (e.g., Artz & Kamalipour, 2004, Kamalipour & Snow, 2004, Rampton & Stauber, 2003, Tiffen, 2009), although there was considerable variation between outlets in the accuracy of their coverage, as revealed by survey research into the persistence of misinformation. Stephen Kull and colleagues (e.g., Kull et al., 2003) have repeatedly shown that the level of misinformation among segments of the public varies dramatically along a continuum of preferred news outlets from Fox (most misinformed on most issues) to National Public Radio (least misinformed overall).

The role of the internet

The internet has revolutionized the availability of information; however, it has also facilitated the spread of *mis*information because conventional "gate-keeping" mechanisms, such as professional editors, have ceased to apply to the internet. This is particularly the case with the development of Web 2.0, where Internet users have moved from passive consumers of information to active creators of content on websites such as Twitter and YouTube.

On the positive side, people who use new media, such as blogs (McCracken, 2011), to source their news, find them fairer, more credible, and more in-depth than traditional sources (T. Johnson & Kaye, 2004). Blog users judged war blogs as more credible sources for news surrounding the conflicts in Iraq and Afghanistan than traditional media (T. Johnson & Kaye, 2010).

On the (potentially) more negative side, information on the internet can be highly misleading, and it is progressively replacing expert advice. For example, people are increasingly sourcing their health care information from social networks. In 2009, 61% of American adults looked online for health information (Fox & Jones, 2009). Relying on the internet as a source of health information is fraught with risk because the reliability of health information on the internet is highly variable. Amongst the worst performers are dietary websites. A survey of the first 50 websites matching the search term "weight loss diets" found only 3 sites that delivered sound dietary advice (Miles, Petrie, & Steel, 2000). Other domains fare more favorably: A survey of English-language websites found that 75% of sites on depression were completely accurate and 86% of obesity websites were at least accurate (Berland et al., 2001).

Online videos are an effective and popular means of disseminating information (and misinformation), with 1.2 billion people viewing online videos in October 2011 (Radwanick, 2011). A survey of 153 YouTube videos matching the search terms 'vaccination' and 'immunization' found that approximately half of the videos were not explicitly supportive of immunization, with information in the negative videos often contradicting official reference material (Keelan, Pavri-Garcia, Tomlinson, & K. Wilson, 2007). A survey of YouTube videos on the H1N1 Influenza Pandemic found that 61.3% of videos had useful information about the disease, whereas 23% were misleading (Pandey, Patni, Singh, Sood, & Singh, 2010).

Finally, there are hoax websites whose sole purpose is to disseminate misinformation. While these can take many forms, including parody, the more dangerous sites pass themselves off as official sources of information. The Martinlutherking.org site (created by a white power organization) disseminates hateful information about Dr. King while pretending to be an official King website (Piper, 2000).

Consequences of increasing media fractionation

Growth of cable TV, talk-back radio, and the internet make it easier for people to find news sources that support their existing views, a phenomenon known as selective exposure (Prior, 2003). When people have more media options to choose from, their choices are more biased towards like-minded media sources. The emergence of the internet in particular has led to a fractionation of the information landscape into "echo chambers"; that is, (political) blogs that primarily link to others of similar persuasion and not to those with opposing viewpoints. Blog readers employ selective exposure to source information from blogs that support their existing views. More than half of blog users seek out

blogs that support their views, whereas only 22% seek out opposing blogs, leading to the creation of "cyber-ghettos" (T. J. Johnson, Bichard, & Zhang, 2009). Those cyber-ghettos, in turn, have been identified as one reason for the increasing polarization of political discourse (McCright, 2011; Stroud, 2010).

One consequence of a fractionated information landscape is the emergence of "strategic extremism" among politicians (Glaeser, Ponzetto, & Shapiro, 2005). Although politicians have traditionally vied for the attention of the political center, extremism can be strategically effective if it picks up more voters at one extreme of the political spectrum than it loses in the center or the opposite end of the spectrum. A precondition for the success—defined as a net gain of voters—of strategic extremism is a fractionated media landscape in which information (or an opinion) can be selectively channeled to people who are likely to support it, without alienating others. The long-term effects of such strategic extremism, however, may well include a pernicious and prolonged persistence of misinformation in large segments of society, especially when such information leaks out of "cyber-ghettos" into the mainstream. This fractionation of the information landscape is important in that, as we show later, worldview plays a major role in determining people's resistance to corrections of misinformation.

This concludes our survey of societal trends and mechanisms, and we now turn to the individual-level cognitive processes that are involved in the acquisition and persistence of misinformation. We provide a brief roadmap for the forthcoming discussion as a list of bullet points:

- We begin by considering how people assess the truth of a statement—what makes people believe certain things but not others?

- Once people have acquired information and believe in it, why do corrections and retractions so often fail? Worse yet, why can attempts at retraction backfire, and entrench belief in misinformation rather than reduce it?

- We next survey the successful techniques by which the impact of misinformation can be reduced.

- In matters of public and political import, people's personal "worldviews" or ideology can play a crucial role in preventing debiasing. We examine how these difficulties arise and whether they can be overcome.

- Finally, we condense our discussion into specific recommendations for practitioners, and we consider some ethical implications and practical limitations of debiasing efforts in general.

Assessing the Truth of a Statement: Recipients' Strategies

Misleading information rarely comes with a warning label. Recipients usually cannot recognize that an item of information is incorrect until they receive a later correction or retraction. For better or worse, the acceptance of information as true is favored by the tacit norms of everyday conversational conduct, where information comes with a "guarantee of relevance" (Sperber & D. Wilson, 1986) and speakers are assumed to be truthful, relevant, and clear (Grice, 1975; Schwarz, 1994, 1996). Some research even suggests that comprehension of a statement requires at least temporary acceptance of its truth (Gilbert, 1991) before it can be checked against relevant evidence. On this view, belief is an inevitable consequence—or indeed precursor—to comprehension.

While suspension of belief is possible (Hasson, Simmons, & Todorov, 2005; Schul, Mayo, & Burnstein, 2008), it seems to require a high degree of attention to the task, considerable implausibility of the message, or high levels of distrust at the time the message is received. So in most situations, the deck is stacked in favor of accepting information rather than rejecting it, provided there are no salient markers that call the speaker's cooperativeness into question. Going beyond this default of acceptance requires additional motivation and cognitive resources, so if the topic is not very important to you or you have other things on your mind, misinformation will likely slip in.

When people do thoughtfully evaluate the truth value of information, they are likely to attend to a limited set of features. First, is this information compatible with other things I believe to be true? Second, is this information internally coherent? Do the pieces form a plausible story? Third, does it come from a credible source? Fourth, do others believe it? These questions can be answered on the basis of declarative or experiential information; that is, by drawing on one's knowledge or by relying on one's subjective experience of fluency and familiarity (Schwarz, 2004; Schwarz, Sanna, Skurnik, & Yoon, 2007). We now turn to these questions and illustrate the rationale with select findings.

Is it compatible with what I believe?

As numerous studies in the social judgment and persuasion literature have shown, information is more likely to be accepted when it is consistent with other things the person assumes to be true (for reviews, see McGuire, 1972; Wyer, 1974). This check assesses the logical compatibility of the information with other facts and beliefs. Once a new piece of knowledge-consistent information has been accepted, it is highly resistant to change, especially when there is a larger, consistent knowledge base. From a judgment perspective, this resistance derives from the large amount of supporting evidence (Wyer, 1974); from a cognitive consistency perspective (Festinger, 1957), it derives from the

numerous downstream inconsistencies that would arise from rejecting the prior information as false. Accordingly, compatibility with other knowledge increases the likelihood that misleading information is accepted, and decreases the likelihood that its impact can be successfully corrected.

