Misinformation and How to Correct It

JOHN COOK, ULLRICH ECKER, and STEPHAN LEWANDOWSKY

Abstract

The increasing prevalence of misinformation in society may adversely affect democratic decision making, which depends on a well-informed public. False information can originate from a number of sources including rumors, literary fiction, mainstream media, corporate-vested interests, governments, and nongovernmental organizations. The rise of the Internet and user-driven content has provided a venue for quick and broad dissemination of information, not all of which is accurate. Consequently, a large body of research spanning a number of disciplines has sought to understand misinformation and determine which interventions are most effective in reducing its influence. This essay summarizes research into misinformation, bringing together studies from psychology, political science, education, and computer science. Cognitive psychology investigates why individuals struggle with correcting misinformation and inaccurate beliefs, and why myths are so difficult to dislodge. Two important findings involve (i) various "backfire effects," which arise when refutations ironically reinforce misconceptions, and (ii) the role of worldviews in accentuating the persistence of misinformation. Computer scientists simulate the spread of misinformation through social networks and develop algorithms to automatically detect or neutralize myths. We draw together various research threads to provide guidelines on how to effectively refute misconceptions without risking backfire effects.

INTRODUCTION

Misinformation by definition does not accurately reflect the true state of the world. In the present context, we apply the term misinformation to information that is initially presented as true but later found to be false (cf. Lewandowsky, Ecker, Seifert, Schwarz, & Cook, 2012). For example, one might initially believe a news report that a causal link has been found between use of deodorants and breast cancer but find out later that this is (most likely) just a myth.

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There are several reasons why misinformation has a more potentially damaging effect than ignorance, that is, the absence of knowledge. (i) Misinformation can be actively disseminated with an intent to deceive (it is then sometimes referred to as *dis*information). For example, antiscience campaigns misinform the public on issues that have achieved consensus among the scientific community, such as biological evolution, and the human influence on climate change. However, an intention to deceive need not always be present—for example, news coverage of unfolding events by its very nature requires regular updating and correcting of earlier information (e.g., the death toll after a natural disaster). (ii) False beliefs based on misinformation are often held with strong conviction, which is rarely the case with ignorance. For example, people who reject climate science also believe they are the best informed about the subject. (iii) Misinformation is often immune to correction. Despite clear retractions, misinformation and associated false beliefs may continue to influence people's reasoning and judgments. This continued influence can be observed even when people explicitly remember and believe the retractions. Misinformation may thus adversely affect decision making in democratic societies that depend on a well-informed public.

The psychological and social implications of misinformation have been under investigation for decades, although interest has intensified in recent years, arguably because misinformation has an increasing presence in society and its adverse consequences can no longer be overlooked. The meteoric rise of social media, the acceleration of news cycles, and the fragmentation of the media landscape have facilitated the dissemination of misinformation.

Accordingly, much research has explored how misinformation originates and propagates through society, and what its effects are at a societal level. We focus on how misinformation unfolds its effects at the level of the individual. This requires research into the psychology of how a person accesses information and updates memories and beliefs, and how this is affected by cultural factors and worldviews. Applied research has been looking into the effectiveness of various intervention techniques to determine which methods are most effective in reducing the influence of misinformation and how technology can help achieve this.

Understanding misinformation is a multidisciplinary topic, where cultural values, individual cognition, societal developments, developing technology, and evolving media all come into play. Therefore, reducing the influence of misinformation requires a multidisciplinary response, synthesizing the findings of social and political science, information and computer science, and psychology.

FOUNDATIONAL RESEARCH

Sources of Misinformation

False information can derive from a number of sources, and the analysis of the origin and dissemination of misinformation has yielded a new field known as "agnotology": the study of culturally produced ignorance and misinformation-driven manufactured doubt (Proctor, 2008).

Misinformation can be disseminated even by seemingly counterintuitive sources. For example, straightforward fiction is effective at implanting misinformation, even when readers are warned beforehand that the content is nonfactual. This is especially concerning when a writer pretends to base fictional work on a scientific basis, thereby misrepresenting the science (e.g., Michael Crichton's novel *State of Fear*, which grossly distorts climate science).

