Optimising myth correction during a global pandemic

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Summary of thesis

COVID-19 was accompanied by an unprecedented amount of misinformation. This information's ability to spread was aided by several social and political phenomenon (e.g., science denialism). Humans are not good at making truth judgements and their judgements can be led astray by phenomenon such as the illusory truth effect whereby repetition makes things appear more truthful. Misinformation is problematic for Public Health as it can foster unhelpful behaviours (e.g., not following social distancing guidance). It has also been demonstrated to continue to influence decisions following correction (i.e., debunking). Recommendations for debunking have evolved over the years, for example the shift from the recommendation that misinformation should always be excluded from corrections to the acknowledgement that it can be shown in some contexts. However, the contexts in which misinformation can be shown is unclear and many recommendations have not been tested within the context of public health. In this thesis, I aimed to test debunking recommendations within a Public Health context to examine how we can optimise the way in which public health campaigns decrease myth agreement (and increase behaviour intentions).

I tested four types of correction formats throughout this thesis: myth-fact, fact-only, fact-myth, and question-answer. Previous research has experimentally tested three of these correction formats (Swire-Thompson et al., 2021). The comparison of the question-answer format to other corrections was novel. I found that the myth-fact and fact-myth were effective at lowering myth agreement. The fact-only format was also effective at lowering agreement, but it was not as effective when participants had high baseline vaccine concerns, or their baseline myth agreement was high. The question-answer format was also more effective than fact-only, and I found some evidence that question-answer was more effective than fact-myth in the longer term. These findings have implications for debunking recommendations and public health campaigns countering misinformation.

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Statements and declarations

Statement 1

This thesis is being submitted in partial fulfilment of the requirements for the degree of PhD.

Statement 2

This work has not been submitted in substance for any other degree or award at this or any other university or place of learning, nor is it being submitted concurrently for any other degree or award (outside of any formal collaboration agreement between the University and a partner organisation).

Statement 3

I hereby give consent for my thesis, if accepted, to be available in the University's Open Access repository (or, where approved, to be available in the University's library and for inter-library loan), and for the title and summary to be made available to outside organisations, subject to the expiry of a University-approved bar on access if applicable.

Declaration

This thesis is the result of my own independent work, except where otherwise stated, and the views expressed are my own. Other sources are acknowledged by explicit references. The thesis has not been edited by a third party beyond what is permitted by Cardiff University's Use of Third Party Editors by Research Degree Students Procedure.

Acknowledgements

"I hope you understand enough of the ways of the Fates and of the gods to know that only darkness and despair awaits those who believe that their achievements are theirs and theirs alone"
(Fry, 2018, p. 194)

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Author's note

Since I started my PhD in 2017, there have been two US presidents, two UK Monarchs and four UK Prime Ministers (as of 11th November 2022). The political and social aspects of this thesis, therefore, focus on the UK Prime Minister and US President who were in office when the COVIID-19 pandemic arrived in late 2019: Boris Johnson and Donald Trump.

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SECTION 1: COVID-19 AND THE PERFECT STORM

Chapter 1. Introduction and thesis overview

1.1. Introduction

1.1.1. The arrival of the COVID-19 pandemic

In December 2019, the city of Wuhan, Hubei province, China reported pneumonia cases of unknown aetiology (World Health Organization, 2020c). Deep sequencing analysis revealed a novel coronavirus (Huang et al., 2020). The virus was given the official name of "severe acute respiratory syndrome coronavirus 2" (SARS-CoV-2) and the disease was named "coronavirus disease" or "COVID-19" (World Health Organization, 2020b). On 11th March 2020, the World Health Organization (WHO) announced that COVID-19 had achieved pandemic status (World Health Organization, 2020a). That same day, at a media briefing, the WHO's Director-General, Tedros Adhanom, explained that this was the first pandemic caused by a coronavirus, and urged countries to "detect, test, treat, isolate, trace, and mobilize their people in the response" (World Health Organization, 2020e). As of 12th November 2022, the total number of confirmed COVID-19 cases has surpassed 630 million and over 6.6 million deaths have been reported worldwide (World Health Organization, 2022c). On 17th March 2020, Sir Patrick Vallance, the UK government's chief scientific advisor, proposed that a *good outcome* would be to limit the number of British deaths to 20,000 or less (Kelly, 2020). By 17th March 2021, a year after Vallance's 20,000 comment, 126,341 people in the UK had died from the coronavirus (GOV.UK, 2022b). The number of UK deaths currently stands at 208,000, approximately 10.5 times more deaths than the *good outcome* (11th November 2022; GOV.UK, 2022b).

The COVID-19 pandemic arrived in a world that was logistically unprepared for a pandemic, and this had been known for some time. In 2011, the International Health Regulations Review Committee (World Health Organization, 2022b, para. 17) concluded that the world was "ill prepared to respond to a severe influenza pandemic or to any similarly global, sustained and threatening public-health emergency". These sentiments were echoed by the WHO in their annual report on global preparedness for health emergencies. They reported "the world is not prepared for a fast-moving, virulent respiratory pathogen pandemic" (World Health Organization, 2019a, p. 15). They also identified the erosion of trust in institutions as a specific pandemic risk, stating "trust in institutions is eroding. Governments, scientists, the media, public health, health systems and health workers in many countries are facing a breakdown in public trust that is threatening their ability to function effectively. The situation is exacerbated by misinformation that can hinder disease control communicated quickly and widely via social media" (World Health Organization, 2019a, p. 15).

Similarly, within the UK, the government carried out Exercise Cygnus in 2016 to assess the UK's preparedness and response to a worst-case scenario influenza pandemic (GOV.UK, 2017). The report concluded "the UK's preparedness and response, in terms of its plans, policies and capability, is currently not sufficient to cope with the extreme demands of a severe pandemic that will have a nation-wide impact across all sectors" (GOV.UK, 2017, p. 6).

1.1.2. Misinformation

The COVID-19 pandemic not only created an unprecedented challenge for public health to contain and treat the disease but was accompanied by an abundance of information and misinformation. The WHO named this abundance an "infodemic" (World Health Organization, 2020d). The term *misinformation* is used to describe false information regardless of whether the information is spread mistakenly or deliberately to mislead others (Lewandowsky et al., 2020). Pickles et al. (2021) identified three categories of COVID-19 misinformation: 1) Symptom management and prevention, for example, "COVID-19 vaccines weaken your immune system and make it harder for your body to fight the disease" (Full Fact, 2021d). 2) Causes and transmission, for example, "The new coronavirus is actually the impact of 5G exposure." (Full Fact, 2020g). 3) Immunity and cure, for example, "Honey, pepper and ginger can '100%' eliminate the effect of Covid-19 and has been approved by the WHO" (Full Fact, 2021b).

Misinformation is not the only type of false information. *Disinformation* refers to purposefully spreading false information for manipulative or propagandistic purposes (Lewandowsky, Stritzke, et al., 2013). During the current COVID-19 pandemic, the UK Government has been accused of spreading disinformation, for example, they denied pursuing a herd immunity policy early in the pandemic even though "statements from politicians and science advisors clearly prove the opposite" (Horton, 2020, p. 92). The WHO described the abundance of COVID-19 information as an "infodemic" and assigned teams to identify misinformation, such as false prevention and cures, 24 hours a day (World Health Organization, 2020d).

Beliefs based upon misinformation are different to ignorance-based beliefs as ignorance refers to the absence of knowledge to make a decision (Lewandowsky et al., 2012). Ignorance, like misinformation, is unfavourable when it comes to decision making. However, research has indicated that the effects of ignorance-based decisions may be less detrimental than decisions based upon misinformation. When decisions are based upon ignorance, people tend to use simple heuristics, or rules of thumb, when making decisions. Individuals usually have low levels of confidence in their ignorance-based decisions, and they do not typically hold the strong or extreme beliefs seen in individuals making misinformation-based decisions (Lewandowsky et al., 2012). The overconfidence despite low levels of knowledge, seen in people who make decisions based on misinformation, is known as the Dunning-Kruger effect (Dunning, 2011). This effect has been observed in those who oppose vaccinations (Motta et al., 2018) and climate change (Maibach et al., 2011).

Correct information is vital during pandemics as beliefs based upon accurate information foster helpful behaviours whereas beliefs based on misinformation produce unhelpful behaviours (Freeman et al., 2020). For example, if misinformation spreads about treatments, people may take ineffective and/or dangerous remedies (Pennycook et al., 2020). This has been observed during the COVID-19 pandemic. In early 2020, a man in Arizona reportedly died after false claims that the chloroquine can cure the coronavirus prompted him to ingest chloroquine phosphate (Edwards & Hillyard, 2020). Similarly, rumours have spread about Ivermectin, a drug used by veterinarians to kill worms and parasites, being able to treat COVID-19. There is no evidence to support this, however, doctors have reported being threatened with legal action when they have refused to prescribe it to COVID-19 patients (Independent, 2021).

1.2. Thesis synopsis

In April 2020, Nature Cancer wrote, “Suffice it to say that the combination of a rapidly disseminating new virus and a toxic mix of political vacillation and opportunism, misinformation, weak health systems and science denialism created the **perfect storm**” (‘On Being Human in the Face of a Pandemic’, 2020, p. 371).

My thesis is predominantly focused on maximising the efficacy of myth correction for public health campaigns. The primary aim of this thesis was to optimise myth correction methods during the COVID-19 pandemic. However, before addressing the best way to correct COVID-19 misinformation, I will introduce the perfect storm of social and political contexts in which COVID-19 appeared, and the problem COVID-19 presented to public health campaigners. My thesis is split into four sections and has the following structure (see Tables 1.1., 1.2., 1.3., and 1.4. for summaries):

1.2.1. SECTION 1: COVID-19 AND THE PERFECT STORM

1.2.1.1. Chapter 2. The social and political contexts of the pandemic

In Chapter 2, I will describe the context in which COVID-19 appeared as it provided the perfect conditions for COVID-19 misinformation to thrive. Phenomena of note are the post-truth era, populism, science denialism, and social media. These existed before the pandemic, but they created an age in which trust in science, objectivity and political transparency were undermined and undervalued (arguably with catastrophic consequences). I will then discuss how the COVID-19 pandemic has been affected by the social and political phenomena described above.

1.2.1.2. Chapter 3. Making truth judgements

To understand the best way to correct misinformation, we must first understand how people may end up believing myths. In Chapter 3, I will describe how our truth judgements can be led astray by the illusory truth effect (where familiarity increases truth ratings). I will also describe how misinformation can linger following correction (i.e., the continued influence effect). These phenomena are important to understand if we are to maximise the effectiveness of a correction campaign.

1.2.1.3. Chapter 4. A brief history of debunking recommendations

Chapter 3 introduced how familiarity can increase truth ratings via a phenomenon called the illusory truth effect. In Chapter 4, I will review the literature on debunking and how debunking recommendations have changed over time. That is, I will review the "best" way to structure a correction whilst attempting to correct misinformation reactively. For example, when correcting COVID-19 myths such as "hydroxychloroquine and chloroquine are cures for the new coronavirus" (Full Fact, 2020h, para. 1), should public health campaigns and fact checkers present the myth first followed by the fact? Or just provide the fact? For example, "there aren't yet peer-reviewed clinical studies to prove hydroxychloroquine or chloroquine is effective against the symptoms of, or can protect against, the new coronavirus. You should not take either unless you're specifically prescribed them by a doctor." (Full Fact, 2020h, para. 1). Historically, the argument has been in favour of presenting the fact only and omitting the myth due to fears that including it can increase its familiarity. More recently, the advice has become more lenient towards the inclusion of misinformation. However, more research is needed in the domain of public health.

1.2.2. SECTION 2: INFLUENZA MISINFORMATION

1.2.2.1. Chapter 5. Reasons for influenza vaccine non-acceptance amongst healthcare workers

Healthcare workers are recommended to obtain an influenza vaccination annually (NHS, n.d.). However, vaccination rates have consistently fallen below vaccination targets worldwide (Stead, Critchlow, Patel, et al., 2019b). Misinformation has been identified as one of the main reasons for influenza vaccine refusal amongst healthcare workers (Hollmeyer et al., 2009). Chapter 5 examines the reasons for influenza vaccine non-acceptance amongst healthcare workers from the Aneurin Bevan University Health Board (ABUHB) both pre- and post-arrival of the COVID-19 pandemic.

1.2.2.2. Chapter 6. Does correction format influence influenza myth agreement?

Chapter 6 details my work from before the COVID-19 pandemic. It contains two experiments in which I investigated whether using a myth-first correction format effective. I used materials specifically designed for influenza public health campaigns. Experiment 1 compared the myth-first correction format to a control condition. Experiment 2 compared myth-first and fact-only correction formats against a control condition. My final influenza study, where I had planned to test the myth busting materials with healthcare workers was halted five days after I started data collection by the COVID-19 pandemic.

1.2.3. SECTION 3: COVID-19 MISINFORMATION

1.2.3.1. Chapter 7. COVID-19 myth busting: an experimental study

The COVID-19 pandemic forced me to change direction, however, it provided a unique opportunity to examine myth correction formats designed specifically for real-world COVID-19 misinformation during a global pandemic. Chapter 7 contains one experimental study, and one partial replication study. I compared three approaches to myth-busting to establish whether health campaigns might be most effective when they include the myth, omit the myth, or use a question-answer format. I used a randomised trial with a representative sample.

1.2.3.2. Chapter 8. Does debunking increase behaviour intentions?

The correction of misinformation has been demonstrated to have a positive effect on myth agreement. However, what is less clear within the literature is whether debunking produces positive effects on vaccine intentions. Chapter 8 contains data from multiple influenza and COVID-19 experiments that tested the effect of debunking (i.e., correction) on vaccine intentions.

1.2.3.3. Chapter 9. Individual differences: Vaccine concern and age

Chapter 9 aims to identify whether individual differences are related to variations in myth agreement (i.e., how much participants agree with COVID-19 statements) and vaccine acceptance (i.e., how likely participants are to accept a COVID-19 vaccine). Two studies explored 1) whether vaccine concern is correlated with myth agreement, and 2) the relationship between age and myth agreement, and age and vaccine acceptance.

1.2.4. SECTION 4: GENERAL DISCUSSION

1.2.4.1. Chapter 10. General Discussion

Chapter 10 summarises my thesis and draws conclusions based upon my findings and the extant literature.

Table 1.1.

Section 1: COVID-19 and the perfect storm

SECTION 1: COVID-19 AND THE PERFECT STORM	
Chapter Title	**Aim(s)**
Chapter 2 The social and political contexts of the pandemic	1. To provide an overview of the political and social contexts in which COVID-19 appeared. Phenomena of note are the post-truth era, populism, science denialism, and social media.
Chapter 3 Making truth judgements	1. To describe how our truth judgements can be led astray by the illusory truth effect (whereby familiarity increases truth ratings). 2. To demonstrate how misinformation can linger following correction (i.e., the continued influence effect).
Chapter 4 A brief history of debunking recommendations	1. To review the recommendations for debunking campaigns

Table 1.2.