Whether a given piece of information is compatible with one's knowledge can be assessed in an analytic fashion by checking the information against other knowledge. This is effortful, and requires motivation and cognitive resources. A less demanding indicator is provided by one's metacognitive experience and affective response. Information that is inconsistent with one's beliefs elicits negative feelings (Festinger, 1957), an assumption shared by many theories of cognitive consistency. Messages that are inconsistent with one's beliefs are also processed less fluently than messages that are consistent with one's beliefs (Winkielman, Huber, Kavanagh, & Schwarz, 2012). In general, fluently processed information feels more familiar and is more likely to be accepted as true; conversely, disfluency elicits the impression that something doesn't quite "feel right" and prompts closer scrutiny of the message (Schwarz et al., 2007; Song & Schwarz, 2008). This is observed even when the fluency experience merely results from superficial characteristics of message presentation. For example, the same statement is more likely to be judged true when it is printed in high rather than low color contrast (Reber & Schwarz, 1999), presented in a rhyming rather than non-rhyming form (McGlone & Tofighbakhsh, 2000), or delivered in a familiar rather than unfamiliar accent (Levy-Ari & Keysar, 2010). Moreover, misleading questions are more likely to be recognized as such when they are printed in a difficult-to-read rather than easy-to-read print font (Song & Schwarz, 2008).

As a result, analytic as well as intuitive processing favors the acceptance of messages that are compatible with a recipient's pre-existing beliefs: there are no elements that contradict other things one knows and the message is easy to process and "feels right".

Is it a coherent story?

Whether a given piece of information will be accepted as true also depends on how well it fits a broader story that lends sense and coherence to individual elements. This assessment strategy is particularly likely when the meaning of one piece of information cannot be assessed in isolation because it depends on other, related pieces; the strategy has been observed in basic research on mental models (for a review, see Johnson-Laird, 2012) as well as extensive analyses of jury decision making (Pennington & Hastie, 1992, 1993).

A story is compelling to the extent that it organizes the available information without internal contradictions in a way that is compatible with common assumptions about human motivation and

behavior. Good stories are well remembered and gaps are filled with story-consistent intrusions. Once a coherent story has been formed, it is highly resistant to change; within the story, each element is supported by the fit of other elements, and any alteration of an element causes downstream inconsistencies that may render the alteration implausible.

Coherent stories are easier to process than incoherent stories (Johnson-Laird, 2012). Hence, ease of processing can serve as an (imperfect) indicator of coherence, and people draw on their processing experience in making coherence judgments (Topolinski, 2012).

Is it a credible source?

When people lack the motivation, opportunity, or expertise to process a message in sufficient detail, they can resort to an assessment of the credibility of the communicator. Not surprisingly, the persuasiveness of messages increases with the communicator's perceived credibility and expertise (for reviews, see Eagly & Chaiken, 1993; Petty & Cacioppo, 1986). However, even untrustworthy sources are often influential. Several factors contribute to this observation. First, people are often insensitive to contextual cues that bear on the credibility of a source. For example, expert testimony has been found to be similarly persuasive when provided under oath than when provided in another context (Nyhan, 2011). Similarly, Cho, Martens, Kim and Rodrigue (2011) found that messages that denied climate change were similarly influential when recipients were told that the study was "Funded by Exxon" vs. "Funded from donations by people like you." Such findings suggest that situational variations in likely credibility may often go unnoticed, consistent with the common focus on features of the actor rather than the situation (Ross, 1977). Second, the gist of a message is often more memorable than its source and engaging stories from untrustworthy sources may be remembered and accepted long after the source has been forgotten (for a review of such "sleeper effects", see Eagly & Chaiken, 1993).

People's evaluation of the credibility of a source can be based on declarative information, as in the above examples, as well as experiential information. Mere repetition of a name can make an unknown name seem familiar, making its bearer "famous overnight" (Jacoby, Kelley, Brown, & Jaseschko, 1989)—and hence more credible. Even when a message has been rejected at the time of initial exposure, it may gain some familiarity-based credibility later on when one hears it again.

Do others believe it?

Repeated exposure to a statement is known to increase its acceptance as true (e.g., Begg, Anas, & Farinacci, 1992; Hasher, Goldstein, & Toppino, 1977). In a classic study of rumor transmission, Allport and Lepkin (1945) observed that the strongest predictor of belief in wartime rumors was simple

repetition. Repetition effects may create a perceived social consensus even when it does not exist. Festinger (1954) referred to social consensus as a "secondary reality test": if many people believe it, there's probably something to it. Because one is more frequently exposed to widely shared beliefs than to highly idiosyncratic ones, the familiarity of a belief is often a valid indicator of social consensus. But, unfortunately, information can seem familiar for the wrong reason, leading to erroneous perceptions of high consensus. For example, Weaver, Garcia, Schwarz and Miller (2007) exposed participants to multiple iterations of the same statement, provided by the same communicator. When later asked to estimate how widely the conveyed belief is shared, participants estimated higher consensus the more often they had read the identical statement coming from the same single source. In a very real sense, a single repetitive voice can sound like a chorus.

Social consensus information is particularly powerful when it pertains to one's reference group (for a review, see Krech, Crutchfield, & Ballachey, 1962). As already noted, this renders repetition in the echo chambers of social media networks particularly influential. One possible consequence of such repetition is "pluralistic ignorance," a phenomenon that refers to a divergence between the prevalence of actual beliefs in a society and what people in that society think others believe. For example, in the lead-up to the invasion of Iraq in 2003, voices that advocated unilateral military action were given prominence in the American media, thus causing the large *majority* of people who actually wanted the U.S. to engage *multi*laterally, in concert with other nations, to feel that they were in the minority (Leviston & Walker, 2011; Todorov & Mandisodza, 2004). Conversely, the actual minority of people who advocated unilateral action incorrectly felt that they were in the majority.

The extent of pluralistic ignorance can be quite striking: In Australia, people with particularly negative attitudes towards Aboriginals or asylum-seekers have been found to over-estimate support for their attitudes by 67% and 80%, respectively (Pedersen, Griffiths, & Watt, 2008). Specifically, although only 1.8% of people in the sample were found to hold strongly negative attitudes towards Aboriginal Australians, those few individuals thought that 69% of all Australians (and 79% of their friends) shared their fringe beliefs. Perceived social consensus can thus serve to solidify and maintain belief in misinformation. But how do the processes just reviewed affect our ability to correct misinformation? From the perspective of truth assessment, corrections involve a competition between the perceived truth value of misinformation and correct information. In the ideal case, corrections undermine the perceived truth of misinformation and enhance the acceptance of correct information. But as we discuss in the next section, corrections often fail to work as expected. It is the failure of such corrections, known

as the *continued influence effect* (H. M. Johnson & Seifert, 1994) that constitutes the central conundrum of misinformation research.

The Continued Influence Effect:

Retractions Fail to Eliminate the Influence of Misinformation

We first consider the cognitive parameters of credible retractions in neutral scenarios, where people have no inherent reason or motivation to believe one version of events over the other. This research was stimulated by a paradigm pioneered by Wilkes and Leatherbarrow (1988), and H. M. Johnson and Seifert (1994). People are presented with a fictitious report about an event unfolding over time containing a target piece of information. For some readers, the target information is subsequently retracted, while in a control condition, no correction occurs. People's understanding of the event is then assessed with a questionnaire, and the number of clear and uncontroverted references to the target (mis-)information is tallied.

A common stimulus narrative in the literature involves a warehouse fire that is initially thought to have been caused by gas cylinders and oil paints that were negligently stored in a closet (e.g., Ecker, Lewandowsky, Swire, & Chang, 2011; H. M. Johnson & Seifert, 1994; Wilkes & Leatherbarrow, 1988). Some readers then see a retraction, such as "the closet was actually empty." On a subsequent comprehension test, the number of references to the gas and paint is counted in response to indirect inference questions about the event (e.g., "What caused the black smoke?"). In addition, people are asked to recall some basic facts about the event, and to indicate whether they noticed any retraction.