Rumours and urban myths are further significant sources of misinformation that tend to produce "sticky" memes that resist subsequent correction. Social media websites and blogs, which allow the bypassing of traditional gatekeepers such as professional editors or peer reviewers, have contributed to the increased dissemination of such misinformation.

Moreover, Internet content is fast becoming a replacement for expert advice, with a majority of Americans looking online for health information. However, numerous analyses of online content have found that a significant proportion of websites provide inaccurate medical information. Likewise, the quality of information from mainstream media (e.g., newspapers, TV), and thus the standard of consumers' knowledge depends strongly on the news outlet.

Another potential source of bias, ironically, is the media's tendency to present balanced coverage by giving equal weight to both sides of a story. This can result in "balance as bias," when domain experts are given equal voice with nonexperts.

While misinformation can originate inadvertently from all those channels, they can also be used to plant and disseminate misinformation in a targeted manner. For example, to promote their case for the invasion of Iraq in 2003, the Bush administration announced that there was no doubt that Saddam Hussein had weapons of mass destruction (WMDs) and linked Iraq with the 9/11 terrorist attacks. Even though both assertions are now known to have been false, a significant percentage of Americans continued to believe that WMDs had been found in Iraq even after the post-invasion search failed to turn up any WMD, and around half of Americans endorsed (nonexistent) links between Iraq and al-Qaida.

Finally, there is evidence that corporate-vested interests have engaged in deliberate campaigns to disseminate misinformation. The fossil-fuel industry, for example, has demonstrably campaigned to sow confusion

about the impact of fossil fuels on the environment, and tobacco manufacturers have promoted misinformation about the public health impacts of smoking.

Identifying Myths and Misconceptions

Identifying and analyzing the content and rhetorical arguments of misinformation is a necessary step toward understanding misconceptions and developing appropriate interventions. Taxonomically organizing the misinformation landscape allows deeper exploration of root causes, provides insights into the psychology of misconceptions, and can assist in identifying potential policy implications of inaccurate information. Most important, it provides a framework for developing effective refutation strategies.

Foundational work on taxonomies dates back to Aristotle, who defined the first taxonomy of logical fallacies by dividing them into those that are dependent on language (e.g., ambiguity: using a word or phrase that can have more than one meaning) and those that are not (e.g., sweeping generalization). Gilovich (1991) sorted reasoning flaws into two main categories—cognitive (resulting from the tendency to find order in random data) and motivational/social (wishful thinking or self-serving distortions of reality). This taxonomy has been applied, for example, to the most common antivaccine myths (Jacobson, Targonski, & Poland, 2007). In another domain, Rahmstorf (2004) categorized climate skepticism into three types: trend (climate change is not happening), attribution (climate change is not caused by humans), and impact (impacts from climate change are inconsequential).

The benefits of the taxonomical approach can be illustrated with an analysis of myths associated with the burning of charcoal in sub-Saharan Africa (Mwampamba, Ghilardi, Sander, & Chaix, 2013). By taxonomically organizing a diverse set of myths, the authors identified the root problem (conflation of charcoal with wood-based fuels), provided policy consequences of each myth, and recommended responses. For example, the myth that "charcoal is used only by the poor" had resulted in interventions that targeted the wrong user groups. By dispelling this misconception, communicators were able to target interventions more appropriately.

Despite the diversity of taxonomies, arguably one of the more useful and applicable taxonomies is a general approach applied to a number of domains. A broader synthesis has identified five common characteristics across a number of movements that deny a well-supported scientific fact: fake experts, cherry picking, unrealistic expectations, logical fallacies, and conspiracy theories (Diethelm & McKee, 2009). There is a deeper psychological reason why this is a potentially effective approach: providing an alternative explanation for how misinformation originates is an important element to refutation, as

explored in subsequent sections on retraction techniques. To understand why this is important, we need to examine the psychological challenges in reducing the influence of misinformation.

Challenges in Retracting Misinformation

Misinformation is surprisingly resilient to correction or retraction. In some cases, refutations have actually reinforced misconceptions. Such ironic reinforcements of false information are known as "backfire" or "boomerang" effects. Even when corrections do not backfire, people often cling to misinformation in the face of a retraction, a phenomenon known as the Continued Influence Effect.