Section 2: Influenza misinformation and healthcare workers

SECTION 2: INFLUENZA MISINFORMATION AND HEALTHCARE WORKERS	
Chapter Title	**Research Question(s)**
Chapter 5 Reasons for influenza vaccination non-acceptance amongst healthcare workers	1. What were the most reported reasons for non-acceptance given by healthcare workers pre-arrival of COVID-19? 2. Is there a difference between the reasons for non-acceptance given during each influenza season? 3. What were the most reported reasons for non-acceptance post-arrival of COVID-19? 4. Did reasons for non-acceptance change following the arrival of the COVID-19 pandemic?
Chapter 6 Does correction format influence influenza myth agreement and vaccine intentions?	1. Is the myth-fact format effective at reducing beliefs in misinformation? 2. Is misinformation required for effective correction to take place?

Table 1.3.

Section 3: Debunking COVID-19 misinformation

SECTION 3: DEBUNKING COVID-19 MISINFORMATION	
Chapter Title	**Research Question(s)**
Chapter 7 COVID-19 myth busting: An experimental study	1. Which formats are effective immediately and after a delay? That is, does each format lower agreement with myths (effective correction), increase agreement (a backfire effect), or neither? 2. What is the most effective myth correction format?
Chapter 8 Does debunking increase behaviour intentions?	1. What are the immediate and delayed effects of debunking on vaccine intentions? 2. What are the effects of debunking on vaccine intentions for a subgroup of participants with high vaccine concern?
Chapter 9 Individual differences: Vaccine concern and age	1. Does debunking effectively lower myth agreement amongst participants with high vaccine concern? 2. Does debunking effectively lower myth agreement amongst a) younger and b) older participants? 3. Does debunking increase vaccine intentions of a) younger and b) older participants?

Table 1.4.

Section 4: General Discussion

SECTION 4: GENERAL DISCUSSION	
Chapter Title	**Overview**
Chapter 10 General Discussion	1. What was the gap in the literature? 2. What I did, what I found and what it means 3. Research implications/recommendations 4. Future directions 5. Limitations 6. Impact 7. Conclusions

Chapter 2. The social and political contexts of the pandemic

2.1. Introduction

When the COVID-19 pandemic arrived, it was accompanied by an abundance of information, “misinformation (i.e., information that turns out to be false), disinformation (i.e., false information that is intentionally spread to mislead people), and conspiracy theories” (Lewandowsky et al., 2022, p. 26). Arguably, the social and political contexts into which COVID-19 arrived greatly affected COVID-19 misinformation’s ability to spread and be believed. In this chapter I will explore the reasons why COVID-19 misinformation created such an impact.

Science and public health do not exist in a vacuum. Some scientific findings are denounced and/or ignored, not due to limitations with the science (which would be understandable) but because the findings to not fit with a group’s ideology. A Nobel Memorial Prize winning psychologist, Daniel Kahneman, suggested that “scientists should scrupulously avoid the political and that if science involves a matter ‘that anybody in Congress is going to be offended by, then it’s political’” (Lewandowsky et al., 2022, p. 27). However, in practice this would result in multiple scientific fields and topics becoming off limits to scientists (Lewandowsky et al., 2022). For example, evolutionary biology, climate change and childhood vaccinations have all become politicised. Furthermore, some political groups (conservatives) are more likely to reject scientific findings than others (Lewandowsky & Oberauer, 2021). Thus, if scientists were to scrupulously avoid the political, what was deemed unoffensive and acceptable to study scientifically would be dictated by the few.

Moreover, it seems any topic can become political. In June 2022, the Supreme Court in America voted revoke a person’s right to abortion (Glenza et al., 2022). Each of the 50 states are now able to ban abortions (The Royal College of Obstetricians and Gynaecologists, 2022). Following the verdict, the UK Conservative MP Danny Kruger argued he would “probably disagree” with other MPs about abortion and whether “women have an absolute right to bodily autonomy” (Giordano, 2022, para. 1). Kruger has since argued that his comments have been misinterpreted, however, in in 2020 he voted against continuing to permit abortions in Norther Ireland (Schifano, 2022; The Public Whip, n.d.). The Royal College of Obstetricians and Gynaecologists, the Royal College of Midwives, the Royal

College of Anaesthetists, and the British Medical Association were just three UK organisations to add their names to a global list of over 100 organisational signatories who have condemned the US Supreme Court's decision to overturn Roe v Wade (International Federation of Gynecology and Obstetrics, 2022). Nevertheless, this insidious example shows that even basic human rights have the potential to be politicised. Another reason science and politics are inseparable is that science informs political policies, and the decisions of politicians affects research funding and research-policy priorities.

Many of the phenomena in this chapter may seem absurd to scientists who, for the most part, seek truth and wish to measure the world accurately and objectively. As one scientist wrote in Nature, "science's quest for knowledge about reality presupposes the importance of truth, both as an end in itself and as a means of resolving problems. How could truth become passé?" (Higgins, 2016, para. 2).

2.2. The post-truth era, and the rise of populism

The term "post-truth" has been used by writers in the media and academics to describe the difficulties science and technical expertise have faced over the last decade or so (Lewandowsky et al., 2017; Lynch, 2020). The era has been described as an age "that denigrates knowledge, dislikes expertise and demonizes experts" (Applebaum, 2017, para. 1). Shaping public opinion via appeals to emotion or personal beliefs rather than objective facts is problematic as it can weaken the public's ability to make informed choices and therefore threaten democracy (Berinsky et al., 2014). In 2016, the EU referendum in the UK (Brexit) and Trump's presidential election in the US resulted in post-truth being named the Oxford Dictionaries Word of the Year (Oxford Languages, 2016). An independent fact checker rated 70% of Donald Trump's statements during his 2016 presidential campaign as false or mostly false (Lewandowsky et al., 2017). On Brexit's sixth anniversary, the Evening Standard described Brexit as a "campaign based on lies" (Gill, 2022, para. 2). Furthermore, in the UK during the 2019 election, a report found that of the 6,749 Conservative Facebook Ads examined, 88% contained misinformation (Dotto, 2019).

The post-truth era has coincided with the rise of populism in politics. The defining characteristic of a populist party is its anti-establishment message (Kennedy, 2019). The policies enacted by populist governments often emphasise the importance of satisfying the will of the common people (Urbinati, 2019). They often hold anti-elite or anti-expert sentiments, and these are "often present in the rejection of scientific evidence with populist governments regularly attacking scientific evidence, especially if it contradicts their reasoning" (Bayerlein et al., 2021, p. 4) Their policies are typically quick fixes, or advocate anti-scientific attitudes. For example, Kennedy (2019) found a significant positive association between the percentage of people in a country (within Western Europe) who voted for populist parties and the number of people who believe vaccines are either unimportant or ineffective.

Following World War Two, Western European parliaments have mostly been dominated by centre-left and centre-right parties (Kennedy, 2019). Populist parties can be right wing (as they are predominantly in Europe), left wing, or reject the right-left distinction completely. Populism has been accused of "pitting the 'common sense' of a virtuous people against expert knowledge" (Gugushvili et al., 2020, p. 721). For example, during the UK's Brexit campaign, Michael Gove refused to provide evidence of economists who were in support Brexit and exclaimed "the people in this country have had enough of experts" (Mance, 2016, para. 1).

2.3. Science denialism

Anti-scientific attitudes and arguments against the scientific consensus are referred to as science denialism (Kalichman, 2014). Science denialism can occur because an individual has been convinced by misinformation (Lewandowsky & Oberauer, 2016). It can also, however, arise because the scientific consensus is at odds with an individual's politics, religion, or worldviews (Lewandowsky & Oberauer, 2016). When science is rejected due to conflict with an individual's worldview, it "is rejected on the basis of motivated identity-protective cognition that cannot be understood without consideration of the broader societal and political context" (Lewandowsky & Oberauer, 2016, p. 217).

A clear example of the motivated rejection of science due to worldview can be seen amongst people who deny human's role in climate change. Contrary to the high levels of scientific consensus, over 99% (Lynas et al., 2021), many still argue against it. Specifically, there is a partisan divide in US politics, 88% of Democrats believe that the Earth's rising temperature is due to pollution from human activities, however, only 32% of Republicans believe so

(Saad, 2021). This finding was echoed by Lewandowsky (2021a) who found that participants' political views were strongly predictive of their climate change beliefs. The more conservative participants were, the more likely they were to reject the scientific consensus and attribute the consensus to conspirational factors such as the suppression of dissent.

2.3.1. Scepticism and denialism

Science denialism differs from scepticism. Scepticism is a vital part of the scientific process. Scepticism serves to uphold science's purported self-correcting nature by maintaining high standards via processes such as peer review and replication (Schmid & Betsch, 2019). In fact, one could argue that scientists' scepticism can increase the standard of science via reforms. In recent years, science has been in the midst of a reproducibility crisis (Nosek et al., 2015). That is, findings have not been successfully repeated when tested. A collaboration of scientists who attempted 100 replications of psychological research found only 36% yielded significant results (Open Science Collaboration, 2015). Other fields have identified similarly low replication rates (Begley & Ellis, 2012). This led a group of scientists to propose "a manifesto for reproducible science" which advocated the implementation of measures such as pre-registration and Registered Reports to overcome this crisis (Munafò et al., 2017, p. 1). Uptake has been encouraging, the Center for Open Science currently reports that over 300 journals are using the Registered Reports publishing format where manuscripts are peer-reviewed prior to data collection, and therefore before the results are known (Center for Open Science, 2022). Registered Reports help to prevent poor research practices such as hypothesising after results are known (HARKING) whereby the "experimental hypothesis (H1) of a study is altered after analyzing the data in order to pretend that the authors predicted the results that, in reality, were unexpected" (Chambers, 2017, p. 18).

Denialism and denialists, on the other hand, ignore information that doesn't confirm their beliefs, or worldview, and reject science (Schmid & Betsch, 2019). A modern-day, well-known example of denialism comes in the form of Flat Earthers. The Flat Earth Society reject that the Earth is spherical and instead believe that the Earth is, as its name suggests, a flat disk shape (The Flat Earth Society, 2022). Denialists, unlike science, do not correct their beliefs as new evidence comes to light, instead, "evidence that counters a theory is re-interpreted as evidence for that conspiracy, on the notion that the stronger the evidence against a conspiracy, the more the conspirators must want people to believe their version of events" (Lewandowsky, 2021a, p. 18). Although one might wish to correct flat earthers for sanity's sake, flat earthers and their extraordinary beliefs pose little threat to public health. The rejection of scientific evidence in the face of a majority scientific consensus, however, has not been reserved for the bizarre and benign. There are many examples in public health and the dangerous repercussions of some can still be seen today.

2.3.2. Scientific consensus

Perceived scientific consensus plays an important part in the acceptance of science. For example, Lewandowsky, Gignac & Vaughan (2013) assigned participants to a scientific consensus condition or control condition (where no consensus information was issued). In the scientific consensus condition, participants received information highlighting the scientific consensus amongst climate change scientists (97% agreement that global warming is caused by burning fossil fuels). They found that participants' acceptance of science increased when the scientific consensus was highlighted. They concluded that highlighting scientific consensus could play a vital role when communicating scientific facts.

Denialists often use techniques that distort the scientific consensus and cause confusion, leading people to believe that a topic is up for debate when it is not (Kalichman, 2014). In 1953, the link between smoking and lung cancer was confirmed by scientists (Brandt, 2012). The tobacco industry, refusing to admit defeat, set into motion a new plan to purposefully confuse the public and erode trust in science (Brandt, 2012). They did this, not by demonising science, but by championing it, aligning themselves with sceptical scientists and funding further research into the link. In doing this, they successfully created the illusion that the question of whether there was a link between smoking and lung cancer was still being investigated and that there was not a scientific consensus (Brandt, 2012).

It is not only the general public who fall foul of denialism. Governments have also been misled by denialists. In 1999, an AIDS disinformation campaign misinformed the public health decisions made by the President of South Africa, Thabo Mbeki, with disastrous consequences. Despite a large scientific consensus arguing to the contrary, President Mbeki's government restricted AIDS treatment for over half a decade (Kalichman, 2014). Instead of anti-retroviral drugs, his health minister promoted the use of garlic, lemon juice and beetroot

(Associated Press, 2009; 'Debunking Science Denialism', 2019; Mail Online, 2006). A modelling study has estimated that between 2000 and 2005, more than 330,000 lives were lost (and 35,000 HIV positive babies were born) because antiretroviral drugs were not used to treat HIV/AIDS (Chigwedere et al., 2008). When the health minister who promoted the use of garlic and beetroot, Manto Tshabalala, died in 2009, the Guardian reported that Mbeki and Tshabalala "have been blamed for failing to prevent more than 300,000 deaths, according to a Harvard University study. There have been calls by activists for them to be charged with genocide" (Associated Press, 2009).

Denialism is still very much a part of today's society. There is a majority consensus (over 99%) among scientists that human activity affects the Earth's climate (Lynas et al., 2021). Governments and the media, however, have portrayed the relationship between humans and climate change as uncertain (Oreskes, 2004). In the UK, before and during his role as Prime Minister, Boris Johnson has not historically supported policies aimed at alleviating climate change (They Work for You, 2022). Before, and during his US Presidency, Donald Trump vacillated between supporting the scientific consensus and supporting denialists. In 2009 he signed an open letter, published in the New York Times, urging President Barack Obama to support climate action (Adler & Leber, 2016). But by 2012, he had changed his opinion and tweeted that "Global warming is based on faulty science and manipulated data (D. Matthews, 2017, para. 15). He also came under fire during his presidency for pressing forward with policies that undermine environmental protections (Tollefson, 2020).

One of the most problematic branches of science denialism for public health (especially during a global pandemic) is the anti-vaccination movement. Despite the unanimous agreement within the scientific community that vaccines are both needed, safe, and the most effective way to protect human health against diseases, an anti-vaccination movement has been connected to the resurgence of almost extinct diseases (Faasse et al., 2016; Reich, 2018). This form of science denialism is particularly relevant for the COVID-19 pandemic, and my thesis. Therefore, in the next section, I will discuss it in more detail.