This research has consistently found that retractions rarely, if ever, have the intended effect of eliminating reliance on misinformation even when people believe, understand, and later remember the retraction (e.g., Ecker, Lewandowsky, & Apai, 2011; Ecker, Lewandowsky, Swire, et al. 2011; Ecker, Lewandowsky, & Tang, 2010; Fein, McCloskey, & Tomlinson, 1997; Gilbert, Krull, & Malone, 1990; Gilbert, Tafarodi, & Malone, 1993; H. M. Johnson & Seifert, 1994, 1998, 1999; Schul & Mazursky, 1990; van Oostendorp, 1996; van Oostendorp & Bonebakker, 1999; Wilkes & Leatherbarrow, 1988; Wilkes & Reynolds, 1999). In fact, a retraction will at most halve the number of references to misinformation found in a no-retraction control condition (Ecker, Lewandowsky, & Apai, 2011; Ecker, Lewandowsky, Swire, et al., 2011), while in some studies, a retraction did not reduce reliance on misinformation at all (e.g., H. M. Johnson & Seifert, 1994). Because people acknowledge and remember the retraction and yet continue to rely on misinformation in their reasoning, the continued influence effect is a matter of considerable relevance to the public interest.

When misinformation is presented through media sources, the remedy is the presentation of a correction of fact, often available in an unconnected format (such as a column in a subsequent newspaper edition). In these laboratory studies of correction, the misinformation is retracted, in some cases, immediately, and within the same narrative (H. M. Johnson & Seifert, 1994). Despite their temporal and contextual proximity, retractions are ineffective. Subsequent studies (Seifert, 2002) examined whether clarifying the correction (minimizing misunderstanding) might reduce the continued influence. The correction was thus strengthened to include the phrase "paint and gas were never on the premises." The results showed that the enhanced negation of the presence of flammable materials backfired, making people even *more* likely to use the misinformation in their responses. Other additions to the correction were found to mitigate, but not remove, the continued influence effect: For example, when given a rationale for how the misinformation originated, such as, "a truckers' strike prevented the expected delivery of the items," people were somewhat less likely to make reference to it. Even so, continued influence of the misinformation could still be detected. The wealth of studies on this phenomenon document its pervasive effects, showing that it is extremely difficult to return those participants who hear misinformation to a baseline similar to those never exposed to it. Multiple explanations have been proposed for the continued influence effect, and we summarize their key assumptions next.

Mental models

One explanation assumes that people build mental models of unfolding events (H. M. Johnson & Seifert, 1994; van Oostendorp & Bonebakker, 1999; Wilkes & Leatherbarrow, 1988). On this view, factor A (e.g., negligence) led to factor B (e.g., improper storage of flammable materials) and factor B in conjunction with factor C (e.g., an electric fault) caused outcome X (e.g., the fire) to happen. If a retraction then invalidates a central piece of information—for example, factor B, the presence of gas and paint—then people are left with a gap in their model of the event. Recipients are left with an event representation that just "doesn't make sense" unless they maintain the false assertion. Thus, when questioned about the event, a person may still respond using the retracted misinformation (e.g., "What caused the explosions?" — "The gas cylinders."), despite being aware of the correction when asked directly. In support of the mental-model notion, misinformation becomes particularly resilient to correction if participants are asked to generate an explanation for why the misinformation might be true (Anderson, Lepper, & Ross, 1980). It is also known from the false memory literature that people tend to

fill gaps in episodic memory with inaccurate but "fitting" information if readily available from event schemata (Gerrie, Belcher, & Garry, 2006).

Nevertheless, why a discredited mental model continues to be used *despite* explicit correction remains poorly understood. On the one hand, people may be uncomfortable with gaps in their event knowledge, and hence prefer an incorrect model over an incomplete model (Ecker et al., 2010; Ecker, Lewandowsky, & Apai, 2011; H. M. Johnson & Seifert, 1994; van Oostendorp & Bonebakker, 1999). Having a plausible answer to a question readily available, but at the same time knowing that it is wrong, may generate a state of conflict that is most easily resolved by sticking to the original idea and ignoring the retraction. On the other hand, deliberate assessments of truth may be most likely when people are directly asked about it. Absent direct questions, people may rely on their metacognitive experience of fluency to monitor the plausibility of their thoughts, giving well formed coherent models an advantage—as long as thoughts flow smoothly, people may see little reason to question their veracity (Schwarz et al., 2007).

Retrieval failure

A second type of explanation for the continued influence of misinformation is the failure of controlled memory processes. First, misinformation effects could be based on source confusion or misattribution (M. K. Johnson, Hashtroudi, & Lindsay, 1993). People may correctly recollect a specific detail (e.g., it was assumed the fire was caused by oil and paints), but incorrectly attribute this information to the wrong source. For example, people could falsely recollect that this information was contained in the final police report rather than an initial report subsequently retracted.

Second, misinformation effects could be due to a failure of strategic monitoring processes (Moscovitch & Melo, 1997). Ayers and Reder (1998) argued that both valid and invalid memory entries compete for automatic activation, but that contextual integration requires strategic processing. In other words, it is reasonable to assume that a piece of misinformation that supplies a plausible account of an event will be activated by the questions. A strategic monitoring process is then required to determine the validity of this automatically retrieved piece of information. This may be the same monitoring process involved in source attribution, when one has to decide whether a memory is valid and put into the correct context, or whether it was received from a reliable source (Henkel & Mattson, 2011).

Third, there is some evidence that the processing of retractions can be likened to attaching a "negation tag" to a memory entry (e.g., "there were oil paints and gas cylinders—NOT"; Gilbert et al., 1990; H. M. Johnson & Seifert, 1998). Johnson and Seifert (1998) showed that automatic memory

activation of misinformation continues whenever it is referred to even after a clear correction. For example, after reading, "John played hockey for New York. Actually, he played for Boston," reading "the team" resulted in both cities becoming active in memory. The "negation" tag on the information can be lost, especially under conditions of impaired strategic memory processing such as old age (E. Wilson & Park, 2008) or processing under cognitive load (Gilbert et al., 1990), thereby leaving only the misinformation behind. From this perspective, negations should be more successful when they can be encoded as an affirmation of an alternate attribute (Mayo, Schul, & Burnstein, 2004). Mayo and colleagues (2004) observed support for this possibility in the domain of person perception. For example, the information that Jim is "not messy" allows an affirmative encoding in terms of "Jim is tidy", the polar opposite of the bipolar trait "messy"; in contrast, learning that Jim is "not charismatic" does not offer an alternative encoding, due to the unipolar nature of the trait. Accordingly, people were more likely to misremember unipolar traits (e.g., remembering "not charismatic" as "charismatic") than bipolar traits (e.g., "not messy" was rarely misremembered as "messy", presumably because "not messy" was recoded as "tidy" upon encoding).

Fluency and familiarity

Whereas the preceding accounts focus on whether people are more likely to recall the misinformation or its correction, a fluency approach focuses on the experience of processing the respective information at a later re-exposure (Schwarz et al., 2007). From this perspective, misinformation can exert an influence even when it is not explicitly recollected by increasing the perceived familiarity and coherence of related material encountered at a later point in time. As a result, retractions may fail, or even backfire (i.e., entrench the initial information), when they directly or indirectly repeat false information in order to correct it, thus further enhancing its familiarity.

For example, explaining that there were *no* oil paints and gas cylinders requires the repetition of the idea that "paints and gas were present." Generally, repetition of information strengthens that information and leads to stronger belief simply because repeated information seems more familiar, or because repeated information is associated with different contexts which can serve as later retrieval cues (Allport & Lepkin, 1945; Eakin, Schreiber, & Sergent-Marshall, 2003; Ecker, Lewandowsky, Swire, et al. 2011; Henkel & Mattson, 2011; Mitchell & Zaragoza, 1996; Schul & Mazursky, 1990; Verkoeijen, Rikers, & Schmidt, 2004; Zaragoza & Mitchell, 1996). It follows that when people later re-encounter the misinformation ("oil paints and gas cylinders"), it may be more familiar than it would have been without the retraction. This has been demonstrated in studies where professionals considered hypothetical

outcomes before making judgments (Kadous, Krische, & Sedor, 2006): The sense of familiarity and ease of retrieval of information, even though hypothetical, in turn increased acceptance of it: "I think I heard that before, so there's probably something to it." Thus, because retractions repeat the misinformation, they may backfire by increasing familiarity and fluency of processing of the misinformation (Schwarz et al., 2007; Sanna, Schwarz, & Stocker, 2002).