In a commonly used experimental design, participants are presented with a news report that describes an unfolding event, such as a fire or a robbery. A critical piece of information (e.g., the cause of the fire) is provided but later retracted (i.e., the earlier information is identified as being incorrect). People's reliance on the retracted information is then measured with inference questions (e.g., "why was there so much smoke?"). Studies using this paradigm show that retractions rarely have the intended effect of eliminating reliance on misinformation, even when participants remember the retraction. People draw inferences from the same discredited information whose correction they explicitly acknowledge.

One explanation of the lingering effects of misinformation invokes the notion that people build mental models of unfolding events. If a central piece of the model is invalidated, people are left with a gap in their model, while the invalidated piece of information remains accessible in memory. When questioned about the event, people often use the still readily available misinformation rather than acknowledge the gap in their understanding.

There are several cases in which attempts to correct misinformation have been shown to actually reinforce them. For example, in an experiment where people were exposed to health claims that were either labeled valid or invalid, after a delay of 3 days, older people classified 40% of repeatedly encountered invalid claims as valid. This represents one instance of the "familiarity backfire effect," when refutations make a myth more familiar.

There is also suggestive evidence that refutations may backfire when they become too complex, an effect described as an "overkill backfire effect." For example, researchers have found that asking people to generate a few arguments for why their belief may be wrong was successful in changing a belief, whereas generating *many* counterarguments reinforced the belief. People generally prefer simple explanations over complicated ones, and hence when it comes to refutations, less might sometimes be more.

Successful Retraction Techniques

Three techniques have been identified to date that can make retractions of misinformation more effective. First, reliance of misinformation can be reduced if people are explicitly warned about possibly being misinformed at the outset. Advanced warnings put the person cognitively on-guard so they are less likely to be influenced by the misinformation.

Second, retractions are more effective if they are repeated or strengthened. Especially if misinformation is encoded strongly, repeating the retraction helps reduce the misinformation effect although it does not necessarily eliminate it. However, strengthening of the initial misinformation seems to have a stronger *negative* effect than strengthening of the retraction has a *positive* effect. This unfortunate asymmetry results in an unlevel playing field, with a seemingly natural advantage ceded to initially encoded misinformation.

Third, corrections should provide an alternative explanation that fills the gap created by the retraction. An effective alternative explanation is plausible, it explains the causal chains in the initial report, it explains why the misinformation was initially thought to be correct, and it explains the motivation behind the misinformation. An effective alternative explanation is also simpler (or at least not more complicated) than the misinformation.

Addressing Misconceptions in Education

A key element of education is conceptual change, a large part of which involves the correction of misconceptions. This is all the more important as misconceptions can interfere with new learning. For these reasons, educators seek to address misconceptions despite the inherent risks associated with ineffective or backfiring retractions.

Fortunately, there is a growing literature on the explicit refutation of misinformation as an educational tool. A number of studies have explored the effectiveness of different classroom interventions designed to reduce misconceptions. Thorough evidence-based refutations were found to be significantly more effective than nonrefutational lessons (Guzzetti, Snyder, Glass, & Gamas, 1993). That is, in refutation-style lectures, misconceptions were first activated and then immediately countered with accurate information. Nonrefutational lectures, by contrast, would teach the accurate information without any reference to the misconceptions. The former was found to be far more effective.

Refutation in the classroom can be an opportunity to foster critical thinking, encouraging students to skeptically assess empirical evidence and draw valid conclusions from the evidence. Use of multimedia in combination with

refutational formats has shown to be more effective than standard lecture formats in reducing physics misconceptions (see Ecker, Swire, & Lewandowsky, 2014, for a review).

Thus, while there is a danger of a familiarity backfire effect by familiarizing students with misconceptions, this research demonstrates that activating myths followed by immediate refutations—combining a retraction with a detailed explanation—can be an effective way to induce conceptual change.

CUTTING-EDGE RESEARCH

Research into misinformation has recently extended into other disciplines. Computer scientists have developed models to simulate the spread of misinformation and detect disinformation in real time. Cognitive scientists are investigating the role of attitudes and worldviews in accentuating the persistence of misinformation.

Computer Science and Misinformation

When Charles Spurgeon quipped in 1859 that "a lie will go round the world while truth is pulling its boots on," he could scarcely have imagined the speed with which information is exchanged in the Twitter age. Spam is one form of misinformation and is often posted on social media sites such as Twitter. While moderators seek to quickly remove spam URLs, tweets are viewed with such speed that over 90% of visitors will have viewed a spam tweet before the link could be removed.