2.3.3. The anti-vaccination movement

Vaccinations are the use of the whole or part of an infectious virus, bacterium, or other microorganism to produce an immune system response (Plotkin, 2014). This immune system response teaches the vaccinated individual’s body to produce the necessary tools to protect the individual against future infections with the real disease-causing pathogen (S. Plotkin, 2014; Z. Wang et al., 2016). Some vaccines, for example childhood vaccines, require multiple doses to achieve strong immunity, whereas others require only a single dose (Brewer et al., 2017). The effectiveness of a vaccination is measured in terms of its direct effects and indirect effects. Direct effects refer to a vaccine’s ability to protect the vaccinated individual, and indirect effects describe its ability to prevent the spread of disease throughout a population (Z. Wang et al., 2016). In the United Kingdom, vaccines are used to protect the health of the population from birth to old age. The routine immunisation programme schedules the delivery of vaccines from aged 8 weeks to 70 years old (GOV.UK, 2022e). The schedule has been carefully designed to protect people from infections at the life stage that the diseases are the most dangerous.

2.3.3.1. Vaccine hesitancy

Some people accept some vaccines but refuse others. Other people chose to delay vaccinations. Some people may agree to vaccination but not feel confident about their decision. The WHO describe vaccine hesitancy as “the reluctance or refusal to vaccinate despite the availability of vaccines” (World Health Organization, 2019b, para. 27). Vaccine hesitancy therefore describes a continuum of vaccine beliefs that range from total acceptance of all vaccines to complete refusal (MacDonald & SAGE Working Group on Vaccine Hesitancy, 2015). People who are vaccine hesitant are described in several ways. People who point blank “refuse on principle to accept a recommended vaccination are commonly referred to as vaccine refusers, vaccine sceptics or members of an anti-vaccine movement” (World Health Organization, 2017, p. 8). Vaccine refusers exist at the extreme end of the vaccine hesitancy continuum (MacDonald & SAGE Working Group on Vaccine Hesitancy, 2015). They are also referred to colloquially, for example by the media, as “anti-vaxxers”. These terms will be used interchangeably throughout this thesis.

Vaccine hesitancy is dangerous because it threatens herd immunity. Herd immunity is an indirect effect of vaccine effectiveness and refers to the vaccination levels required for the population to successfully keep diseases at bay (Hussain et al., 2018). It is the ability of immune individuals to prevent the spread of a disease throughout a population (Z. Wang et al., 2016). It works by reducing the likelihood of someone who is not immune to a disease encountering someone who has been infected by a disease (Z. Wang et al., 2016). Typically, if a disease is highly infectious, high numbers of immune people within the population are needed. Immunity can be brought about by natural immunity gained through previous exposure to a disease, or vaccination. However, this carries high risk as members of the population become ill with the disease before immunity is gained. Vaccination is a very effective way to increase herd immunity. In fact, it is so effective that it is often cited as the reason why vaccinations are a victim of their own success. Herd immunity gained through vaccinations decreases the incidence of diseases and individuals mistakenly perceive the disease to be lower risk than the vaccination and do not vaccinate (Bauch & Bhattacharyya, 2012). This phenomenon, whereby individuals do not vaccinate and rely on others' herd immunity, has been named "the free rider problem" (Bauch & Bhattacharyya, 2012).

2.3.3.2. A famous example of vaccine hesitancy

Vaccines have been described as "one of the brightest chapters in the history of science" for their transformative effect on the health and longevity of human beings (S. Plotkin, 2014, p. 12283). They are rigorously tested and monitored and are considered one of the safest medical products (Miller et al., 2015). The term vaccination was coined by Edward Jenner who derived the term from the Latin word for cowpox: "vaccinia" (Riedel, 2005). Throughout the 16th century, Jenner investigated the use of cowpox as a vaccine after it was noted that dairy maids, who had been infected with cowpox, appeared to be protected against smallpox (Riedel, 2005). Smallpox often claimed the lives of up to 30% of its victims (Bean, 2011). Therefore, one would hope that Jenner's smallpox vaccination programme would have been welcomed with open arms. Unfortunately, Jenner was attacked and often ridiculed for his work (Riedel, 2005). Nevertheless, Jenner persisted, and his work led to the beginnings of a smallpox vaccination programme which eventually led to the eradication of smallpox in the 20th century (S. A. Plotkin, 2005). We should be grateful for vaccines and Jenner's efforts, "if a vaccine had not eradicated smallpox, someone would now die from the disease every 6 seconds of every day" (Lewandowsky et al., 2021, p. 3). Nevertheless, vaccines continued to be greeted sceptically in the 18th century. For example, in 1772, in a sermon called "The Dangerous and Sinful Practice of Inoculation", Reverend Edmund Massey described vaccines as "diabolical operations" that attempted to "oppose God's punishments upon man for his sins" (Hussain et al., 2018, p. 2). Later, in the mid-19th century, the pushback against vaccines continued when the Anti-vaccination League in London was formed following the introduction of mandatory vaccination laws (Hussain et al., 2018). Thus, hesitancy, scepticism, and tentativeness towards vaccines are not modern phenomena.

Arguably, the most famous example of vaccine hesitancy due to misinformation stems from Andrew Wakefield's now retracted 1998 paper "Ileal-lymphoid-nodular hyperplasia, non-specific colitis, and pervasive developmental disorder in children" published in the Lancet (Wakefield et al., 1998). The paper insinuated links between the measles, mumps and rubella vaccine, and the developmental disorder autism. The paper is often cited as the cause of the worldwide controversy concerning the erroneous link between MMR and autism (Poland & Jacobson, 2011).

To date, no evidence has been found to support this link (e.g., (Taylor et al., 1999, 2014). The most recent notable study is a nationwide cohort study by (Hviid et al., 2019a) which followed 650,943 children born in Denmark to Danish mothers from January 1999 until December 2010. Any children diagnosed with autistic disorder, atypical autism, or Asperger syndrome were included in the outcome variable "autism". The authors also analysed subgroups of children who were at high risk of autism due to environmental or familial factors, for example, autism history in siblings. This study did not support the claim that MMR vaccination increases the risk for autism. The authors did not find a link between the MMR vaccination and autism in children at high risk of autism. Additionally, there was no evidence to suggest a clustering of autism cases following vaccination.

Following an investigation into the findings of the original paper, journalist Brian Deer found that of the twelve cases reported in Wakefield's paper, "no case was free of misreporting or alteration. Taken together, NHS records cannot be reconciled with what was published, to such devastating effect, in the journal" (Deer, 2011, p. 1). Wakefield was removed from the medical register (i.e., struck off) in 2010 (Boseley, 2018). He has since made his way to America where he has been "embraced" by anti-vaxxers, and made an anti-vaccination film, which was released in 2016, called "Vaxxed" (Boseley, 2018).

MMR vaccination rates are still suboptimal. For example, from April to June 2022, the UK failed to reach the 95% vaccination target for MMR1 (90.2%) and MMR2 (85.3%, (GOV.UK, 2022a).

2.3.3.3. Anti-vaxxers

It’s important to note that anti-vaxxers are the minority. Most parents choose to vaccinate their children (Getman et al., 2018). In 2018, the Vaccine Confidence Project surveyed vaccine confidence in Europe, that is the trust in the safety and effectiveness in vaccines as well as the healthcare system that delivers them (Larson et al., 2018). They found that across the 28 EU member states, participants had positive perceptions of vaccines. Most people agreed that vaccines are important (90%), safe (82%), and effective (88%). Regarding the MMR vaccine, 84% of participants thought that it was important, and 82% believed it was safe. They did, however, find that young adults (those aged 18-24 years and 25-34 years) were less likely to believe that the MMR vaccine is safe than adults aged over 65 years (Larson et al., 2018). In the UK, a recent survey using the Vaccine Hesitancy Scale found that up to 4% of participants reported vaccine hesitancy in all items (Luyten et al., 2019). Politically, anti-vaxxers are more likely to be on the political right (Lewandowsky & Oberauer, 2021). Reasons cited for vaccine refusal are diverse and often personal, therefore the people who deny vaccines are a very heterogenous group (World Health Organization, 2017).

The levels of vaccine hesitancy and refusal may be low, but they remain problematic. Highly infectious diseases require almost all the population to be vaccinated to maintain herd immunity. Additionally, vaccine hesitancy is not evenly distributed across the population, and geographical clusters of vaccine hesitant individuals or anti-vaxxers mean that some communities have very high levels of inadequately vaccinated people (Faasse et al., 2016; Tomeny et al., 2017).

The World Health Organisation has estimated that approximately three million deaths are avoided each year thanks to the use of vaccinations (Anderberg et al., 2011). More specifically, (Callender, 2016) calculated that if a hypothetical cohort of 4 million children born in America in 2009 received all their paediatric vaccinations, 42 thousand deaths and 20 million illnesses could potentially be prevented. These vaccinations would not only save lives and the suffering caused by disease, but it is also estimated that the monetary savings would be approximately $14 billion in direct costs and $69 billion in indirect costs (Callender, 2016). As newer, animal borne diseases such as Ebola, Zika and COVID-19 begin to infect humans, vaccinations will continue to be a key tool in protecting human health for the foreseeable future (Z. Wang et al., 2016). Vaccine hesitancy is a global phenomenon and refusal poses a real threat to the success of vaccination programmes and public health (Dubé et al., 2014).

In 2019, the World Health Organisation named vaccine hesitancy as one of the top ten threats to global health (World Health Organization, 2019b). It placed alongside antimicrobial resistance, a global influenza pandemic, air pollution and climate change. Thus, vaccine hesitancy is an important factor to consider when designing public health communications, especially during a pandemic.

2.4. Misinformation and media

The success of post-truth politics, populism, and the rise of science denialism has been due in part to media, particularly social media. Media has the potential to affect public health in several ways. Misinformation within news stories on television, in newspapers and on the radio can create media firestorms that can decrease trust in science and play a role in public health. The everyday misreporting of health-related in the media can also erode the public's trust in science and medicine (Cooper et al., 2012; Schwitzer, 2008). More recently, with the advent of social media, news has moved to an online digital universe where information, and misinformation, can be shared and consumed more easily than ever before. In this section I will give an overview of news media, the internet, and social media. I will also describe the potential influence they may have over the public's health behaviours.

2.4.1. News Media

Periods of intense news media coverage can have lasting effects on public health (Hussain et al., 2018). For example, Wakefield's erroneous "MMR-autism" paper created a media firestorm (Bauch & Bhattacharyya, 2012), and the fallout from this paper has seen the unsubstantiated "link" between the MMR vaccination and autism named as the "most damaging medical hoax in 100 years" (Hussain et al., 2018, p. 5).

Another example of the link between intense media coverage and health-related behaviour is the statins controversy over whether the risks associated with taking statins outweighed their benefits. Matthews et al. (2016) conducted an interrupted time series analysis of prospectively collected data to investigate whether intense media coverage was associated with changes in statins initiation or cessation. They found no evidence for changes in statin initiation among patients with a high risk of cardiovascular disease or patients who had recently experienced a cardiovascular event (such as myocardial infarction or stroke). They did, however, find a relationship between patients who were already taking statins (due to their high risk of cardiovascular disease or experience of a cardiovascular event) and cessation. The period of intense media coverage was followed by an increased rate of cessation in both groups (odds ratio 1.11 (95% confidence interval 1.05 to 1.18) and 1.12 (1.04 to 1.21), respectively). These heightened levels of cessation returned to normal, predicted levels after six months (A. Matthews et al., 2016). Dr Liam Smeeth, one of the study's authors, commented "Our findings suggest widespread coverage of health stories in the mainstream media can have an important, real-world impact on the behaviour of patients and doctors. This may have significant consequences for people's health" (Boseley, 2016, para. 6).

2.4.1.1. False journalistic balance

News media have since been criticised as their methodologies, which under normal circumstances promote good journalism, feed into the denialism narrative. This potential source of confusion is false journalistic balance. Journalists strive for balance and accuracy when covering topics of debate (Boykoff & Boykoff, 2004). Balance requires journalists to be bipartisan and therefore include the opinions of individuals who are for and against the issues at hand (Antilla, 2005). For example, if a journalist is covering a controversial issue such as the death penalty, it is expected that they will present information on both sides of the debate.

Difficulties arise, however, when scientific evidence favours one side of the argument. When one side is overwhelmingly supported over another, presenting two arguments side by side presents the public with a false balance: each side of the argument appears equal (Murdoch & Caulfield, 2018). Presenting information in this way, when there is one favoured view, can create the illusion of uncertainty where none exists (Clarke, 2008). Examples of balanced reporting skewing the level of certainty and elevating the opinion of a non-expert minority to the same level of an expert majority can be seen in both health and non-health related fields. Furthermore, the authenticity and expertise of each party is not always equal. When discussing whether climate change is real, one television panel in Australia consisted of a climate policy consultant who was a former climate change advisor to Tony Blair.

Counterarguments were provided by a “weather expert” and self-confessed psychic/magician who “predicts” the weather using moon and solar cycles and whose previous work included a book on cat palmistry (Lewandowsky et al., 2012; Readfearn, 2011).

A study investigating whether vaccine judgements can be influenced by falsely balanced reporting found participants were more likely to believe that there was not a scientific consensus for the autism-vaccine controversy (Dixon & Clarke, 2013). They also found participants who read balanced news articles reported that they were less certain that autism is not caused by the MMR vaccine. False journalistic balance, therefore, can obstruct effective communication of health information and weaken perceptions of science.

2.4.2. The internet and social media

With the advent of the internet and social media consumption of both science-related and political information has switched from physical newspapers to online newspapers and social sites such as Facebook, YouTube, Twitter, and Pinterest. The average person's role in the consumption and distribution of news and other information has changed. When newspapers were in paper format, the public’s role was purely a consumer role. Nowadays, the public can use the internet to consume information, distribute it (e.g., by sharing on Facebook or retweeting on Twitter) and become an author (e.g., by tweeting, posting status updates or blogging). Information on the internet lacks the gatekeeping or policing of yesteryear when most of the information was fact checked by experts or professionals (Lewandowsky et al., 2012). Historically, the spread of information was quite slow as it relied on printed newspapers. Today, ideas can spread from one side of the world to the other in less than one second with the click of a button. This quick and easy method for the dissemination of information has many advantages, however it is also a dangerous tool in the spread of misinformation. The World Economic Forum has named massive digital misinformation as one of the main threats to society since the year 2013 (World Economic Forum, 2022).

Not all social media users were created equally. Whilst many people use social media responsibly, there are some who do not conduct themselves well online. The negative aspects of social media are exacerbated by trolls (i.e., people who use social media to argue with, upset, or confuse other users) and bots (i.e., automated social media accounts that pretend to be human; Iyengar & Massey, 2019). Trolls and bots are not distinct entities as many bots are programmed to be trolls that spread misinformation online (Iyengar & Massey, 2019).

Humans, however, may be more problematic regarding the spread of misinformation online than bots. For example, following an analysis of approximately 126,000 true and false stories shared on Twitter, one study concluded that false stories spread significantly farther, faster, deeper, and more broadly than true stories (Vosoughi et al., 2018). True stories took almost six times as long as false stories to reach 1500 people, and false stories were 70% more likely to be retweeted. Falsehoods were more likely to be novel and, contrary to conventional wisdom, humans (and not bots) were found to be more likely to spread them.