Such fluency-based effects (Reber & Schwarz, 1999) occur when the misinformation is re-encountered; unfortunately, this impairs the effectiveness of public information campaigns intended to correct misinformation. A common format of such campaigns is a "myth vs. fact" approach that juxtaposes a given piece of false information with a pertinent fact. For example, the U.S. Center for Disease Control offers patient hand-outs that counter an erroneous health belief (e.g., "The side-effects of flu vaccination are worse than the flu") with relevant facts (e.g., "side-effects are rare and mild"). When recipients are tested immediately after reading such hand-outs, they correctly identify myths and facts, and report behavioral intentions that are consistent with the information provided (e.g., an intention to get vaccinated).

However, a short delay is sufficient to reverse this effect: After a mere 30 minutes, readers of the hand-outs identify more "myths" as "facts" than people who never received a hand-out to begin with (Schwarz et al., 2007). Moreover, people's behavioral intentions are consistent with this confusion, and they report lower vaccination intentions than people who were not exposed to the hand-out. Because recollective memory shows more age-related impairment than familiarity-based memory (Jacoby, 1999), older adults (and potentially children) are particularly vulnerable to these backfire effects because they are particularly likely to forget the details of a retraction and retain only a sense of familiarity (Bastin & Van Der Linden, 2005; Holliday, 2003; Jacoby, 1999). Hence, they are more likely to accept a statement as true after exposure to explicit messages that it is false (Skurnik, Yoon, Park, & Schwarz, 2005; E. Wilson & Park, 2008).

A similar effect has recently been reported in the very different field of corporate event sponsorship. While some companies spend large amounts of money to be officially associated with a certain event, such as the Olympic Games, other companies try to create the impression of official affiliation without any sponsorship (and hence without expenditure on their part), a strategy known as "ambushing." Not only is this strategy successful in associating a brand with an event, but attempts to publically expose a company's ambushing attempt (i.e., "counter-ambushing") may lead people to remember the feigned brand-to-event association even better (Humphreys, Cornwall, McAlister, Kelly, Quinn, & Murray, 2010).

Reactance

Finally, retractions can be ineffective because of social reactance (Brehm & Brehm, 1981). People generally do not like to be told what to think and how to act, so particularly authoritative retractions may be rejected. For this reason, misinformation effects have received considerable research attention in a courtroom setting where mock jurors are presented with a piece of evidence that is later ruled inadmissible. When jurors are asked to disregard the tainted evidence, they show *higher* conviction rates when an "inadmissible" ruling was accompanied by a judge's extensive legal explanations than when the inadmissibility was left unexplained (Pickel, 1995, Wolf & Montgomery, 1977). For a review of the literature on how jurors process inadmissible evidence, see Lieberman and Arndt (2000).

Reducing the Impact of Misinformation

We have seen that simply retracting a piece of information will not stop its influence. A number of other techniques have been explored to enhance the effectiveness of retractions, but many of those have failed. Examples include enhancing the clarity of the retraction (Seifert, 2002; van Oostendorp, 1996), or giving the retraction immediately after the misinformation rather than later to avoid further inferences using the initial misinformation before correction (H. M. Johnson & Seifert, 1994; Wilkes & Reynolds, 1999).

Only three factors have been identified to date that can increase the effectiveness of retractions; namely, warnings at the time of the initial exposure to misinformation, repetition of the retraction, and corrections that tell an alternative story that fills the coherence gap otherwise left by the retraction.

Pre-exposure warnings

Misinformation effects can be reduced if people are explicitly warned up front that information they are about to be given may be misleading (Chambers & Zaragoza, 2001; Ecker et al., 2010; Jou & Foreman, 2007; Schul, 1993). Ecker et al. (2010) found, however, that the warning needs to specifically explain the ongoing effects of misinformation, rather than just generally mention its potential presence (as in Marsh and Fazio, 2006). This result has obvious application: In any situation where people are likely to encounter misinformation—for example, in advertising, in fiction that incorporates historical or pseudoscientific information, or in court settings where jurors often hear information they are later asked to disregard—warnings could be given routinely to help reduce reliance on misinformation.

Warnings seem to be more effective when administered before the misinformation is encoded (Chambers & Zaragoza, 2001; Ecker et al., 2010; Schul, 1993). This can be understood within Gricean maxims (Grice, 1975) about communication: People by default expect presented information to be valid, and an a priori warning can potentially change that expectation. This allows recipients to monitor the encoded input and "tag" it as "suspect." In support, Schul (1993) found that people took longer to process misinformation they had been warned about, suggesting that rather than quickly dismissing false information, people took care to consider the misinformation within an alternative mental model. Warnings may therefore induce a temporary state of skepticism, which may work to maximize people's discrimination between true and false information. Later, we return to the issue of skepticism and show how it can facilitate detection of misinformation.

The fact that warnings are still somewhat effective *after* misinformation is encoded supports a dual process view of misinformation retrieval, where a strategic monitoring process can be used to assess the validity of automatically retrieved pieces of misinformation (Ecker et al., 2010). Because this monitoring requires effort and cognitive resources, warnings may be effective in suggesting the need to be vigilant.

Repeated retractions

The success of retractions can also be enhanced if they are repeated or otherwise strengthened (Ecker, Lewandowsky, Swire, et al., 2011). In this study, if misinformation was encoded repeatedly, repeating the retraction helped alleviate (but not eliminate) misinformation effects. However, misinformation encoded only once persisted to the same extent given one or three retractions. This means that even after only weak encoding, misinformation effects are extremely hard to eliminate or drive below a certain level of "irreducible persistence," irrespective of the strength of the retraction.

There are a number of reasons why this could be the case: First, some misinformation impact may arise from automatic processing, which can only be counteracted by strategic control processes to the extent that a person is aware of the automatic misinformation influence on their reasoning (cf. T. Wilson & Brekke, 1994). Second, misinformation inferences are based on sampled memory representations of misinformation, where each representation may be offset (thereby reducing but not eliminating its impact) by only one retraction. Once a memory token has been associated with a "retracted" marker, further retractions do not strengthen that marker—thus, repeated retractions do not further reduce reliance on weakly-encoded misinformation because weak encoding means only a single representation is created, whereas the multiple representations that arise with strong encoding

can benefit from strong (i.e., multiple) retractions. For a computational implementation of this sampling model, see Ecker, Lewandowsky, Swire, et al. (2011). Finally, repetition of corrections may ironically decrease their effectiveness. On the one hand, some evidence suggests a "protest too much" effect, where overexerting a correction may lead to less confidence in its veracity (Bush, H. Johnson, & Seifert, 1994). On the other hand, as noted above, in some circumstances corrections may paradoxically enhance the impact of misinformation because the misinformation is repeated in the retraction (e.g., Schwarz et al., 2007).

Whatever the underlying cognitive mechanism, the findings of Ecker, Lewandowsky, Swire et al. (2011) suggest that the repetition of the initial misinformation has a stronger and more reliable (negative) effect than the repetition of its retraction. This asymmetry in repetition effects is particularly unfortunate for social networking media, where information is disseminated quickly, widely, and without much fact-checking, and taken only from sources consonant with people's own worldviews.

Filling the gap—providing an alternative account

We noted earlier that retractions can cause a coherence gap in the recipient's understanding of an event. Given that internal coherence plays a key role in truth assessments (Johnson-Laird, 2012; Pennington & Hastie, 1993), the resulting gap may motivate the use of the misinformation in spite of the retraction—"it wasn't the oil and gas, but what else could it be?" Providing an alternative explanation of the event can fill the gap left behind by retracting misinformation. Studies show the continued influence of misinformation can be eliminated by provision of an alternative that explains *why* the misinformation was incorrect (e.g., "There were no gas cylinders and oil paints but arson materials have been found"; "The initial suspect may not be guilty as there is an alternative suspect"; H. M. Johnson & Seifert, 1994; Tenney, Cleary, & Spellman, 2009).