Computer science provides tools that can illuminate the nature and reach of misinformation. For example, a content analysis of 1000 Twitter status updates matching terms such as "cold + antibiotics" was used to explore misconceptions related to antibiotics. Tweets demonstrating misunderstanding or misuse of antibiotics were found to reach 172,571 followers. Conversely, health providers are being encouraged to use social networks to communicate with patients and people seeking health information.

Computer scientists are developing algorithms that can identify intentionally disseminated misinformation in real time. There are a series of cognitive, psychological, and emotional cues associated with false intent that make it possible to automatically detect misinformation without having to rely on domain knowledge. Software such as a Linguistic Pattern Analyzer can be programmed to scan linguistic patterns to detect disinformation and locate the sources (Mack, Eick, & Clark, 2007).

For example, one form of misinformation gaining prominence in recent years is deceptive opinion spam, such as fictitious consumer reviews written to appear authentic. Deceptive text can be automatically detected using

a combination of text categorization, classifiers and psycholinguistic deception, and has been found to accurately detect nearly 90% of deceptive opinion spam (Ott, Choi, Cardie, & Hancock, 2011). This outperforms most human judges.

Social network analysis allows researchers to simulate the spread of misinformation through a network with a model adopting traits similar to the spread of a disease across a population. This approach also allows researchers to model ways to limit the spread of misinformation. For example, researchers can simulate how one might select a small number of "early adopters" in a network in order to trigger the spread of positive information, minimizing the number of people who adopt negative information. Social network algorithms can compute which nodes in a network are most effective in blocking negative influences (Nguyen *et al.*, 2012).

An exciting new area of research is the incorporation of other disciplines into computer science. Social network analysis typically considers who is connected to whom to determine how information diffuses through a network. However, one must also consider the cultural values of the people in the network and the relevance of the misinformation to their values. This is particularly important when culturally relevant information disseminates through a network. It turns out that research into the role of cultural values and worldview has taken center stage in advancing our understanding of how people process misinformation and react to retractions.

The Role of Cultural Values and Worldview

Worldviews and ideology have been shown to influence basic cognitive processes and shape attitude formation. For example, conservatives pay more attention to negative information (e.g., threatening or antisocial behavior) compared to liberals. This causes conservatives to place more weight on negative behavior of numerically smaller groups, which may explain why conservatives are more likely to form negative attitudes toward social minorities.

Research is also revealing a strong role of worldview in how people process and retain misinformation. For example, Democrats are more likely to believe statements underplaying the risks of higher oil prices, whereas Republicans are more likely to believe myths concerning President Obama's birthplace.

Similarly, retractions of politically relevant misperceptions were found effective only if the retraction supported the person's political orientation. However, when the retraction conflicted with a person's ideology, a "worldview backfire effect" was sometimes observed where the retraction caused stronger adherence to the misinformation. For example, correcting the misconception that President G. W. Bush's tax cuts in the 2000s increased government revenue led to a backfire effect among Republican participants.

When confronted with information compellingly debunking a preexisting belief, only a minute proportion of people—2% of participants in one study—explicitly acknowledged their beliefs were mistaken. The majority of people, however, displayed some form of motivated reasoning by counterarguing against the refutation. This is consistent with other research into "motivated skepticism," which shows participants expressing active skepticism to worldview-incongruent information. The most intransigent people engage in a strategy termed "disputing rationality": insisting on one's right to an opinion without it being supported by factual reasoning.

Associated with the worldview backfire effect is a phenomenon known as belief polarization. This occurs when the same information results in people with contrasting prior beliefs to update their beliefs in opposite directions. For example, when presented with supporting and opposing information about the death penalty, participants rated arguments that confirmed their own beliefs to be more convincing and consequently strengthened prior beliefs. Polarization is also observed across education levels concerning views on climate change or beliefs that President Obama is a Muslim.

This summary of worldview effects demonstrates how preexisting attitudes and beliefs can affect the processing of misinformation and its retraction. In our view, it is the motivated reasoning fueled by worldviews that presents the main obstacle to efficient debiasing, and hence the greatest challenge for future research into misinformation.