Vosoughi et al. (2018) also found that politics reached the most people and was also the fastest spreading topic. Politicians have capitalised on social media and have used it as a tool to communicate with the general public. One might hope that the power of social media would be harnessed for good, however, it has been exploited. For example, social media has been used to influence voters during election campaigns (Lee, 2020). During the US presidential elections in 2016, an estimated one in four Americans visited a fake news website (A. Guess et al., 2018). Social media has aided the current state of politics. In fact, social media and its associated "echo chambers, fake websites, bots and other instruments of systematic manipulation, anonymity, simplification, polarization and the brutalization of language are generally regarded a key component, if not the major cause of post-truth politics" (Braun, 2019, p. 433).

2.5. The COVID-19 pandemic

2.5.1. The post-truth era, and the rise of populism

Early in the pandemic, Dr Susan Erikson, a medical anthropologist who was working in Sierra Leone during the Ebola outbreak, noted:

> I am struck by the similarities between the early days of the COVID-19 pandemic and the West African Ebola outbreak. In both cases, denialism and an initial slow response proved deadly, albeit understandable: humans don't tend to quickly embrace changes to their circumstances, no matter where they are in the world. Defiance of social-distancing and home-isolation imperatives is common (Erikson, 2020, p. 441).

The UK Government have been criticised for its slow response to the COVID-19 pandemic. In his book, The COVID-19 Catastrophe, the Editor-in-Chief of the Lancet, Professor Richard Horton, wrote that the UK Government's "moderate" risk assessment of COVID-19's threat to the UK population was a "genuinely fatal error of judgement" (Horton, 2020, p. 54). He also stated that "this failure to escalate the risk assessment led to mortal delays in preparing the NHS for the coming wave of infection" (Horton, 2020, p. 54).

In October 2021, the House of Commons published their enquiry "Coronavirus: lessons learned to date". They reported that the UK Government's poor decisions on "lockdowns and social distancing during the early weeks of the pandemic—and the advice that led to them—rank as one of the most important public health failures the United Kingdom has ever experienced" (Health and Social Care, and Science and Technology Committee, 2021, p. 32). The report noted that "if the national lockdown had been instituted even a week earlier 'we would have reduced the final death toll by at least a half'" (Health and Social Care, and Science and Technology Committee, 2021, p. 32). The enquiry also pointed out disparity in COVID-19 outcomes, particularly the "unacceptably high death rates amongst people from Black, Asian and Minority Ethnic communities" (Health and Social Care, and Science and Technology Committee, 2021, p. 9). The report concluded that the disparities between White people and Black, Asian and minority ethnic people are due to inequalities in society and the economy. For example, "greater likelihood of jobs that come with higher exposure to covid infection; more challenging social and economic circumstances; more densely occupied housing; and comorbidities from different health conditions" (Health and Social Care, and Science and Technology Committee, 2021, p. 105).

In fact, it wasn't just the UK who performed poorly, populist governments overall did not perform optimally. The majority of "populist governments downplayed the severity of the virus, suggested unfounded quick and short-term fixes, and strongly avoided regulations like wearing masks or limiting private interaction" (Bayerlein et al., 2021, p. 4). In the US, Gollwitzer et al. (2020) suggested that political partisanship was linked to COVID-19 behaviour and outcomes. They found that counties with a high proportion of the votes were for the Republican party (Donald Trump) had lower physical distancing than the counties who voted for the Democratic party (Hilary Clinton). Analyses also revealed that the reduced physical distancing was connected to an increase in COVID-19 infection and fatality rates.

2.5.2. Science denialism

Uscinski et al. (2020) examined U.S. adults' beliefs in two COVID-19 conspiracy theories: 1) the danger posed by COVID-19 had been exaggerated to harm President Trump, 2) the coronavirus was made and spread on purpose. They found that denialism, that is "the psychological predisposition to reject expert, authoritative information" (Uscinski et al., 2020, p. 2), was one of the strongest predictors of belief in the two myths.

In the UK, anti-vaccine and so called "freedom" protests have been organized by anti-vaccine and conspiracy groups such as Save Our Rights UK (https://saveourrights.uk/), and "World Wide Demonstration" (Ondrak & Wildon, 2021). The UK arm of a worldwide anti-vaccination and anti-lockdown rally at Trafalgar Square (organised by World Wide Demonstration) took place on July 24th, 2021. It hosted conspiracy theorists David Icke, Gillian McKeith and Piers Corbyn, and far-right commentator Katie Hopkins (Pyman, 2021; Stubley, 2021). The group behind the World Wide Rally for Freedom has voiced QAnon, other conspiracy beliefs, and Islamophobia (Ondrak & Wildon, 2021). Protesters held signs depicting slogans such as "We're the lions! In a world of sheep" and "Jabs + 5G genocide wake up!!" (Pyman, 2021). During the event Kate Shemirani, a former nurse who was struck off by the Nursing and Midwifery Council in June 2021 for spreading COVID-19 misinformation (Stubley, 2021) addressed the crowd. She called for the names of healthcare professionals to be recorded and compared them to Nazis stating, "At the Nuremberg Trials, the doctors and nurses stood trial and they hung" (Rawlinson, 2021; Sky News, 2021; Wadhera, 2021). Sky News reported that Shemirani has previously referred to vaccination teams as "death squads" and nicknamed the NHS as "the new Auschwitz" (Sky News, 2021). Her comments have caused concern for the doctors and nurses who have worked tirelessly throughout the pandemic. Rallies like the one described above are concerning because they may attract newcomers and "lead to further radicalization" (Ondrak & Wildon, 2021, p. 1).

Furthermore, conspiracy theorists have not just held up signs at protests. False claims linking 5G to the spread of COVID-19 (e.g., "5G WiFi networks are responsible for the rapid spread of the coronavirus") have been circulating since early in the pandemic (Full Fact, 2020g). The 5G conspiracy theory has resulted in attacks on telecommunication engineers and 5G masts in multiple countries (Jolley & Paterson, 2020). For example, in the UK, Openreach engineers, who do not work directly on the 5G network, have been "assaulted, spat on, and forced to flee groups of angry people because of baseless fears that the new mobile phone standard poses a risk to health and is linked to the coronavirus" (Hern, 2020, para. 2). One study investigated the relationship between COVID-19 conspiracy theories and violence (Jolley & Paterson, 2020). They found that belief in the 5G conspiracy theory was positively correlated with the justification of violence (e.g., "I am quite willing to use physical violence to assert my interests") and willingness to use violence (e.g., "I think it's good if there are people who also use violence to bring back order"). Anger mediated the role between 5G conspiracy beliefs and violent responses to the alleged 5G-COVID-19 link. That is, conspiracy belief was positively correlated with anger which was subsequently associated with the justification of real-life and hypothetical violence in response to the 5G-COVID-19 link. Thus, the repetition of false information and science denialism is dangerous. It should be taken seriously, and attempts should be made to prevent others from becoming misled and potentially radicalised.

2.5.3. Media and social media

Social media was arguably the most problematic form of media during the pandemic. Some of the unvaccinated COVID-19 victims and their families have cited social media sites, such as Facebook and YouTube, as the source of anti-vaccination misinformation. One might ask whether communication (or poor communication) is a determinant of vaccine hesitancy. When assessing whether communication is a determinant of vaccine hesitancy, the SAGE Working Group on Vaccine Hesitancy concluded that communication was a tool (or a service) and not a determinant of vaccine hesitancy (MacDonald & SAGE Working Group on Vaccine Hesitancy, 2015). They noted

> Poor quality services of any type, including poor communication, can undermine acceptance. This can be a problem in any setting. In high income countries with well-resourced vaccination programs, inadequate or poor immunization program communications can increase vaccine hesitancy and outright refusal (MacDonald & SAGE Working Group on Vaccine Hesitancy, 2015, p. 4163).

For example, acceptance of the HPV vaccine in the US was hindered by its initial licensure and poor communication/marketing as it was aimed at adolescent girls and not boys (Brewer et al., 2017). News media was also involved in the spread of COVID-19 misinformation, and political ideology was connected to misinformation within news media. For example, one study found that right-leaning news outlets, such as Fox News, were more likely to report

COVID-19 misinformation than left-leaning news. Additionally, people who reported consuming the right-leaning media were more likely to express misinformed views, for example they were more likely to think that public health experts had over-estimated the severity of COVID-19 (Motta et al., 2020).

Humans, particularly those with certain political beliefs, were found to be important in the spread of COVID-19 misinformation online. One study investigated the most influential accounts behind the #FilmYourHospital conspiracy theory campaign on (Gruzd & Mai, 2020). The #FilmYourHospital campaign claimed that quiet hospitals (and hospital car parks) provided proof that COVID-19 was a hoax. The theory failed to consider that most hospitals had suspended clinics, patients weren't allowed visitors, and lockdowns meant that fewer people were injuring themselves. They found that the most influential accounts behind the campaign on Twitter were humans (98%), and not bots. In particular, the conspiracy theory was spread by far politically far right groups and conservative personalities.

During the COVID-19 pandemic, Facebook reported several ways in which they achieved the "largest worldwide campaign to promote authoritative information about COVID-19 vaccines" (Jin, 2021, para. 1). They accomplished this by giving £88 million in free advertising to Governments, Non-Governmental Organisations, and United Nations agencies; helping people to find information about where to get vaccinated; sharing reliable information about COVID-19 and vaccines; and increasing their efforts to remove COVID-19 and vaccine misinformation from Facebook and Instagram (Jin, 2021).

Despite these positive steps, however, Facebook and social media sites have also contributed to the spread of misinformation. Anecdotally, as well as citing social media sites, such as Facebook, as the source of anti-vaccination misinformation (BBC News, 2021; Independent, 2021). Some victims of the disease have taken to social media to express how much they regret refusing the vaccine. One 44-year-old male, who had attended anti-lockdown protests, wrote:

> Those of you that have stayed connected to me have seen posts that can now be described as grossly wrong on the subject of lockdowns, masks, and restrictions … I apologise to all those that I have offended and argued

> with. If you are still in the Covid-19 hoax or Covid overreaction camp, please believe the virus is painfully real (Kale, 2021, para. 21).

Following an online search of Twitter in February 2020, Kouzy et al. (2020) found that 25% of COVID-19 related tweets contained misinformation. Most misinformation came from informal/personal group accounts, and unverified accounts posted more misinformation than verified accounts. The authors concluded "medical misinformation and unverifiable content pertaining to the global COVID-19 epidemic are being propagated at an alarming rate on social media" (Kouzy et al., 2020, p. 7).

Yang et al. (2021) examined Facebook posts between 1st March 2020 to 1st March 2021. They included posts that contained nine important COVID-19 vaccine misinformation topics, for example, vaccines alter DNA. They found that approximately half of the COVID-19 vaccine posts contained misinformation, and the other half were fact checking posts. More fact-checking posts (29%) repeated misinformation within their correction versus facts alone (19%). Furthermore, fact-checker posts that included misinformation within their correction received significantly more comments than other types of posts. However, they found that misinformation spreaders (such as fake news accounts, Trump-supporting groups, and anti-vaccine groups) had a larger number of connections and more central positions in the misinformation URL co-sharing network than fact checkers. Thus, misinformation spreaders are effective communicators on social media.

2.6. Summary

The spread of both the coronavirus and misinformation about the disease has been aided by social and political phenomena. In this chapter I discussed how trust in science has been eroded by the emergence of a post-truth era within politics (Lewandowsky et al., 2017). In this era, truth does not hold the high status it was once afforded, and political campaigns have been characterised by misinformation (Berinsky et al., 2014; Lewandowsky et al., 2017).

The post-truth era has coincided with the rise of populism within politics which claims to represent the "will of the people" but often advocates anti-scientific attitudes (Bayerlein et al., 2021; Kennedy, 2019; Urbinati, 2019). Anti-scientific attitudes and arguments against the scientific consensus are referred to as science denialism (Kalichman, 2014). Science denialism opposes the scientific consensus on many issues such as global warming

(Lewandowsky, Gignac, et al., 2013; Lynas et al., 2021). One of the most problematic branches of science for public health is the anti-vaccination movement which seeks to deter people from accepting vaccinations (Callender, 2016; Faasse et al., 2016; Tomeny et al., 2017). The success of the post-truth era, populism, and science denialism has been due in part to media, particularly social media (Bauch & Bhattacharyya, 2012; Schmid & Betsch, 2019).

Populist governments have not performed optimally throughout the pandemic (Bayerlein et al., 2021). Studies have found that countries with right-leaning populist politics are less likely to comply with social distancing measures and are more likely to have higher infection and fatality rates (Gollwitzer et al., 2020). Within Europe, the majority of far-right parties initially pointed out the danger posed by COVID-19, however, they reversed this narrative once "the number of cases had peaked, and some even started to spread misinformation" (Wondreys & Mudde, 2022, p. 88). In line with this, right-leaning politicians and activists were found to be more likely to spread misinformation on social media (Gruzd & Mai, 2020; Motta et al., 2020).

During the COVID-19 pandemic, one quarter of tweets on Twitter (Kouzy et al., 2020), and approximately half of the posts on Facebook contained misinformation (Yang et al., 2021). Fact-checkers on Facebook made up approximately 50% of the remaining posts on Facebook, however, they were less centralised and had fewer connections than posts containing misinformation (Yang et al., 2021).

When social media users are engaging with information online, how do they judge whether the claims they are reading are true or not? Are humans good at judging whether information is true or not? If people believe the misinformation they read online, can this misinformation be effectively corrected? I will address these questions in Chapter 3.

Additionally, in Chapters 8 and 9, I will explore vaccine concern. This was motivated by (Nyhan & Reifler, 2015) who, in short, found that participants who reported being extremely concerned" or "very concerned about the side effects from vaccines showed lower intentions to obtain the influenza vaccine after a myth-busting intervention. In Chapter 9 I will test whether participants with strong concerns about vaccine side effects can correct their beliefs using three correction formats. In Chapter 8 I will investigate whether vaccine acceptance, that is how likely someone is to get a COVID-19 vaccination, is affected by vaccine concern.

Chapter 3. Making truth judgements

In Chapter 2, I explained how the post-truth era, populism, science denialism and social media created a perfect storm for COVID-19 and its associated misinformation. Distrust of science and anti-scientific beliefs during the COVID-19 pandemic has seen people take to the streets to protest against protective measures such as mask-wearing and COVID-19 vaccines. Furthermore, people have been attacked and telecommunication masks destroyed following the propagation of and belief in the conspiracy theory that 5G has influenced the spread of COVID-19.

In this chapter, I will start by discussing the five types of questions people usually refer to when making truth judgements. I will then describe how our truth judgements can be led astray by phenomena such as the illusory truth effect. Finally, I will explain how misinformation can continue to influence our beliefs following correction.