To successfully replace the misinformation, the alternative explanation provided in the correction must be plausible, account for the important qualities in the initial report, and ideally, explain why the misinformation was thought to be correct in the first place (e.g., Rapp & Kendeou, 2007; Schul & Mazursky, 1990; Seifert, 2002). For example, explaining that the suspected WMD sites in Iraq were actually grain silos would not explain why the initial report occurred, and this alternative might therefore be ineffective. An alternative that "causally covers" the bases of the initial report will be more compelling; for example, by noting that the suspected WMD site was actually a chemical factory (cf. H. M. Johnson & Seifert, 1994). Acceptance of a correction can also be improved by accounting for why the

initial incorrect information was offered; for example, by stating that WMD's had been present in Iraq, but were destroyed before 2003.

Corrections can be particularly successful if they explain the motivation behind an incorrect report. For example one might argue that the initial reports of WMD facilitated the U.S. government's intention to invade Iraq, so the misinformation was offered without sufficient evidence (they were "trigger-happy"; cf. Lewandowsky, Stritzke, Oberauer, & Morales, 2005, 2009). Drawing attention to the motivation of a specific source can undermine the impact of misinformation. For example, Governor Ronald Reagan defused President Carter's attack on his Medicare policies in a 1980 U.S. presidential candidate debate by stating, "There you go again!"—by referring to information to be "as expected" from a given source, it is discredited (Cialdini, 2001).

There are some boundary conditions of the alternative-account technique. The mere mention, or self-generation, of alternative ideas is insufficient to reduce reliance on misinformation (H. M. Johnson & Seifert, 1994, 1999; Seifert, 2002). That is, the alternative must be integrated into the remaining information.

Also, people generally prefer simple explanations over overly complex explanations (Chater & Vitanyi, 2003; Lombrozo, 2006, 2007). When misinformation is corrected by offering an alternative, but much more complex explanation, people may reject it in favor of a simpler account that maintains the misinformation. Hence, providing too many counter-arguments, or asking people to generate many counterarguments, can potentially backfire (Schwarz et al., 2007). This "overkill" backfire effect can be avoided by asking people to generate only a few counterarguments to why their belief may be wrong, in which case the self-generation can assist debiasing (Sanna & Schwarz, 2006). Moreover, suspicion about the rationale behind the correction, as well as for the initial presentation of the misinformation, may be particularly important in political corrections; that is, specific motivations likely lie behind a politician's explanation for events, so people may place more suspicion on alternative explanations from some sources.

In summary, reducing the continued influence of misinformation can be achieved by three established techniques: People can be warned about the potentially misleading nature of forthcoming information before it is presented; the corrections can be repeated to strengthen their efficacy; and the correction can be accompanied by an alternative explanation for the event, thus preventing the occurrence of a causal gap in the account. The latter technique is particularly effective; however, it is not always applicable because an alternative explanation may not be available when an initial report is found to be in error. Moreover, although those techniques have been shown to be successful with

neutral information (e.g., involving a fictitious warehouse scenario), further complications arise when corrections of misinformation challenge the recipients' worldview more broadly, as will be discussed next.

Corrections in the Face of Existing Belief Systems: Worldview and Skepticism

The characteristics of the recipient play an important role in determining whether misinformation continues to exert an influence. Here we address two such characteristics, namely a person's worldview and level of skepticism, that exert opposing effects on the efficacy of a correction.

Worldview

Given that statements consistent with our beliefs are more readily accepted, it is not surprising that people's worldview, or personal "ideology," plays a key role in the persistence of misinformation. For example, Republicans are more likely than Democrats to continue to believe the "birthers" and to accept WMD-related claims despite retractions (Travis, 2010; Kull et al., 2003). At the opposite end of the political spectrum, liberals are less well calibrated than conservatives when it comes to judging risks regarding the consequences of higher oil prices. In particular, while experts foresee considerable future risks to human health and society arising from "peak oil" (Schwartz, Parker, Hess, & Frumkin, 2011), liberals are less likely than conservatives to recognize the magnitude of those risks (Nisbet, Maibach, & Leiserowitz, 2011).[2]

From this real-world survey research, we know that pre-existing attitudes often determine the level of belief in misinformation after it has been retracted. What is less well understood is whether (1) retractions fail to lower reliance on misinformation specifically in those people for whom the retraction violates personal belief, or whether (2) retractions are equally effective in all people, and the observed post-retraction differences just mirror pre-retraction differences. Both possibilities are consistent with our earlier discussion of truth assessments. Retractions that contradict one's worldview are inconsistent with other beliefs, less familiar, more difficult to process, less coherent, less supported in one's social network, and viewed as coming from an untrustworthy source. All of these factors may undermine a retraction's apparent truth value if it challenges one's belief system. Conversely, misinformation consistent with one's worldview fits with other beliefs, and is therefore more familiar, easy to process,

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[2] There is ongoing debate whether the effects of worldview during information processing are more prevalent among conservatives than liberals (e.g., Greenberg & Jonas, 2003; Jost, Glaser, Kruglanski, & Sulloway, 2003b, 2003a). This debate is informative and important but not directly relevant in this context. We are concerned with the existence of worldview-bound effects on information processing irrespective of their partisan origin, as misinformation effects are generic.

coherent, socially supported within one's network, and from a trusted source. Accordingly, worldview differences in the effectiveness of retractions may reflect either the differential appeal of the misinformation, the retraction, or both. The evidence concerning these distinctions is sparse and mixed.

One study presented people high and low in racial prejudice with a narrative of a robbery involving an indigenous Australian as either the suspect or a hero preventing the crime (Ecker, Lewandowsky, Fenton, & Martin, 2012). People's references to the racial information covaried with their racial attitude; that is, if they were prejudiced, they mentioned the indigenous suspect more often and the indigenous hero less often. However, this effect was found both with and without a retraction, and hence the retraction was equally effective in low- and high-prejudice participants. Similarly, in a study in which a fictitious plane crash was initially attributed to a terrorist bomb before later investigation revealed a faulty fuel tank, people high in islamophobia mentioned terrorism-related material more often than their counterparts who scored lower in islamophobia, but a retraction was equally effective for both groups of people (unpublished analysis of Ecker, Lewandowsky, & Apai, 2011).

In contrast to those findings, there are other reports of worldviews affecting how people process corrective messages. In one study, retractions of non-fictitious misperceptions (e.g., the mistaken belief that President Bush's tax cuts of the early 2000s had increased revenues; that there were WMD's in Iraq, etc.) were effective only in people for whom the retraction supported their political orientation (Nyhan & Reifler, 2010). When the corrections were worldview-dissonant (in this instance, for Republican participants), a "backfire" effect was observed, and people became further entrenched and *more* committed to the misinformation. Hart and Nisbet (2011) reported a similar backfire effect using stimuli related to climate change. In their study, people saw messages highlighting the adverse effects on health from climate change. Compared to a control group, Democrats were found to increase their support for climate mitigation policies, whereas support declined among Republicans.

The long reach and sway that people's worldview holds over their perceptions and cognitions can be illustrated by considering some other instances of polarization. Gollust, Lantz, and Ubel (2009) showed that even public-health messages can have a similarly polarizing effect along party lines: When people were presented with evidence that Type 2 diabetes can be caused by social circumstances (e.g., scarcity of healthy food combined with abundance of junk food in poor neighborhoods), subsequent endorsement of potential policy options (e.g., banning fast food concessions in public schools) was found to decline among Republicans, but increase among Democrats in comparison to a control group which did not receive any information about the causes of diabetes. Berinsky (2012) reported similar

polarizing effects in experiments in which the "death panel" myth surrounding President Obama's health plan was rebutted.