KEY ISSUES FOR FUTURE RESEARCH

Worldview

There is a need for further research into interventions that reduce the biasing influence of worldview. Ecker, Lewandowsky, Fenton, and Martin (2014) argued that worldview will have a strong influence on the acceptance of counterattitudinal retractions only if accepting the retraction requires a change in attitudes. In other words, the worldview backfire effect may not be ubiquitous, and counterattitudinal retractions will be (relatively) effective as long as a person can accommodate the retraction within their more general belief framework. For example, an ethnically prejudiced person could readily accept that a particular crime was *not* committed by an immigrant but still believe that most immigrants are criminals. In contrast, for a Republican it would actually require some shift in attitude toward President Bush to acknowledge that his tax cuts were ineffective and his claims to the contrary were incorrect.

Furthermore, Ecker *et al*. (2014) proposed that part of the empirical discrepancy regarding worldview effects may lie in the difficulty of measuring

beliefs. That is, under some circumstances people may change their underlying attitudes but not acknowledge that change in order to "save face." Worldview backfire effects could then occur when people overcompensate, that is, explicitly state that their belief has grown stronger when (or because) in fact it has decreased.

Some preliminary research indicates that the source of the retraction is important; for example, corrections of the death-panel myth were effective among Republicans primarily when communicated by a Republican politician. "Cultural cognition" theory shows that framing information in worldview-consonant terms can effect positive belief change. For example, opponents of climate science respond more positively if climate action is presented as a business opportunity for the nuclear industry rather than a regulatory burden involving emission cuts. Even simple wording changes such as "carbon offset" instead of "carbon tax" has a positive effect among Republicans whose values are challenged by the word "tax."

One of the underlying cognitive processes that distinguish conservatives from liberals is an emphasis on different moral principles, with liberals placing more value on harm prevention and equality. Thus, liberals view the environment in moral terms, whereas conservatives do not. Research has shown that the effect of ideology on environmental views can be neutralized by reframing pro-environmental rhetoric in terms of purity, a moral value highly emphasized by conservatives (Feinberg & Willer, 2013). Exploring the role of moral intuitions in framing politically charged issues is an area of future research.

An alternative approach to this kind of "worldview-affirmation" is self-affirmation. In one study, participants were asked to write about a time they felt good about themselves because they acted on an important personal value. Self-affirmed people were more receptive to messages that threatened their worldviews. Likewise, reminding people of the diversity of attitudes in their frame of reference can make them more open to consider counterattitudinal information (Levitan & Visser, 2008).

While these avenues to reduce worldview-associated biases in information processing are worth pursuing, some researchers have also argued that the effects of worldview are so difficult to overcome that approaches to target behavior-change directly, bypassing attitude and belief change, are more promising. These approaches include the creation of choice architectures, such as "opt-out" rather than "opt-in" organ donation schemes, and the use of government-controlled taxation or financial incentives. For example, using taxes to raise the price of alcohol has been shown to be an effective means of reducing drinking (Wagenaar, Salois, & Komro, 2009).

More research is required on experimentally testing different refutation structures, and more work is needed to create a solid empirical database on

which to base recommendations. For example, evidence for the familiarity backfire effect in young adults is somewhat mixed, so further research could clarify its boundary conditions. Existing studies finding an overkill backfire effect were based on asking participants to generate a small or large number of counterarguments, but an examination more applicable to real-world situations would involve presenting prewritten counterarguments to experimentally measure the relative impact of different refutation formats. Future research should explore under what conditions the overkill backfire effect and familiarity backfire effects arise, and it should clarify the role of expertise and trustworthiness of the source of the refutation.

There is much potential in the interdisciplinary approach of integrating psychological research with other disciplines. Experimental clarification is needed concerning the conditions under which the refutation of misconceptions can be expected to be beneficial for educational purposes, as reviewed earlier, and when refutations run the risk of producing a familiarity backfire effect. Similarly, integrating psychology with computer science presents exciting opportunities to respond to misinformation in innovative new ways.