3.1. Introduction

Are social media users good at making truth judgements? How do they know if the information they are engaging with is true (or not)? “Virtually all human cultures have some prohibition against lying” (Serota et al., 2010, p. 2). Irrespective of this, humans are frequent tellers of tales and lie an estimated 1.65 times a day (Serota et al., 2010). Examples of lying can be found in most areas of life from the dinner table (that meal was delicious), to online dating, advertising, politics, and the media. Just as lying can cause harm to others, failure to judge information accurately can lead to poor decisions and behaviours. For example, convicting the wrong person of a crime, or choosing not to vaccinate our children. Our ability to accurately judge the veracity of information has far reaching implications. In psychology, many studies have been undertaken to determine how people make veracity decisions, and whether we are any good at it.

In short, humans are not very good at making truth judgements. After reviewing 206 studies, Bond and DePaulo (2008) found participants correctly identified lies between 31% and 73% of the time and reported an average lie-truth discrimination rate of 54%. Bond and DePaulo also identified that lies were rated as true more than truths were classified as lies. This bias towards rating deceptive messages as true has been said to reflect the high rate at which true statements exist in daily life. In our daily lives, most of the statements we encounter are “mundane and true” (Brashier & Marsh, 2020, p. 501). This bias was considered by (Gilbert,

1991) who explored how humans believe information. He noted “people are credulous creatures who find it very easy to believe and very difficult to doubt” (Gilbert, 1991, p. 117). Gilbert suggested that we accept things to be true by default and this process is likely involuntary. (Lewandowsky et al., 2012) agreed adding that “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 intention of cooperative conversation into question” (p 112).

During the COVID-19 pandemic, many rumours were circulating that COVID-19 was manmade, for example, “scientists believe that coronavirus may have come from bats in a Chinese research facility” (Full Fact, 2020f, para. 1). These claims spread despite there being no credible evidence available to support them (Full Fact, 2020a). At the beginning of the pandemic, in March 2020, Uscinski et al. (2020) used a representative survey of U.S. adults to examine how widespread beliefs about COVID-19 conspiracy theories were. They found that almost one third of participants (31%) believed the myth that the virus was purposefully created and spread.

Statements that contradict well known facts are less likely to be believed than statements that contradict little known facts (Begg et al., 1992). For example, the falsehood “tangerines are blue” is less likely to be believed than “the duck-billed platypus has two sex chromosomes”. It is common knowledge that tangerines are orange, however, it is not commonly known that the duck-billed platypus violates mammalian norms and has ten sex chromosomes (Khamsi, 2020). In a pandemic such as COVID-19, however, most information is new and therefore it is not always possible to rely on common knowledge. Additionally, some COVID-19 misinformation manipulated common, familiar, knowledge to appear more trustworthy. For example, the NHS recommends treating a sore throat with warm, salty water (NHS, 2021). Early in the pandemic, a false claim featuring advice on how to treat coronavirus with salty water began circulating on Facebook. The claim wrongly suggested that “gargling water mixed with salt or vinegar eliminates the new coronavirus from your throat” (Full Fact, 2020b, p. 1). Fact checkers were quick to refute the claim stating that there was no evidence to support the gargling of salt to treat COVID-19; and repeating the NHS’ advice that “there is currently no specific treatment for coronavirus” (Full Fact, 2020b).

When making judgements of truth, we can approach the problem analytically or intuitively. The analytic process, perhaps unsurprisingly, is cognitively demanding and uses mental resources such as our prior knowledge to judge whether information is false. Analytic answers are cognitively demanding, and we do not always possess the ability, or resources, to answer questions of veracity using this method (Schwarz & Jalbert, 2021). When we do not have enough information to process a claim analytically, for example if we are unsure about someone's credentials, we fall back on intuitive factors. The intuitive process is quick and less demanding (Schwarz & Jalbert, 2021).

3.1.1. The Big Five of truth assessment

In general, when making truth judgements, research has demonstrated that we typically refer to a limited number of questions known as "the Big Five of truth assessment" (Schwarz, 2015):

1. Is the claim shared by others?
2. Is the claim supported by evidence?
3. Is the claim supported by my other beliefs?
4. Is the claim coherent?
5. Is the claim from a credible source?

Each of the Big Five questions can be answered analytically or intuitively. Intuitive answers are based on heuristics, or rules of thumb, such as familiarity and processing fluency. Intuitive responses have been described as "a key gatekeeper for whether people will further engage with the message using a critical eye or just nod along in agreement" (Schwarz & Jalbert, 2021, p. 74) as people rarely engage critically with a claim unless it feels intuitively wrong. This means that our judgements can be led astray if misinformation is familiar or processed fluently. I will give examples using each of the Big Five criteria below.

3.1.1.1. Is the claim shared by others?

If a claim is shared by others or there is a perceived social consensus, people are more likely to believe that the claim is true. For example, Lewandowsky et al. (2013) found that when the scientific consensus amongst climate change scientists (97% agreement that global warming is caused by burning fossil fuels) was highlighted, participants' acceptance of science increased. To evaluate whether a claim is believed by others, we can approach the question analytically and research public opinion polls or survey our friends and family. This method is time consuming and resource intensive, therefore people frequently rely on intuitive processing, such as familiarity, to judge social consensus (Schwarz & Jalbert, 2021). For example, Weaver et al. (2007) found that participants who read the same opinion three times from one person in a focus group estimated that the focus group was more in support of an issue than participants who only read one opinion from the same person. Thus, repetition skewed the participants' judgements of social consensus and subsequently their judgements.

3.1.1.2. Is the claim supported by evidence?

To answer the question "is the claim supported by evidence?" analytically, we can conduct a literature search on the internet or in libraries etc. for evidential information, or even rely on our memory (Schwarz & Jalbert, 2021). Alternatively, we can intuitively assess whether a claim is supported by evidence by the ease at which we can retrieve evidence for a claim from our memory. Tversky and Kahneman (1973) described the availability heuristic whereby the strength of the associative bonds is used to make judgements about frequency. because the associative bonds between items in our memory are strengthened by repetition. Tversky and Kahneman demonstrated the availability heuristic using several experiments. For example, in one experiment they found that when 19 names of well-known famous men were read out to participants alongside a list of 20 lesser-known famous women (or well-known famous women and lesser-known men), the participants recalled the famous list more easily than the less famous list. They also judged there to be more people in the well-known famous list than the lesser-known list. Thus, the quantity of names was influenced by the ease at which participants could recall the name.

3.1.1.3. Is the claim supported by my other beliefs?

Naturally, claims that match our other beliefs are more likely to be rated as true. It is illogical to hold beliefs that we believe are false. Or current beliefs and knowledge can be led astray by processing fluence. This was demonstrated by Song and Schwarz (2008) using the Moses illusion. To test for the Moses illusion, participants are presented with the question "How many animals of each kind did Moses take on the Ark?" Despite knowing that it was in fact Noah, and not Moses who built the Ark, the Moses illusion often results in participants responding "two" instead of picking up on the discrepancy. Song and Schwarz manipulated the question's processing fluency by presenting it in an easy-to-read font (black Arial font size 12) or a difficult-to-read font (grey Brush Script size 12; see Figure 3.1). They found that participants were more likely to answer the question incorrectly (i.e., answer “two” instead of “don’t know”) when the font was easy to read (88%) than when the font was difficult to read (53%). Thus, the ease at which we process information can mislead our beliefs.

Figure 3.1.

An example of the materials used by Song and Schwarz (2008)

How many animals of each kind did Moses take on the Ark?

How many animals of each kind did Moses take on the Ark?

Note: The question “How many animals of each kind did Moses take on the Ark?” was either presented in an easy-to-read font (black Arial font size 12) or a difficult-to-read font (grey Brush Script size 12).

3.1.1.4. Is the claim coherent?

Information is more likely to be rated as true if it is coherent (Schwarz & Newman, 2017). “Coherence can be determined through a systematic analysis of the relationships between different pieces of declarative information” (Schwarz & Jalbert, 2021, p. 75). Alternatively, coherence can be assessed intuitively by how easy a claim is to process. Claims that are coherent can be processed fluently whereas those that are incoherent are processed disfluently, they don’t feel right and are flagged for further inspection. Thus, our judgements of coherence can be swayed by the same factors that influence processing fluency such as the or the font that the information is written in (Song & Schwarz, 2008).

3.1.1.5. Is the claim from a credible source?

Information from credible sources is more likely to be believed than information from non-expert sources (Fazio et al., 2019). The heuristic that “experts are usually correct” if often a helpful shortcut when making truth judgements (Fragale & Heath, 2004). We can gage someone’s credibility and expertise by looking at their achievements, qualifications, affiliations, past behaviour. However, many of our memories for factual information do not contain source information or information about how the information was obtained (Henkel

& Mattson, 2011). Subsequently, repetition can make a name or source appear more familiar and therefore more credible (Lewandowsky et al., 2012). This pattern, whereby repetition of information from an unreliable source increased how truthful statements were rated, has been shown with delays ranging from a few days to four weeks (Henkel & Mattson, 2011).

3.1.2. Taking a wrong turn

Using the Big Five of truth assessment, I highlighted how our intuitive judgements can be led astray by familiarity, repetition, and processing fluency (i.e., how easy it is to process a statement). These phenomena can help to explain why we make mistakes when assessing the veracity of misinformation. They also related to one of the arguments against presenting misinformation during correction. I will discuss them in the next section.

3.2. Illusory truth effect

Why are false claims such as “gargling salt water can cure COVID-19” believed? One potential explanation is the illusory truth effect (or repetition truth effect; Brashier & Marsh, 2020; Cook & Lewandowsky, 2011). It was first proposed by Hasher et al. (1977) who found that when they experimentally manipulated the number of times participants viewed a claim, the repeated statements were rated as truer than the new claims.

Inferring truth from repetition alone may be considered illogical as seeing a statement twice provides no additional information or evidence to support the claim. Begg et al. (1992) referenced how a philosopher called Wittgenstein likened it to “buying a second newspaper to see if the first one was right” (p. 446). Nevertheless, the illusory truth effect has been observed for statements presented in both written (Arkes et al., 1989) and oral formats (Gigerenzer, 1984) across a broad range of topics including trivia (Bacon, 1979), fake headlines (Pennycook et al., 2018) and advertising (Johar & Roggeveen, 2007).

Fazio and Sherry (2020) investigated when people begin to use repetition as a heuristic for making truth judgements. They compared the truth ratings of five-year olds, ten-year olds, and adults. They found that participants rated repeated statements as true more often than new statements regardless of their age. They concluded that we begin to learn the association between repetition and truth from a very young age.

3.2.1.1. Warnings about misinformation

(Dechêne et al., 2010) conducted a meta-analytic review of 51 studies examining the truth effect. They concluded that the truth effect is of a medium effect size (with confidence intervals (CI) ranging between d = .32 and d = .55). (Brashier et al., 2020) argued that the medium effect size observed by Dechêne et al. may be a conservative estimate as, unlike everyday life, the participants in the studies were warned that they would see true and false information. Generally, false information is rarely accompanied by a warning (Lewandowsky et al., 2012a). (Jalbert et al., 2020) tested whether the illusory truth effect is smaller when participants are warned that the experiment contains both true and false information. Using three experiments, they demonstrated that warnings reduced the size of the truth effect by approximately half. Even after a delay of three to six days, repeated statements were rated as more true than novel statements. Common paradigms testing for the illusory truth effect often contain warnings and therefore the illusory truth effect's effect sizes have been underestimated in the literature. Warnings reduced the influence of repetition, but they did not help participants to distinguish between factually true and factually false statements.

Fazio et al. (2022) noted that despite decades of research into the illusory truth effect in laboratory studies, very little is known about how repetition influences beliefs in naturalistic situations. Most laboratory studies repeated information up to three times in one to sittings. In the real world, however, misinformation can be viewed up to hundreds of times over a much longer timescale (i.e., multiple days or weeks). Fazio et al. sent participants five text messages per day. There were twenty-eight possible trivia statements that the participants could receive. Ten of them were key statements, half of these statements were true, and half were false. They were presented to participants 1, 2, 4, 8 or 16 times. The remaining eighteen statements functioned as filler items. Participants received five text messages a day and were asked to respond by rating how interesting each statement was. On the last day of the experiment, participants received a final link to a survey which asked participants to rate the accuracy of statements. They found that repetitions increased mean truth ratings. Echoing the results of previous work (DiFonzo et al., 2016) they also found that the increase was logarithmic, that is the initial repetition led to the highest increase in truth ratings. The truth ratings also continued to increase throughout all sixteen exposures (Fazio et al., 2022). Repetitions increased truth ratings for both the true and false trivia statements. Therefore, the first few repetitions of misinformation are the most harmful as they result in larger increases in truth ratings (Pillai & Fazio, 2021).

3.2.1.2. Prior knowledge

Paradigms testing for the illusory truth effect generally contain two phases: the exposure phase and the test phase. During the exposure phase, participants view a set of claims. Then, following a delay, which can vary from a short delay of minutes (Arkes et al., 1989) to a longer delay lasting months (Brown & Nix, 1996), participants view claims and make truth ratings. Traditionally, unfamiliar statements that participants won't know are true or not (i.e., ambiguous claims) are used in paradigms investigating the illusory truth effect such as "The zipper was invented in Norway" (Dechêne et al., 2010, p. 238). Vague, or ambiguous, statements are used to reduce the likelihood of participants basing their truth judgements on prior knowledge (Fazio et al., 2015).

In their meta-analysis, (Dechêne et al., 2010, p. 241) noted that the truth effect "disappears when the actual truth status is known". More recently, however, experiments have demonstrated that people are influenced by cues such as repetition even when they have the correct prior knowledge. For example, Fazio et al. (2015) investigated whether prior knowledge protected against the illusory truth effect. They tested whether the illusory truth effect was reliant on the absence of knowledge. They found that repetition resulted in higher truth ratings for all statements, regardless of whether the participants had correct knowledge. If participants read an incorrect statement during the exposure phase (e.g., "a dart is the name of the object hit back and forth by ice hockey players"), their truth ratings during the test phase were increased even though they knew the correct answer (e.g., they could correctly answer "puck" to the question "What is the name of the object hit back and forth by ice hockey players?" There was no significant interaction between repetition and knowledge; that is the illusory truth effect occurred when both known and unknown statements were repeated. Fazio et al. concluded that even when people have knowledge, they can sometimes fail to retrieve it and instead rely on intuition, or fluency cues (see Section 3.2.3. The processing fluency explanation).