The role of "worldview" may not be limited to political issues: When people with high "brand connection" were provided with negative information about their favorite brand, they reported a lowered self-esteem while retaining their positive brand image, whereas those with low personal connection to brands remained unchanged in self esteem (Cheng, White, & Chaplin, 2011).

What are the boundary conditions for one's worldview to affect corrections? The study by Ecker, Lewandowsky, Fenton, and Martin (2012) presented fictitious episodes that contained attitude-relevant information, whereas the studies just discussed involved real-world events where people likely had pre-existing opinions associated with actual politicians (Nyhan & Reifler, 2010). We therefore suggest that worldview affects the effectiveness of a retraction when the misinformation is a real-world "event" that relates to pre-existing beliefs (e.g., it is harder to accept that the report of WMD in Iraq was false if one supported the 2003 invasion). In confirmation, the political-science literature also contains reports of people being sensitive to factual or corrective information on issues that are arguably less salient and emotive (Barabas & Jerit, 2009; Blais et al., 2010; Gaines, Kuklinski, Quirk, Peyton, & Verkuilen, 2007; for a review of that literature see Nyhan & Reifler, 2012). Those findings suggest that not all political issues necessarily lead to polarization.

Making things worse: Backfire effects

From a societal view, misinformation is particularly damaging if it concerns complex real-world issues such as climate change, tax policies, or the decision to go to war. The preceding discussion suggests that in those real-world scenarios, people will refer more to misinformation that is in line with their attitudes *and* will be relatively immune to corrections, with retractions potentially even backfiring and strengthening the initially-held beliefs (Nyhan & Reifler, 2010). This backfire effect has been attributed to people implicitly "counter-arguing" against any information that challenges their worldview. Using a "challenge interview" technique, Prasad et al. (2009) illuminated this "counter-arguing" process particularly strikingly by asking participants to respond aloud to information that was debunking previously-held beliefs. Participants either came up with counterarguments or simply remained unmovable (e.g., "but I guess we still can have our opinions and feel that way even though they say that"). Those findings mesh well with the work on "motivated skepticism" by Taber and Lodge (2006), which shows similar effects with political arguments (as opposed to facts). In their study, people uncritically accepted arguments for their own position, but were highly skeptical of opposing

arguments, and were actively counter-arguing to deride or invalidate the information (as revealed through protocol analysis).

Such backfire effects, also known as "boomerang" effects, are not limited to the correction of misinformation but characterize other areas of communication—such as persuasive health messages—as well (for a review, see Byrne & Hart, 2009). In other areas of research, backfire effects have been linked to people not only rejecting the message at hand, but also becoming predisposed to reject any future messages from that particular source (Brehm & Brehm, 1981). Although we are not aware of any examinations of such generalizations of distrust in the context of corrections of misinformation, their potential existence must give rise to concern.

A phenomenon that is closely related to the backfire effects arising with worldview-dissonant corrections involves belief polarization. Belief polarization is said to occur if presentation of the same information elicits further divergence between the attitudes of people with opposing views on an issue (Lord, Ross, & Lepper, 1979). For example, when both religious believers and non-believers were exposed to a fictitious report disproving the Biblical account of the Resurrection, belief increased among believers, whereas non-believers became more skeptical (Batson, 1975). In the present context, the increasing belief among believers is isomorphic to the worldview-related backfire effect observed with corrective information, as reviewed earlier.

In another instance, supporters and opponents of nuclear power reacted in opposite fashion to identical descriptions of technological breakdowns—whereas supporters focus on the fact that the safeguards worked to prevent a worse accident, opponents focused on the fact that the breakdown occurred in the first place (Plous, 1991). Not unexpectedly, techniques to reduce belief polarization are therefore very similar to techniques with which worldview-related resistance to correction of misinformation can be overcome.

Feelings of affiliation with a source are also a likely factor influencing whether or not one accepts a piece of information at face value. For example, Berinsky (2012) found that among Republicans, corrections of the "death panel" myth were effective primarily when issued by a Republican politician. However, judgments of source credibility are themselves a function of beliefs: If you believe a statement, you judge its source as more credible (Fragale & Heath, 2004). This interaction between belief and credibility can lead to an epistemic circularity whereby no opposing information is ever judged sufficiently credible to overturn dearly-held prior knowledge. For example, Munro (2010) has shown that belief-threatening scientific evidence can lead to the discounting of the scientific method itself—people will rather believe that an issue cannot be resolved scientifically, thus discounting

the evidence, than accept the scientific evidence that is in opposition to their beliefs. Indeed, even increasing levels of education do not protect against the effects of worldview-based rejection of information; for example, Hamilton (2011) showed that increasing education made it more likely that Democrats would view global warming as a threat, whereas the reverse was true for Republicans. This constitutes an extreme case of belief polarization (see also Malka, Krosnick, & Langer, 2009; McCright & Dunlap, 2011). Similarly, among Republicans, greater education was associated with a greater increase in their belief that President Obama was a Muslim (he is not) between 2009 and 2010 (Sides, 2010). Among Democrats, few held this mistaken belief, and education did not serve as a moderator.

In summary, personal beliefs can facilitate the acquisition of attitude-consonant misinformation, increase reliance on misinformation, and inoculate against correction of false beliefs (Ecker, Lewandowsky, Fenton, & Martin, 2011; Kull et al., 2003; Lewandowsky et al., 2005, 2009; Nyhan & Reifler, 2010; Pedersen, Clarke, Dudgeon, & Griffiths, 2005; Pedersen, Attwell, & Heveli, 2007). Interestingly, the extent to which material is emotive does not appear to affect its persistence in memory after correction (Ecker, Lewandowsky, & Apai, 2011). For example, after a retraction, people will continue to refer to a terrorist attack as the cause of a plane crash just as much as they will refer to bad weather or a technical fault, even when they are demonstrably emotionally affected more by the former than by the latter. Thus, people do not simply cling to the most emotional "variant" of an event. Although information that challenges people's worldview is likely to elicit an emotive response, emotion by itself is not sufficient to alter people's resistance to corrections.

One limitation of this conclusion is that "worldview" does not by itself serve as a process explanation. Although it is indubitably useful to be able to predict a person's response to corrections based on their party affiliation or some other measure of worldview, it would be helpful if the cognitive processes underlying that link could be characterized in greater detail. Recent advances in illuminating those links have been promising (e.g., Castelli & Carraro, 2011; Carraro, Castelli, & Macchiella, 2011; Jost et al., 2003b). It is possible that one's worldview forms a frame of reference for determining, in Piaget's (1928) terms, whether to assimilate information, or accommodate it. If the investment in a consistent worldview is great, changing it to accommodate inconsistencies may be too costly or effortful. In a sense, the worldview may serve as a schema for processing related information (Bartlett, 1932), and so relevant information may be discarded, or preserved despite its falsity.

Taming worldview by affirming it

The research on pre-existing attitudes and worldviews implies that debiasing messages and retractions must be tailored to the specific audience, preferably by ensuring that the correction is worldview-consonant. For example, the work on "cultural cognition" by Kahan and colleagues (e.g., Kahan, 2010) has repeatedly shown that the framing of solutions to a problem in worldview-consonant terms can enhance acceptance of information that would be rejected when presented in a different framing. Thus, people who might oppose nanotechnology because of an "eco-centric" outlook may be less likely to dismiss evidence of its safety if presented as part of an effort to protect the environment; and, people who oppose findings from climate science because it challenges their worldview may do so less if the response is presented as a business opportunity for the nuclear industry (cf. Feygina, Jost, & Goldsmith, 2010). Even simple changes in wording can make information more acceptable by rendering it less threatening to a person's worldview. For example, Republicans are far more likely to accept an otherwise identical charge as a "carbon offset" than as a "tax", whereas the wording has little effect on Democrats or Independents—because their values are not challenged by the word "tax" (Hardisty, Johnson, & Weber, 2010).