Future Trends in Computer Science and Misinformation

Social network analysis offers the opportunity to investigate how misinformation propagates through a network and offers methods to reduce the spread of misinformation across a network. This research can lead to the development of tools that permit investigation into how misinformation propagates and persists through social networks. Potentially, this may lead to practical applications that facilitate the neutralization of or "inoculation" against misinformation by identifying influential members of a network to efficiently disseminate accurate information. This approach is of particular interest, given that it has been shown that the effectiveness of misinformation campaigns can be reduced through preemptive inoculation (Pfau, Haigh, Sims, & Wigley, 2007).

As seen in the previous section, cultural values and worldview play a significant role in how people retain misinformation. A further area of future research is the incorporation of other disciplines such as psychology into social network analysis. One approach takes into account the impact of cultural values, as culturally relevant information disseminates through a network (Yeaman, Schick, & Lehmann, 2012). Another interesting method is the combination of social network analysis with social and psychological characteristics of people. An example is the combination of an agent-based model employing an iterative learning process (where people repeatedly receive information and gradually update their beliefs) with social network analysis to determine how nodes (e.g., people) in a social network would be

influenced by the spread of misinformation through the network (Monakhov *et al.*, 2012).

An area of future research is the development of more sophisticated and accurate tools that can detect and respond to online misinformation. An example of such a tool is *Truthy*, a system originally designed to detect orchestrated misinformation campaigns on Twitter. Similarly, the browser extension *Dispute Finder* examines text on a webpage, and drawing upon a database of known disputed claims highlights disputed information. The advantage of this approach is that tagging misinformation as false at the time of initial encoding reduces the likelihood that the misinformation shows persistence. Research should also measure the effectiveness of these tools, particularly across different demographics, to determine how the effectiveness of such interventions may vary for people of different worldview or background.

The practice of automatically detecting and responding to misinformation does come with risks. One experiment that issued real-time corrections of political misinformation found that the corrections had a positive effect for people whose attitudes were predisposed against the misinformation. However, the real-time correction was less effective than a delayed correction among those whose political beliefs were threatened by the correction (Garrett & Weeks, 2013). One approach to mitigate this risk would be to couch corrections in positive terms.

Understanding and Formalizing Misperceptions

To design appropriate intervention strategies, researchers need to identify which misconceptions are most prevalent. A survey of climate views adopting Rahmstorf's (2004) "trend/attribution/impact" taxonomy found that different types of skepticism are strongly interrelated (Poortinga, Spence, Whitmarsh, Capstick, & Pidgeon, 2011): those who were skeptical about one aspect of climate change (e.g., attribution skepticism, i.e., skepticism that humans are causing climate change) were more likely to be skeptical about other aspects of climate change (e.g., trend skepticism, or skepticism that climate change is occurring). Understanding that it is a minority of people holding all kinds of misconceptions (rather than many people holding different, singular misconceptions) is clearly informative for both intervention strategies and policy implementation.

While taxonomies classify misperceptions into hierarchical categories, another method of formalizing misinformation is the development of ontologies. These involve defining a set of properties for specific myths or misperceptions (e.g., motivation, type, channel, profile of misinformer). The Web Ontology Language is a standard for defining ontologies and has been

used to develop a digital misinformation library (Zhou & Zhang, 2007). Such a library can be used to increase public awareness of misinformation and be imported into algorithms that automatically detect patterns of misinformation.

In conclusion, the combined contribution of information and computer science to misinformation research is a clear demonstration of the importance of a multidisciplinary approach to understanding and refuting misinformation. More broadly, the integration of psychological, political, and computer science offers the potential of implementing the insights of cognitive science in practical, real-world applications.

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Professor **Stephan Lewandowsky** is a cognitive scientist at the University of Bristol. He was an Australian Professorial Fellow from 2007 to 2012, and he received a Discovery Outstanding Researcher Award from the Australian Research Council in 2011. He held a Revesz Visiting Professorship at the University of Amsterdam in 2012. He received a Wolfson Research Merit Award from the Royal Society in 2013 upon moving to the UK. His research examines memory, decision making, and knowledge structures, with a particular emphasis on how people update information in memory. He has published over 140 scholarly articles, chapters, and books, including numerous papers on how people respond to corrections of misinformation (see www.cogsciwa.com for a complete list of scientific publications). He has also contributed numerous opinion pieces to global media outlets on issues related to climate-change skepticism and the coverage of science in the media. A complete list of his public essays can be found at

http://www.shapingtomorrowsworld.org/inthemedia.htm.

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