Studies of the illusory truth effect have been criticised as, like (Fazio et al., 2015), most have failed to explicitly measure participants' knowledge prior to completing the illusory truth manipulations. Many, like Fazio et al., used normed statements databases to select questions that were likely to be known and unknown to participants. One criticism stated, "since the knowledge check occurred after the experimental randomization of statements, it is possible that what people were able to remember during the knowledge check was affected by whether the statement was new or repeated in the experiment” (Fazio et al., 2020, p. 5). To overcome this methodological criticism, (Fazio et al., 2020) measured participants’ knowledge and then invited them back to complete an illusory truth study two weeks later. Fazio found that repeated statements were given higher truth ratings than new statements. This was true even when the participants’ prior knowledge was contradicted. Prior knowledge did not protect participants from the illusory truth effect. In addition to overcoming prior knowledge, the illusory truth effect has been demonstrated using implausible statements such as “the Earth is a perfect square” (Fazio et al., 2019, p. 1706). Thus, even farfetched misinformation, if repeated, may become more plausible.

Memory research typically distinguishes between our episodic memory and semantic memory. Episodic memory refers to our personal memory or conscious recollection of our day-to-day experiences, whereas semantic memory, represents our general knowledge, that is the feeling of familiarity or knowing in the absence of remembering (Yonelinas, 2002). Recollection is more effortful than familiarity as it requires a more conscious effort to recall contextual details such as a specific time or place (Wang et al., 2018). Familiarity, however, is considered to be an automatic process that does not invoke reliving as the individual knows the information (Wang et al., 2018). For example, many people know that the Greek God Hades has a three headed dog called Cerberus (Fry, 2017).

Wang et al. (2018) attempted to disentangle recollection and familiarity using known and unknown statements to examine activation of brain areas associated with the two retrieval processes. Contrary to the behavioural studies, they found that known statements were retrieved from memory through familiarity, whereas unknown statements were retrieved through recollection. Moreover, known statements produced faster reaction times than unknown statements. This is consistent with known statements utilising an automatic and familiarity-based process, whereas unknown statements, which were retrieved via recollection, used a slower controlled process.

Relatedly, Begg et al. (1992) investigated source recollection, statement familiarity and the illusory truth effect. They found that truth judgements are influenced by source recollection and statement familiarity, however, these are independent from each other. They suggested that recollection is controlled and intentionally engages memory processes. However, repetition's impact upon perceived truth is unintentional and automatically occurs following exposure to a statement. Despite having very accurate recognition memory, participants did not spontaneously use this process and information to stop the illusory truth effect (which is driven, at least in part, by familiarity).

3.2.1.3. Considerations for public health

An important consideration for public health campaigns is that the illusory truth effect can also occur without the original information being presented in the exact way it was first viewed. That is, statements that match previously studied topics, or single words, can yield higher truth ratings (Begg et al., 1985). For example, the (true) statement "the planet Saturn is less dense than water and could float in a bathtub" (NASA, 2017) would yield higher truth ratings if the topic "Saturn" was familiar. During public health crises such as the COVID-19 pandemic, the topic "COVID-19" is constantly discussed by news outlets, friends, and family.

Furthermore, this effect has been demonstrated when cautious language (epistemic qualifiers) is used. When we make judgements, we often use epistemic qualifiers such as "impossible", "unlikely", "doubtful", and "improbable" to communicate uncertainty. Stanley et al. (2019) investigated the long-term effects of qualifiers by asking whether later truth judgements reflected the way in which the original claim was qualified. As noted previously, prior exposure to singular words can increase truth ratings (Begg et al., 1985). In multiple experiments, Stanley et al. presented participants with statements that had been positively or negatively qualified (e.g., "certain" and "impossible"). They found that, after a two-day delay, the epistemic qualifiers did not influence the participants' truth judgements. Even when the researchers ensured that the qualifiers had been encoded and could be recalled correctly, illusory truth effects were still observed. Thus, despite having correct knowledge stored in memory, the participants failed to use it when assigning truth judgements. In Experiment 4, only negative epistemic qualifiers were used and therefore familiar statements should have been biased towards doubting a claim and assigning a low truth rating. However, they found that the old previously negatively qualified statements were still given higher truth ratings than new statements. They concluded that these findings have far reaching implications for decision makers operating in several fields such as law, medicine, and intelligence.

3.2.2. Familiarity

Originally, it was believed that familiarity could account for the illusory truth effect. Repeated statements are more familiar than novel statement and this increased familiarity leads to higher truth ratings (Arkes et al., 1989). Arkes et al. suggested that the using familiarity to infer truth is not completely illogical and hypothesised that “true statements are more likely to be repeated than are false ones, all other things being equal” (p. 91). Therefore, familiarity can be used as a shortcut or heuristic to judge truth. There are, however, circumstances under which truth effects occur without any prior exposure to the stimulus. To understand why this might happen, we need to consider other explanations.

3.2.3. The processing fluency explanation

Historically, the dominant explanation of the illusory truth effect has been processing fluency. Processing fluency has been linked to the illusory truth effect and familiarity because it is easier to process and understand familiar information than unfamiliar information (Ecker, Lewandowsky, et al., 2020). This subjective experience of ease when processing information is referred to as a metacognitive experience (Schwarz, 2015). When we first encounter information, we must engage many different thought processes to create a mental representation of the information. The second time we encounter a piece of information, we can call upon this mental representation and the information is easier to process and processed more fluently, and it is more likely to be judged as truthful (Unkelbach, 2007).

Just as familiarity can aid fluency, fluency can lead “to feelings of familiarity, and this is used as a meta-cognitive cue in conjunction with the heuristic that familiarity is correlated with truth” (DiFonzo et al., 2016, p. 23). Thus, it appears that the relationship between familiarity and fluency is bi-directional. Familiarity can aid fluency and easy retrieval of information can be mistaken for familiarity (ten Brinke & Weisbuch, 2020).

The metacognitive experience of processing fluency can explain the occurrence of truth effects when familiarity, or repetition is absent. For example, it can explain why people are more likely to rate easy to process statements as true than difficult to process statements (Song & Schwarz, 2008).

Processing fluency has been demonstrated using a variety of methods. For example, Reber and Schwarz (1999) manipulated the clarity of statements by presenting them in colours that varied the ease at which they could be read against a white background. They found that statements presented in the easy-to-read colours were rated as true more often than the moderately visible colours. For example, the true statement “Mars’ gravity is about a third of the strength of the Earth’s” is more likely to be rated true when it is written in blue than when it is written in yellow (see Figure 3.2.; NASA, 2017). The higher contrast between the blue text and white background (compared to the yellow text and white background) makes the blue font easier to read and therefore process (Dechêne et al., 2010). This was supported by Unkelbach (2007) who presented participants with well known and unknown facts in either high-contrast or low-contrast font colours. The study found that the fluent, high-contrast statements were rated as true more often than the disfluent, low-contrast statements. This effect has also been used using rhyming aphorisms. Rhyming aphorisms for example “Woes unite foes”, were more likely to be rated as true than non-rhyming aphorisms such as “Woes unite enemies” (McGlone & Tofighbakhsh, 2000, p. 426).

Figure 3.2.

A statement presented in blue (fluent) and yellow (disfluent)

Mars’ gravity is about a third of the strength of the Earth’s
Mars’ gravity is about a third of the strength of the Earth’s

Note: Reber and Schwartz (1999) found that processing fluency mediated the relationship between familiarity and illusory truth. Statements were more likely to be believed if they were presented in the colour blue compared to the colour yellow.

During a global pandemic, knowledge and expertise are shared internationally and public health advice is given by many well-respected experts and scientists who have non-English names and who speak with foreign accents. (Lev-Ari & Keysar, 2010) found that when participants listened to statements spoken by non-native English speakers, they were less likely to rate the statement as true. Furthermore, during a Trust Game where participants had to decide whether to transfer their tokens to another player, a trustee, to “invest” their money. Zürn and Topolinski (2017) found that players transferred their money to players with easy to pronounce names, even when the names were artificially produced and therefore less likely to be labelled by participants as foreign. Similarly, Silva et al. (2017) manipulated the usernames and reputations of sellers via simulated eBay profiles. The eBay sellers who had easy to pronounce names were rated as more trustworthy than the sellers whose names were of medium difficulty to pronounce. Therefore, processing fluency has potentially far-reaching effects on truth and trust ratings during a pandemic. When an individual shares their expertise truth and trust ratings should not be based upon their accent or name. These findings, therefore, have social justice implications.

3.2.3.1. Non-probative photos

Human communication is not always limited to a singular source of communicative information, for example, a written statement or audio recording. Human interaction has historically been face-to-face and relied on the integration of both verbal and nonverbal information. For example, when communicating, humans integrate verbal and non-verbal communication to make judgements. Using video recordings, ten Brinke and Weisbuch (2020) demonstrated that the consistency of a speaker’s, or sender’s, verbal and nonverbal communication is important. They found that when a sender’s non-verbal and verbal behaviour was consistent, it was processed more fluently than when they were at odds and was more likely to be rated as true.

Similarly, written text is often accompanied by images. In a series of experiments using nonprobative photos (i.e., photos that did not give additional information that could help answer a question), Newman et al. (2012) demonstrated that nonprobative photos increase truthiness. Truthiness was increased for both “true” and “false” equally. It was also increased irrespective of whether the claims were about whether celebrities were alive or if the claims were about general knowledge. For example, participants were more likely to rate the false claim “macadamia nuts are in the same evolutionary family as peaches” (Newman et al., 2012, p. 973) as true if it was accompanied by a photo of macadamia nuts. The authors surmised that the nonprobative photos may have aided fluency and consequently increased the participants' perceptions of truthiness.

Fenn et al. (2013) used the same materials and procedures as Newman et al. (2012), however, they invited the participants back to complete truthiness ratings of statements (without any photos) after a 48-hour delay. They found that the effect observed by Newman et al. whereby nonprobative photos increased truthiness persisted after two days. The distorting effects of photos upon people's judgements has implications for social media. A recent study by Fenn et al. (2019) simulated a social media environment and showed participants 96 statements that either appeared with or without a photograph. The participants were told that they were viewing a beta version of a webpage and were invited to give feedback for each statement about whether they liked it, if they would share it and whether they thought that the statement was true. They found that the participants liked statements more if they were accompanied by a photo. Participants were also more likely to share posts if they contained a photo (irrespective of whether the post contained true or false information). Participants shared posts if they liked its content and believed the information to be true. The authors warned that the presence of photos within posts on social media, could increase the likelihood that false information is shared.

3.2.4. Combatting the illusory truth effect

One way to reduce, but not eliminate, the truth effect is to warn participants that some of the information they will see will be false (Jalbert et al., 2020). A recent approach has tested whether asking participants to engage critically with information can combat the effect. Using four experiments, Brashier et al. (2020) investigated whether prompting participants to engage with internal fact checking (i.e., to search their memory) can protect them from the illusory truth effect. Participants were asked to engage in fact checking upon their first exposure to the claims. They found that asking participants to focus on the accuracy of claims protected them from the illusory truth effect if they had the relevant knowledge (i.e., correct information stored in memory). Interestingly, in Experiment 4, Brashier et al. extended the delay between exposure and test from immediate testing (used in Experiments 1-3) to two days. This allowed them to investigate the longer-term effects of fact checking on the illusory truth effect as this delay is more representative of how information is acquired and used in the real world. In Experiment 4, the participants also completed a knowledge check. They found that participants who were not requested to fact check showed an illusory truth effect for the claims they had correct information for and the claims they did not. Participants who were asked to fact check also demonstrated an illusory truth effect for the claims they did not have knowledge for. However, the illusory truth effect did not occur (even after a two-day delay) for the participants who were asked to fact check claims that they had correct knowledge for. The authors concluded "in addition to considering the source, our findings suggest that we can simply ask ourselves *is this true?*" (Brashier et al., 2020, p. 5).

3.3. Continued influence effect

The illusory truth effect demonstrates that we can wrongly judge false information to be true. When such instances occur, how easy is it to correct the misinformation? One might hope that upon correction, the misinformation would cease to be believed, however, the reality is not so simple. Even when misinformation is corrected, it can linger and continue to influence an individual's memory and reasoning (Ecker, Lewandowsky, et al., 2020; Hamby et al., 2020). The phenomenon whereby misinformation is corrected but continues to influence memory, is referred to as the continued influence effect (Chan et al., 2017; Lewandowsky et al., 2012; Paynter et al., 2019). This effect poses a challenge for public health and can also be problematic in politics and voter decision making.

Misinformation affects many of the most important and potentially dangerous issues in politics. It "has in some cases prevented human societies from recognizing environmental threats like climate change, embracing potentially valuable innovations such as genetically modified foods and effectively countering disease epidemics like HIV/AIDS" (Flynn et al., 2017, p. 127). Other examples of the continued influence effect include the mistaken belief that Barack Obama was born outside of the United States (he was born in Hawaii; Lewandowsky et al., 2012), and the erroneous link between the MMR vaccination and autism (Hviid et al., 2019a).

Paradigms testing for the continued influence effect of misinformation often use a stimulus narrative whereby participants read a situation report. Two types of report are typically used. One in which critical information pertaining the cause of the situation is included, and another in which the causal information is omitted (Ecker & Antonio, 2021). A popular stimulus narrative is one in which a warehouse fire is described. In the condition containing information about the cause of the fire, the participants read that a short circuit occurred near a cupboard full of paint and gas cylinders (Ecker, Lewandowsky, Swire, et al., 2011; Johnson & Seifert, 1994). For a subset of participants, this information is then corrected: the participants are told that the cupboard was empty. A test phase follows during which participants answer comprehension questions and answer questions about the stimulus narrative to assess whether they can recall the retraction. The number of times participants refer to the corrected misinformation (i.e., the cupboard was full of paint and gas cylinders) is used as the dependent variable to measure the continued influence effect. Research employing this paradigm have repeatedly found that retractions do not work, participants continue to be influenced by misinformation.

The continued influence effect has been demonstrated with multiple common myths such as "We only use 10% of our brain" (Ferrero et al., 2020), "Eating before swimming gives you cramps" (Sinclair et al., 2020), and "Liars sometimes give themselves away by physical 'tells' such as not looking you in the eye" (Swire et al., 2017). It has also been observed with both emotionally laden and non-emotional information (Ecker, Lewandowsky, & Apai, 2011).

In their meta-analysis, Chan et al. (2017) proposed that the persistence of misinformation in the face of correction had a large effect size (d = 0.75-1.06). Walter and Tukachinsky (2019), however, criticised the limited scope of Chan et al.'s meta-analysis (they only included eight studies). Walter and Tukachinsky (2019) conducted a meta-analysis that included randomised experiments that compared attitudes of people who had been exposed to corrected misinformation and those who had not been exposed to misinformation. This allowed them to identify the extent to which correction interventions sent the individuals' attitudes and beliefs back to a baseline level. They proposed that if corrections fully corrected misinformation, then there would be no difference between the group who had been exposed to misinformation and those who had never viewed the misinformation in the first place. They included 32 individual studies in their review and found evidence for a significant, weak, and negative continued influence effect (r = –.05, confidence interval = –.10, –.01, p = .045). That is, corrections did not fully revert people's beliefs to their baseline levels. The misinformation continued to have a small and significant effect on beliefs following correction.