Another way in which worldview-threatening messages can be made more palatable involves coupling them with "self-affirmation;" that is, by giving people an opportunity to affirm their basic values as part of the correction process (Cohen et al., 2007, Nyhan & Reifler, 2011). Self-affirmation can be achieved by asking people to write a few sentences about a time when they felt especially good about themselves because they acted on a value that was important to them. In comparison to people who received no affirmation, those who self-affirmed became more receptive to messages that otherwise might have threatened their worldviews. Self-affirmation may give the facts a "fighting chance" (Cohen et al., 2007, Nyhan & Reifler, 2011) by helping people handle challenges to their worldviews. Intriguingly, self-affirmation also enables people who have a high personal connection to their favored brand to process negative brand information more appropriately (by lowering their brand evaluations rather than their own self-esteem; Cheng et al., 2011).

Factors that assist people in facing inconsistencies in their personal perspectives may also help to promote acceptance of corrections. For example, distancing oneself from a "self" perspective has been shown to promote wise reasoning (Kross & Grossman, 2012), and has the potential to be helpful in processing corrections.

Skepticism—key to accuracy

We have reviewed how worldview and prior beliefs can exert a distorting influence on information processing. However, some attitudes can also safeguard against misinformation effects. In particular, *skepticism* can reduce susceptibility to misinformation effects if people question the origin of information that may later turn out to be false. For example, people who questioned the official *casus belli* for the invasion of Iraq (destroying WMD's) have been shown to be more accurate in processing war-related information in general (Lewandowsky et al., 2005). Suspicion or skepticism about the overall context (i.e., the reasons for the war) thus generalized to more accurate processing of specific information about the event in question. Importantly, in this instance, skepticism also ensured that correct information was recognized more accurately, and thus did not translate into "cynicism" or blanket denial of *all* war-related information. In a courtroom setting, Fein et al. (1997) showed that mock jurors who were asked to disregard a piece of inadmissible evidence were still influenced by the retracted evidence despite claiming they were not—unless they were made suspicious of the ulterior motives of the prosecutor who had introduced the evidence.

Those findings mesh well with related research on the role of trust. Though trust plays a fundamental role in most human relationships, and the presence of distrust is often corrosive (e.g., Whyte & Crease, 2010), there are situations in which distrust can have a positive function. For example, Schul, Mayo, and Burnstein (2008) showed that when distrust was elicited by showing people a face that was rated as "untrustworthy" by others, participants were more likely to solve non-routine items on a subsequent, completely unrelated task. By contrast, participants in whom trust was elicited performed much better on routine problems (but not non-routine problems), suggesting that distrust causes people to explore their environment more carefully, thus sensitizing them to the existence of non-routine contingencies. Similarly, Mayer and Mussweiler (2011) showed that priming people to be distrustful enhances their creativity in certain circumstances.

Taken together, these results suggest that a healthy sense of skepticism or induced distrust can go a long way in avoiding the traps of misinformation. Those benefits seem to arise from the non-routine, more "lateral" information processing that is primed when people are skeptical or distrustful (Mayer & Mussweiler, 2011; Schul et al., 2008). However, distrust and skepticism are most likely to exert an influence when they are experienced at the time of message exposure and do not always protect people from unreliable or intentionally misleading sources, in particular when the source's motivation only becomes apparent after message encoding. Even when misinformation is identified as intentionally deceptive (as opposed to wrong by mistake) or stemming from an unreliable

source, its effects can prevail (Green & Donahue, 2011; Henkel & Mattson, 2011). For example, Green and Donahue (2011) first presented people with a report that was found to change people's attitudes (e.g., reading a report about a heroin-addicted child changed people's attitudes towards the effectiveness of social youth-assistance programs). Participants then received a retraction, stating that the report was inaccurate because of a mix-up (error condition), or because the author had made up most of the 'facts' in order to sensationalize the report (deception condition). The results showed that people were motivated to undo their attitude changes especially in the deception condition, but that the effects of misinformation could not be undone in either condition, meaning that the misinformation had a continuing effect on people's atitudes even after a retraction established the author had made up the report.

Using misinformation to inform

Unlike the brief interventions of the "myth-vs.-fact" approach (Schwarz et al., 2007), whose adverse implications we discussed earlier, it appears that a careful and prolonged dissection of incorrect arguments may facilitate acquisition of correct information. To illustrate, Kowalski and Taylor (2009) conducted a naturalistic experiment in which they compared a standard teaching format with an alternative approach in which lectures explicitly refuted 17 common misconceptions about psychology, but left others unchallenged. The results showed that direct refutation was more successful in reducing misconceptions than non-refutational provision of the same information. Based on a more extensive review of the literature, Osborne (2010) likewise argued for the centrality of argumentation and rebuttal in science education, suggesting that classroom studies "…show improvements in conceptual learning when students engage in argumentation" (p. 464).

There are recent indications that argumentation and engagement with an opponent can even work in the political arena (Jerit, 2008). Jerit's analysis of more than 40 opinion polls ran contrary to the conventional wisdom that to win a policy debate, political actors should selectively highlight issues that mobilize public opinion in favor of their position and not engage an opponent in dialogue. Taking the argumentation and refutation approaches to an extreme, there have been suggestions that even explicit misinformation can be used as an effective teaching tool. Bedford (2010) reported a case study in which students learned about climate science by studying "denialist" literature—that is, actual knowledge was acquired by analyzing material that contained misinformation in depth, and by developing the skills required to detect the flaws in the material. In line with Osborne's (2010) review, an in-depth discussion

of misinformation and correction may assist people in working through inconsistencies in their understanding, and promote the acceptance of corrections.

Debiasing in an Open Society

Knowledge of the processes underlying the persistence of misinformation and how it can be avoided or reduced is of obvious public interest. Information is circulated at a faster pace and in greater amounts than ever before in society, and demonstrably false beliefs continue to find traction in sizable segments of the populace. The development of workable debiasing and retraction techniques, such as those reviewed here, is thus of considerable practical importance.

Encouraging precedents for the effectiveness of using such techniques on a large scale have been reported in Rwanda (e.g., Paluck, 2009), where a year-long controlled field experiment found that a radio soap opera built around messages of reducing intergroup prejudice, violence, and trauma altered listeners' perceptions of social norms and their behavior—albeit not beliefs—in comparison to a control group which was exposed to a health-focused soap opera. This field study confirms that large-scale change *can* be achieved using conventional media (although Paluck's experiment involved delivery of the program via tape recorders, this was for reasons of experimental control and convenience only and closely mimicked the way in which radio programs are traditionally consumed by Rwandans).

Concise recommendations for the practitioner

The literature we have reviewed thus far may appear kaleidoscopic in its complexity. Indeed, a full assessment of the debiasing literature must consider numerous nuances and subtleties, which we aimed to cover in the preceding sections. However, it is nonetheless possible to condense the core existing knowledge about debiasing into a limited set of recommendations that can be of use to the practitioner.[3]

We summarize the main points arising from the literature in Figure 1 and in the following list of recommendations:

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[3] Two of the present authors (Cook & Lewandowsky, 2011) have prepared a practitioner's guide to debiasing that, in 7 pages, summarizes those facets of the literature that are particularly relevant to practitioners (e.g., scientists, journalists, or others interacting with the public). The booklet is available for free download in several languages (English, Dutch, German, and French as of March 2012) at http://sks.to/debunk, and can be considered an "executive summary for practitioners" of the material covered in this article.

- Consider what gaps in people's mental event models are created by your debunking and fill them with an alternative explanation.

- Repeated retraction can reduce the influence of misinformation, although this also increases the risk of a backfire effect when the original misinformation is repeated and thereby rendered more familiar.

- To avoid making people more familiar with misinformation (thus risking a familiarity backfire effect), emphasize the facts you wish to communicate rather than the myth.

- Provide an explicit warning before mentioning the myth, to ensure people are cognitively on guard and less likely to be influenced by the misinformation.