3.4. Summary

In this chapter I explored how we automatically engage our intuitive truth judgement processed when reviewing a claim's veracity. When we engage with a statement using an intuitive, rather than an analytical process, our truth judgements can be led astray by familiarity and processing fluency. Research has found that when information is repeated, it is rated as more truthful than novel information (Arkes et al., 1989). Even when we have correct prior knowledge, we can still succumb to the illusory truth effect (Fazio et al., 2015, 2020). The effect has even been demonstrated with implausible statements such as "the Earth is a perfect square" (Fazio et al., 2019, p. 1706). Familiarity was believed to account for the illusory truth effect, however there are circumstances in which illusory truth effects occur without any prior exposure to the information (DiFonzo et al., 2016). Thus, the processing fluency account, whereby the ease at which information is processed influences truth ratings, has been proposed (Ecker, Lewandowsky, et al., 2020). For example, the colour, or font in which a claim is presented can affect truth ratings (Reber & Schwarz, 1999).

One way to reduce but not eliminate the truth effect is to warn participants that some of the information they will see will be false (Ecker et al., 2010). It highlights the stickiness of misinformation (Lewandowsky et al., 2020). One might hope that upon correction, the misinformation would cease to be believed, however, the reality is not so simple. Even when misinformation is corrected, it can linger and continue to influence an individual's memory and reasoning (Ferrero et al., 2020; Sinclair et al., 2020; Swire et al., 2017).

The heightened truth ratings brought about through repetition have led some researchers to question whether misinformation should be presented during correction (Cook & Lewandowsky, 2011). Does the presentation of misinformation make the misinformation easier to remember and therefore more likely to be rated as true when encountered again? I will explore how and if misinformation should be presented within public health campaigns in Chapter 4.

Chapter 4. A brief history of debunking recommendations

> In Chapter 3 I described how the illusory truth effect can increase truth ratings via familiarity and processing fluency. Warning participants that they will encounter true and false information can decrease the illusory truth effect, but it does not eliminate it. When misinformation is corrected, it can continue to influence our memory and reasoning.
>
> The heightened truth ratings brought about through repetition led some researchers to question whether misinformation should be presented during correction (Cook & Lewandowsky, 2011). For example, when correcting the myth “honey, pepper ang ginger can treat the coronavirus” (Full Fact, 2021b), should public health campaigns repeat the myth, or only provide the fact (i.e., “there is no evidence that eating honey, pepper and ginger can treat COVID-19 infections”). The repetition of misinformation may lead to higher truth ratings. In fact, the inclusion of misinformation during correction has been hotly debated in the misinformation literature. Some believed it should be excluded whereas others argued that misinformation can aid correction as it allows the misinformation and the correction to link up in memory (Kendeou et al., 2014). In this chapter, I will describe a brief history of debunking recommendations and the arguments for and against the inclusion of misinformation. I will conclude the chapter with where the literature stands today.

4.1. Introduction

The way in which humans form their beliefs and make truth ratings is complex. Our beliefs can be influenced by phenomena including social factors (e.g., whether a source is credible or whether others believe a claim), cognitive factors (e.g., familiarity and processing fluency) and emotional factors (e.g., the emotive appeals of anti-vaxxers; Ecker et al., 2022). Facts alone, or a scientific consensus on an issue are not enough to ensure accurate attitude formation or truth judgements (Simis et al., 2016). Even when facts are known misinformation can continue to influence beliefs (Fazio et al., 2015). It is therefore wrong to assume that myths can be corrected simply by “packing more information into people’s heads” (Cook & Lewandowsky, 2011, p. 1). Nevertheless, science communication has historically been built upon the information deficit model which posits that providing factual information will overcome ignorance and correct false beliefs (Simis et al., 2016). Nowadays, two key correction strategies have been identified. The first strategy is pre-emptive (prebunking) as it aims to help people identify and resist misinformation before they encounter it (Ecker et al., 2022). The second strategy is reactive (debunking) as it aims to address and correct specific myths (Ecker et al., 2022). Both strategies, prebunking and debunking, have been deployed to counter misinformation during the COVID-19 pandemic.

4.1.1. Prebunking

Prebunking aims to prevent misinformation from sticking by building individuals' resilience to misinformation before they come across it (Lewandowsky et al., 2020). The concept of prebunking was first proposed by McGuire, a social psychologist, (McGuire, 1961a, b) who built upon inoculation theory and described prebunking as akin to using vaccines to protect the body from invading pathogens. However, instead of physically protecting an individual, prebunking provides a psychological inoculation via a weakened dose of misinformation. For example, prebunking has been successful within the context of climate change. It presents people with a dose of misinformation (and the reason why it is wrong) to help them psychologically resist misinformation in the future (van der Linden, Leiserowitz, Rosenthal, & Maibach., 2017).

To be effective, prebunking messages must contain the following two components: 1) An explicit warning to caution individuals that there is impending threat of being misled 2) A refutation of the method used to (Cook et al., 2017; Vivion et al., 2022). In practice, this means providing people with logical fallacies that are common within misinformation arguments. For example, Cook et al. (2017) used the inoculation technique to counter misinformation about climate change. At the time of their experiment, 97% of scientists agreed that global warming is caused by humans, thus there was a large scientific consensus. A common technique used by climate change deniers is to cast doubts on the scientific consensus by keeping a "debate" alive in the public via fake "experts" and false balance withing media coverage (Cook et al., 2017). In their experiment, Cook et al. found that providing participants with information about scientific consensus and explaining the potentially misleading effect of false-balance media coverage before they encountered misinformation neutralised the negative influence of false balance misleading media coverage. Prebunking is a useful tool as it tackles misinformation more broadly and not on a myth-by-myth basis.

A limitation of the prebunking method, however, is its broadness. During public health crises such as COVID-19 "it is often specific pieces of misinformation that cause concern, which call for more specific responses" (Ecker et al., 2022, p. 21). For example, an article was recently shared on social media which falsely claimed that "by the end of February everyone in the UK who has received a Covid-19 vaccine will have Acquired Immunodeficiency Syndrome (AIDS)" (Full Fact, 2022c, para. 5). Warning about false journalistic balance will not provide a specific enough intervention to correct the misinformation and in this case, the debunking strategy would be more effective. Furthermore, during the COVID-19 pandemic, misinformation about the virus preceded the rise of COVID-19 in many countries (Gallotti et al., 2020). It was, therefore, not always possible to pre-empt misinformation. In such cases, misinformation must be corrected reactively (Lewandowsky et al., 2020).

4.1.2. Debunking

Debunking is perhaps the more recognisable correction strategy as it the one we most often encounter in our daily lives. On the surface, it appears simple: if there is a myth, say why it is wrong. However, there has been much debate within the scientific literature about the most effective way to structure a correction. Throughout the years there have been many debates and recommendations about the structure of correction formats but until recently, the formats had not been experimentally tested to identify the most effective (Swire-Thompson et al., 2021). Most of the debate has been about whether misinformation should be present during correction. In the next sections, I will provide a brief history of debunking.

4.2. Beware of the backfire effects

The first debunking handbook opened with the following: "Debunking myths is problematic. Unless great care is taken, any effort to debunk misinformation can inadvertently reinforce the very myths one seeks to correct" (Cook & Lewandowsky, 2011, p. 1). The handbook's focus was primarily on three sorts of backfire effects: the familiarity backfire effect, the overkill backfire effect, and the worldview backfire effect. I will discuss each of the backfire effects and the problems they were believed to cause in this section.

4.2.1. The familiarity backfire effect

Familiarity backfire effects have been proposed to inadvertently strengthen beliefs in misinformation as repeating information makes it easier to remember (Lewandowsky et al., 2012; Swire et al., 2017). Familiarity backfire effects have been linked to two processes. The first is related to the illusory truth effect: by presenting the myth we make it more familiar and increase its processing fluency and therefore the likelihood that it will be recalled (Swire et al., 2017). That is, the misinformation would take precedence over the correct information and a continued influence effect would be observed. Additionally, the strengthened excitatory links to the misinformation within the information network would mean that when the individual encountered factual information (or counterevidence), it would be incoherent with the information within the network. An inhibitory link would be formed, and the information would incorrectly be rated as "false" (Unkelbach et al., 2019). The second process is related to familiarity and the speed at which different types of information are forgotten. The misinformation, for example the myth that "the MMR vaccination causes autism", persists in memory longer than contextual information, for example the additional "myth" or "false" information accompanying the MMR myth (Peter & Koch, 2016).

There has been some confusion in the literature about the definition of the familiarity backfire effect. For example, Peter and Koch (2016) proposed that the backfire effect is characterised by misinformation being falsely remembered as true. They found that participants were more likely to demonstrate a backfire error, and remember false items as true, than they were to misremember true items as false (fact-false error). They found that the backfire errors increased significantly more than fact-false errors after a 5-day delay. However, Peter and Koch's categorisation of a myth-mislabelled-as-a-fact error as a backfire error has been criticised (e.g., (Swire et al., 2017). They argue that backfire effects occur when a correction ironically strengthens belief in myths relative to a baseline measurement or control with no correction and not when originally false information is misremembered as true. This is the definition I will use in this thesis.

Skurnik et al. (2007) is an oft cited but unpublished paper demonstrating the familiarity backfire effect. They investigated whether presenting participants with a myth busting flyer, published by the Centers for Disease Control and Prevention (CDC), containing information about flu vaccinations. Participants were split into three conditions: myth busting, fact only or control. Participants in the myth busting condition read a flyer containing myths and facts about flu vaccines. The fact only flyer contained only the facts about flu vaccines. The control participants did not read a flyer and only answered the questionnaire. After reading the flyer, participants answered questions about the flu and information included in the flyers. They also indicated whether they intended to get the flu vaccine. Immediately after viewing the flyers, the participants in both conditions could correctly identify which statements were myths or facts. After 30 minutes, however, participants in the myth busting condition "showed a clear tendency" to wrongly identify the myths as facts (Skurnik et al., 2007, p. 4). The participants in the myth busting condition also had lower intentions to have a flu vaccination. The researchers concluded "The common 'facts & myths' format, used in many public information campaigns, runs the risk of spreading misinformation in an attempt to discredit it" (Skurnik et al., 2007, p. 6).

4.2.2. The worldview backfire effect

Just as our worldview, or personal ideology, shapes our truth ratings, it also plays a role in the perseverance of misinformation (Lewandowsky et al., 2012). People are more likely to evaluate information that matches their beliefs as true because it is illogical to hold beliefs that we know are not true (Fragale & Heath, 2004). For example, it would be nonsensical to hold the belief that grass is purple. Worldview backfire effects are said to occur when corrective information challenges an individual's beliefs. People are motivated to generate counterarguments to defend their beliefs and make a case against the new information (Cook & Lewandowsky, 2011). Nyhan and Reifler (2010) noted that if people argue against the corrective (or unwelcome) information vigorously enough, they may end up with more information to support their attitudes than before the debate. This may then lead them to form stronger, or more extreme, attitudes and opinions.

People have been shown to hold onto false beliefs if the retraction is not consistent with their beliefs in areas such as politics (Swire-Thompson, Ecker, et al., 2020) or their favourite brands (Cheng et al., 2012). The worldview backfire effect is like the familiarity backfire effect in that following the presentation of corrective information, an individual's attitudes towards the misinformation become stronger. Instead of familiarity driving the effect, however, it is the individual's prior beliefs, or opinions (i.e., their worldview; Cook & Lewandowsky, 2011). There has been some ambiguity in the literature about which backfire effect, familiarity or worldview, has taken place. The backfire effects from two studies, Pluviano et al. (2017) and (2019), were reported as familiarity backfire effects, however, as noted by Swire-Thompson et al. (2020), the true cause of the backfire effects are unclear. Both papers used materials about vaccination which, as noted in Chapter 2, is a highly polarised topic.

A notable worldview backfire effect paper is Nyhan and Reifler (2010). In a series of experiments, they sought to correct pre-existing political misperceptions about contemporary American politics (e.g., the war in Iraq, tax cuts and stem cell research). Participants read mock newspaper articles containing a statement reinforcing a widespread misperception. They were randomly assigned to either read a corrective statement directly below the misinformation (or not). Participants were then invited to complete a series of questions. In study 1, participants read the misinformation "There was a risk, a real risk, that Saddam Hussein would pass weapons or materials or information to terrorist networks, and in the world after September the 11th, that was a risk we could not afford to take" (p. 324). And, depending on the condition, the correction the Central Intelligence Agency had "released a report that concludes that Saddam Hussein did not possess stockpiles of illicit weapons at the time of the U.S. invasion in March 2003, nor was any program to produce them under way at the time" (p. 324). They found that that the effect of correction varied by ideology. Participants who identified as a conservative and who received a correction stating that Iraq did not have weapons of mass destruction, were more likely to believe in the misinformation than controls.

Nyhan and Reifler (2010) conducted a second study to test the generality of the backfire effect observed in their first study. They failed to find a backfire effect in their second experiment for weapons of mass destruction. In fact, they observed the opposite, conservatives were more likely to believe that Iraq did not have weapons of mass destruction. They did not demonstrate a backfire effect when examining stem cell research. However, when examining the falsehood that tax cuts stimulated economic growth and increased government revenue, they found another backfire effect amongst conservative participants. The correction increased belief in the misperception that tax cuts increased government revenue amongst participants who identified as conservatives. They concluded that the success of corrections can vary according to an individual's worldview. In some cases, the corrections can fail or "even worse, they actually strengthen misperceptions among ideological subgroups in several cases" (Nyhan & Reifler, 2010, p. 323).

Further evidence to support the presence of worldview backfire effects has been found when correcting political misinformation (Ecker & Ang, 2019; Nyhan et al., 2013), climate change (Hart & Nisbet, 2012; Zhou, 2016), and vaccine misinformation (MMR vaccine: Nyhan et al., 2014; influenza vaccine: Nyhan & Reifler, 2015).

4.2.3. The overkill backfire effect

It has been suggested that providing too many counterarguments or corrective information can also backfire. This is referred to as the overkill backfire effect (Cook & Lewandowsky, 2011). As discussed previously, the ease at which information can be accessed or recalled can affect our evaluations. Tversky and Kahneman (1973) posited that strong and easily recalled bonds are rated as more frequent than weak bonds that are difficult to recall. Research has found that people hold stronger attitudes (Haddock, 2010), rate themselves as more assertive (Schwarz et al., 1991), and are more likely to buy something (Novemsky et al., 2007) when they have generated few rather than many arguments. (Schwarz et al., 2007) theorised that the more examples one must recall, the less compelling they become.