- Ensure your material is simple and brief. Use clear language and graphs where appropriate. If the myth is simpler and more compelling than your debunking, it will be cognitively more attractive and you risk an overkill backfire effect.

- Consider whether your content may be threatening to the worldview and values of your audience. If so, you risk causing a worldview backfire effect, which is strongest among those with firmly held beliefs. This suggests that the most receptive people will be those who are not strongly fixed in their views.

- If one must present evidence that may be threatening to the audience's worldview, possible ways to reduce the worldview backfire effect are (a) present your content in a worldview-affirming manner (e.g., by focusing on opportunities and potential benefits rather than risks and threats) and/or (b) encourage self-affirmation.

- The role of worldview can also be circumvented by focusing on behavioral techniques such as the design of choice architectures rather than overt debiasing.

Future Directions

Our survey of the literature has enabled us to provide a range of recommendations and draw some reasonably strong conclusions. However, our survey has also identified a range of issues about which relatively little is known and which deserve future research attention. We wish to highlight three such issues in particular; namely, the role of emotion, the role of individual differences such as race or culture, and the role played by social networks.

Concerning emotion, we have discussed how misinformation effects arise independently of the emotiveness of the information (Ecker, Lewandowsky, & Apai, 2011). But we have also discussed that people pass on information based strongly on the likelihood of eliciting an emotional response in the

recipient rather than its truth value (e.g., K. Peters et al., 2009), meaning that the emotiveness of information may have an indirect effect on misinformation persistence. Moreover, the effects of worldview that we reviewed earlier provide an obvious departure point for future work because challenges to people's worldview tend to elicit highly emotional defense mechanisms (cf. E. Peters, Burraston, & Mertz, 2004).

Concerning individual differences, research has already touched on how people's responses to the same information differ depending on their personal worldviews or ideology (Ecker et al., 2012; Kahan, 2010), but remarkably little is known about other individual-differences variables. Intelligence, memory capacity, memory updating abilities, and ambiguity tolerance are just a few factors that could potentially mediate misinformation effects.

Finally, concerning social networks, we have already pointed to the literature on the creation of "cyber-ghettos" (e.g., T. J. Johnson et al., 2009), but considerable research remains to be done to fully understand the processes of (mis-)information dissemination through complex social networks (cf. Eirinaki, Monga, & Sundaram, 2012; Scanfeld, Scanfeld, & Larson, 2010; Young, 2011) and how these facilitate the persistence of misinformation in selected segments of society.

Concluding Remarks: Psychosocial, Ethical, and Practical Implications

We conclude by discussing how misinformation effects can be reconciled with the notion of human rationality, before we address some limitations and ethical considerations surrounding debiasing, and point to an alternative behavioral approach to counteract the effects of misinformation.

Thus far, we have reviewed the copious evidence about people's inability to update their memories in light of corrective information, we have shown how worldview can override fact, and how corrections can backfire. One might be tempted to conclude from those findings that people are somehow "irrational," or cognitively "insufficient." We caution against that conclusion. Jern, Chang, and Kemp (2009) presented a model of belief polarization (which as we noted earlier is related to the continued influence of misinformation) that was instantiated within a Bayesian network. A Bayesian network captures causal relations among a set of variables: In psychological terms, it can capture the role of hidden psychological variables, for example during belief updating. Instead of assuming that people consider the likelihood of a hypothesis being true only in light of the information presented, a Bayesian network acknowledges that people may rely on other "hidden" variables such as one's trust in an information source (e.g., the peer-reviewed literature). Jern et al. (2009) showed that when those hidden variables are taken into account, Bayesian networks can capture behavior that at first glance

might appear "irrational"—such as a variant of the backfire effects reviewed earlier. Although this research can only be considered suggestive at present, people's rejection of corrective information may arguably represent a normatively rational integration of prior biases with new information.

Concerning the limitations of debiasing, there are several ethical and practical issues to consider. First, the application of any debiasing technique raises important ethical questions: While it is in the public interest to ensure that the population is *well*-informed, debiasing techniques can equally be used to further *mis*inform people. The correction of misinformation is cognitively indistinguishable from misinforming people at the expense of previously-held correct beliefs. It follows that it is important for the general public to have a basic understanding of misinformation effects: Being aware of the fact that people may "throw mud" because they know it will "stick" is an important aspect of developing a healthy sense of public skepticism that will contribute to a well-informed populace.

Second, there are situations in which the application of debiasing will not be advisable for reasons of efficiency. In our discussion of the worldview backfire effect, we argued that debiasing will be more effective with people that do not hold strong beliefs concerning the misinformation: In people who strongly believe in a piece of misinformation for ideological reasons, a retraction can in fact do more harm than good by ironically further strengthening the misbelief. In such cases, and in particular when the debiasing cannot be framed in a worldview-congruent manner, debiasing may not be a good strategic choice.

An alternative approach to deal with pervasive misinformation is thus to ignore the misinformation altogether, and to seek more direct behavioral interventions. Behavioral economists have developed "nudging" techniques that can encourage certain decisions over others, without preventing people from making a free choice (e.g., Thaler & Sunstein, 2008). For example, it no longer matters if people are misinformed about climate science when they adopt low-emission behaviors in response to "nudges" such as tax credits. Despite suggestions that even "nudges" can be rendered ineffective by people's worldviews (Costa & Kahn, 2010; Lapinski, Rimal, DeVries, & Lee, 2007), this approach has considerable promise.

Unlike debiasing techniques, behavioral interventions involve the explicit design of "choice architectures" to facilitate a desired outcome. For example, organ donation rates have been shown to nearly double simply by changing the default option from "opt-in" to "opt-out" (E. J. Johnson & Goldstein, 2003). Because the design process for such choice architectures can be entirely transparent and subject to public and legislative scrutiny, the ethical implications of "nudging" are lessened.

A further advantage of the "nudging" approach is that its effects are not tied to a specific delivery vehicle, which may fail to reach target audiences. Thus, whereas debiasing requires that the target audience is in receipt of the corrective information—a potentially daunting obstacle—the design of choice architectures "automatically" reaches any person who is making a relevant choice.

We hence see three situations in which "nudging" seems particularly applicable. First, when behavior changes need to occur quickly and for entire populations in order to prevent negative consequences, "nudging" will be the strategy of choice (cf. the Montreal Protocol to rapidly phase out CFCs to protect the ozone layer; e.g., Gareau, 2010). Second, as discussed in the previous section, "nudging" may offer an alternative to debiasing when ideology is likely to prevent the success of debiasing strategies. Finally, "nudging" may be the only viable option in situations where there are organized efforts to deliberately misinform people, that is, when the dissemination of misinformation is programmatic (a case we reviewed at the outset, using the examples of tobacco smoke and climate change).

In this context, the persistence with which vested interests can pursue misinformation is notable: After decades of opposition to the link between smoking and lung cancer, the tobacco industry's hired experts have now opened a new line of testimony, by arguing in court that even after 1964 there was still "room for responsible disagreement" with the U.S. Surgeon General's conclusion that year that tobacco was a major cause of death and injury (Proctor, 2004). Arguably, this is intended to replace one set of well-orchestrated misinformation—that tobacco does not kill—with another convenient myth—that the tobacco industry did not know it. From (passive) smoking to climate change to GM foods: Spreading doubts and fueling fears by referring to the uncertainty of scientific conclusions is a very popular strategy to misinform the populace (Oreskes & Conway, 2010). For the lay person, the magnitude of (omnipresent) uncertainty does not matter much as long as they are led to believe it is meaningful. In addition to investigating the cognitive mechanisms of misinformation effects, researchers interested in misinformation are therefore also well advised to monitor such socio-political developments in order to better understand why certain misinformation can gather traction and persist in society.

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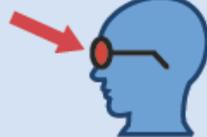
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Author Note

Figure 1. A graphical summary of the misinformation literature relevant to the communication practitioner. The left-hand column summarizes the cognitive problems associated with misinformation and the right-hand column summarizes the solutions as reviewed in this article.