4.2.4. Recommendations: Beware of the backfire effects

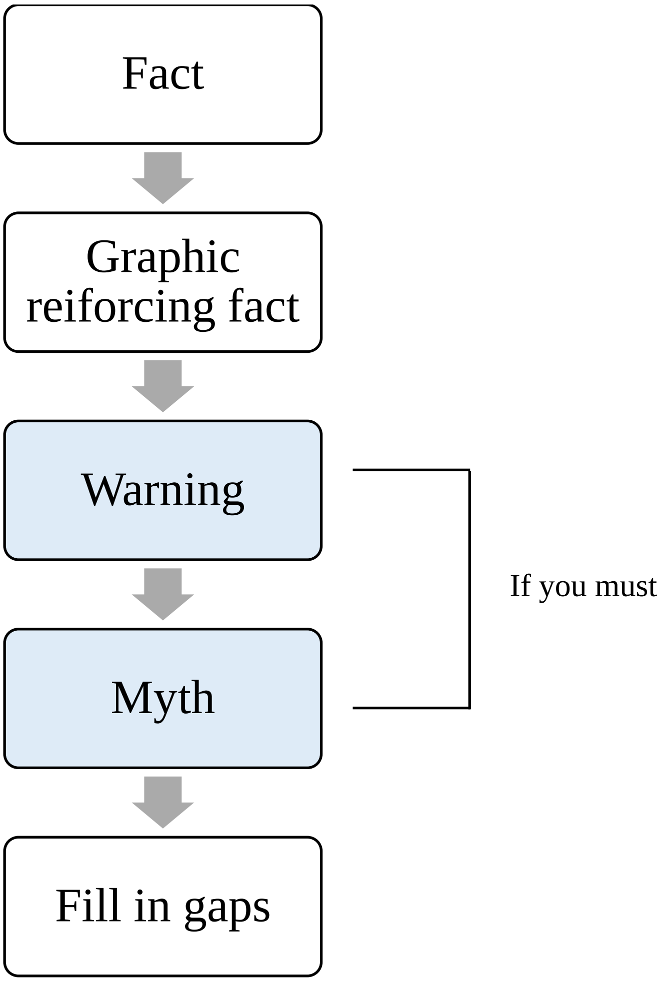
Historically, researchers were concerned about inadvertently causing more damage during correction. This is because backfire effects were believed to result in corrections "backfiring". Instead of correcting misinformation they reinforced it.

The first Debunking handbook (Cook & Lewandowsky, 2011) was very mindful of backfire effects and the dangers of inadvertently reinforcing misinformation during correction. The handbook explored the different types of backfire effects that may impact correction (i.e., the familiarity, overkill, and worldview backfire effects).

Cook and Lewandowsky (2011), therefore, proposed that to avoid familiarity effects the myth should be avoided. In cases where it cannot be avoided, they outlined the following four components of an effective debunking: core facts, explicit warning, alternative explanation and graphics (Figure 4.1). The key fact should be communicated in the headline and be followed by an opening paragraph in which the core fact is reinforced. The reader should then be presented with an explicit statement to warn them that the upcoming information is a myth. Following the presentation of the myth, the gap created by the debunking should be filled with relevant information to support the fact. Cook and Lewandowsky (2011) also recommend that the core fact should be supported with an infographic, that is the core facts should be shown graphically.

Figure 4.1.

Recommendations from The Debunking Handbook (2011)



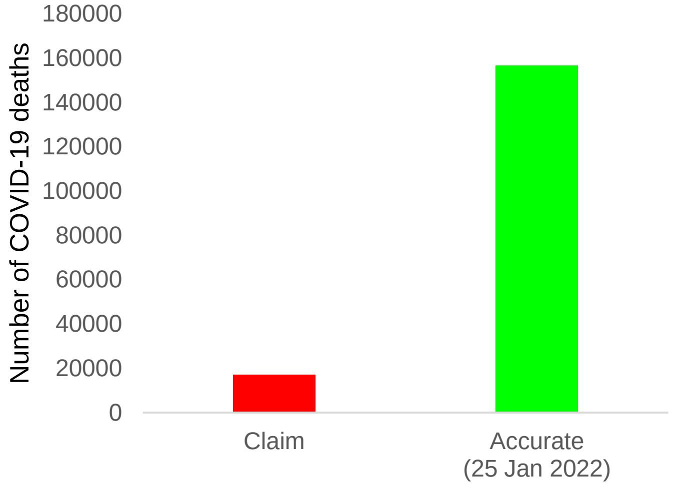
We can use these recommendations to debunk a myth about COVID-19. For example, in February 2022, Full Fact fact checked a COVID-19 claim made by a guest on the Joe Rogan Experience podcast (Full Fact, 2022a) The podcast has been highly criticised for its dissemination of COVID-19 misinformation (Full Fact, 2022b). In the episode, broadcast on 19 February 2022 (but recorded around 25 January 2022), a guest called Maajid Nawaz falsely claimed that data from the Office of National Statistics (ONS) shows that only 17,000 people had died from COVID-19. Nawaz's claim is based on data from the Office of National Statistics (2022). However, the "17,000" statistic he uses does not refer to the total number of people who have died from COVID-19. The 17,000 refers to the number of COVID-19 deaths amongst those who had no other health conditions noted on their death certificate. To suggest that the figure represents to total number of deaths is highly misleading and underestimates the number of people who died from COVID-19. According to the recommendations above, the myth should be corrected as shown in Figure 4.2.

Figure 4.2.

Debunking example using Cook & Lewandowsky (2011) recommendations

The total number of deaths from COVID-19 on 25 January 2022 was 156,594

On 25 January 2022, the data showed that in the UK, 156,594 COVID-19 deaths had been recorded



This large number of COVID-19 related deaths is reported on the UK Government's website. The number represents the number of people who dies within 28 days of a positive COVID-19 test.

However, a guest on the Joe Rogan Experience podcast, Maajid Nawaz, wrongly reported a much lower figure during his appearance.

He incorrectly claimed, "The Office for National Statistics in the UK through a Freedom of Information request has just revealed the number of people who died solely from COVID with no other co-existing illness: 17,731" (Full Fact, 2022a).

This claim is based on data from the Office of National Statistics (2022). However, it refers to the number of COVID-19 deaths amongst those who had no other health conditions noted on their death certificate. To suggest that the figure represents to total number of deaths is highly misleading and underestimates the number of people who died from COVID-19.

One criticism of this recommendation is that it relies on the opportunity to present those who have been misled with material containing lots of information about why or how they were misled and how to overcome it. Public Health campaigns often communicate information via posters which do not typically contain as much text as the recommendations suggest.

4.3. Backfire effects are elusive

When the second debunking handbook was published in 2020 (Lewandowsky et al., 2020), backfire effects had taken a back seat. Although they had been extensively discussed in the misinformation literature, researchers had started to notice their scarcity.

Wood and Porter (2019) sought to understand more about worldview backfire effects. They noted that Nyhan and Reifler (2010) observed worldview backfire effects for highly salient issues (weapons of mass destruction and tax cuts) but did not find any for the less salient and more technical issue (stem cell research). Wood and Porter conducted a series of five studies with more than 10,100 participants. Their materials consisted of 52 commonly misconstrued policy areas that represented important ideological symbols along the political spectrum. Nevertheless, they did not find evidence of any backfire effects. Swire-Thompson et al. (2020) conducted a thorough review of studies investigating both familiarity and worldview backfire effects. They found that neither worldview nor backfire effects occurred consistently in the literature and named them non-robust phenomena. They recommended that “fact-checkers can rest assured that it is extremely unlikely that, at the broader group level, their fact-checks will lead to increased belief in the misinformation” (Swire-Thompson, DeGutis, et al., 2020, p. 292).

After observing the scarcity of backfire effects, Ecker et al. (2020) identified one situation in which they may yet arise. They investigated whether corrections could spread misinformation to participants who had not previously encountered the misinformation. They questioned whether corrections debunking novel misinformation could familiarise participants with the misinformation and thus spread the misinformation to a new audience. Participants were randomly allocated to one of four groups: no exposure control, claim-only, fact check only, claim plus fact check. Claims were presented in the same format as social media posts. Fact checks showed the claim above the word “TRUE” and a tick in green for affirmations and “FALSE” and a cross in red for corrections. The study was “designed to encourage participants to rely on familiarity during retrieval in order to maximize the possibility of observing familiarity-related backfire effects" (Ecker, Lewandowsky, et al., 2020, p. 4).

In experiment 1 they found a small familiarity backfire effect, participants who were in the fact check only condition had higher false-claim inference scores than the control participants who had never viewed the false claim or the corrective information. A further two experiments, however, failed to replicate this finding and concluded "Experiments 2 and 3 yielded substantial evidence against the presence of a familiarity backfire effect, even under conditions that should maximize reliance on familiarity and thus facilitate occurrence of familiarity backfire" (Ecker, Lewandowsky, et al., 2020, p. 20). These findings, however, do not align with those of Autry and Duarte (2021) who found that negated corrections were an unintended source of false beliefs when individuals had not been previously exposed to the misinformation.

With regards to the overkill backfire effect, recent research has found that more arguments can be more persuasive. For example, Wang and Chen (2006) investigated how young and older adults processed varying quantities of arguments, and the role of cognitive resources and motivation. They found that both young and old participants were highly influenced by argument quantity when involvement was low. When involvement was high (the participants were told that they were required to discuss the arguments with the experimenter), young participants examined the arguments carefully and changed their attitudes to the same degree regardless of the number of arguments. Older adults, however, were still influenced by argument quantity and experienced more attitude change after reading more arguments. Similarly, Ecker et al. (2019) conducted a series of three experiments investigating whether, when it comes to corrections, the more arguments the better, or whether less is more. They did not find any evidence to support the presence of an overkill backfire effect. In fact, they found the opposite, more arguments led to stronger belief reduction.

4.3.1. Recommendations: Debunk often and lead with facts

The Debunking Handbook 2020 (Lewandowsky et al., 2020) opened with advice to debunk misinformation as often as possible:

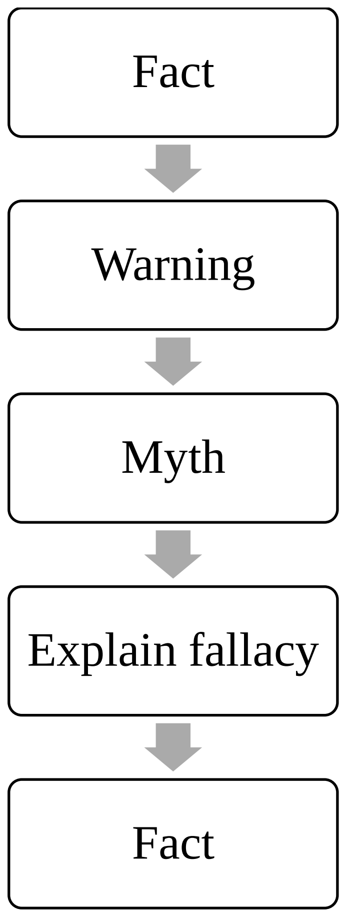
> If you cannot preempt, you must debunk. For debunking to be effective, it is important to provide detailed refutations. Provide a clear explanation of

(1) why it is now clear that the information is false, and (2) what is true instead. When those detailed refutations are provided, misinformation can be "unstuck." Without detailed refutations, the misinformation may continue to stick around despite correction attempts (Lewandowsky et al., 2020, p. 4)

In terms of correction format, the advice was still to lead with the fact, warn about upcoming information before presenting the myth once. Explain why the myth is misleading (i.e., the fallacy) and then finish the correction by reinforcing the fact (Figure 4.3). The recommendations also advised against the use of scientific or technical language and encouraged the use of graphics to aid the clear communication of statistical information (Lewandowsky et al., 2020).

Figure 4.3.

Recommendations from The Debunking Handbook 2020



4.4. Just debunk, correction format doesn't matter

Swire-Thompson et al. (2021) pointed out that many of the debunking correction format recommendations were largely based upon speculation as they had not been experimentally tested. Therefore, they identified and compared three types of correction format: myth-first, fact-first, and fact-only. I will discuss the rationale behind each format in turn.

In the myth-first condition, the misinformation was presented before the fact. This correction format is consistent with a traditional myth busting method. Presenting the myth first was hypothesised by some to be a superior correction method as it allows for the coactivation of the myth in memory. This is based upon research by Kendeou et al. (2014) and (2019) who believe that the integration of the new fact with the old incorrect myth forms the foundation of knowledge revision. Via four experiments, Kendeou et al. (2014) demonstrated that knowledge revision has five key components that form a Knowledge Revision Components Framework: 1) Any information (fact or myth) that has been encoded in memory cannot be deleted and can therefore potentially be reactivated. 2) The process whereby information is reactivated in memory is passive and therefore any information (fact or myth) can become activated and part of the conscious experience. 3) Therefore, new corrective information must be coactivated alongside old incorrect information for knowledge revision to take place. 4). Once coactivation of old and new information has taken place, the new correction can be integrated with the old incorrect information. 5) As more corrective information is encoded, it is activated more and more than the old incorrect information. Eventually activation of the incorrect information is eliminated as the correction dominates. Therefore, using a correction format that starts with the misinformation aids coactivation, allows the fact to be integrated with the myth, and leads to improved knowledge revision (Kendeou et al., 2014, 2019). It has also been proposed that when the fact is presented after the myth, it is more easily retrieved and more strongly represented in memory (i.e., the recency effect, (Baddeley & Hitch, 1993). Therefore, the myth-fist correction format should increase people's reliance on the correction and not the misinformation (Swire-Thompson et al., 2021).

In the fact-first condition, the correction, or fact, was presented before the myth. It has been argued that presenting the myth first emphasises its content and gives the communicator more control over how the message is framed (Cook & Lewandowsky, 2011; Lewandowsky et al., 2020). When the fact is presented first, some argue that the reader is more cognitively prepared for the upcoming misinformation (Swire-Thompson et al., 2021). For example, when participants were provided with warnings about upcoming information, they were less likely to exhibit the continued influence effect (Ecker et al., 2010). Additionally, in contrast to the recency effect, some argue that information that is presented first is encoded more strongly than later information (Farrell & Lewandowsky, 2002). According to Farrel & Lewandowsky (2002), the most strongly encoded information is the item that is presented first. Each subsequent item is encoded with decreasing strength. Using this rationale, the most important information (the fact) should be presented first during correction. The fact-first correction format should result in the fact being encoded more strongly than the myth.

In the fact-only condition, only the fact was presented. It is well documented that repeating information (myth or fact) makes it more likely to be rated as true (Pillai & Fazio, 2021). This phenomenon, known as the illusory truth effect (see Chapter 3.2 for a full discussion; Brashier et al., 2020) is the reason why some have called for the myth to be omitted during correction. The fact-only approach also circumvents concerns regarding familiarity backfire effects, although these have been difficult to replicate in the literature (Swire-Thompson, DeGutis, et al., 2020; Wood & Porter, 2019).

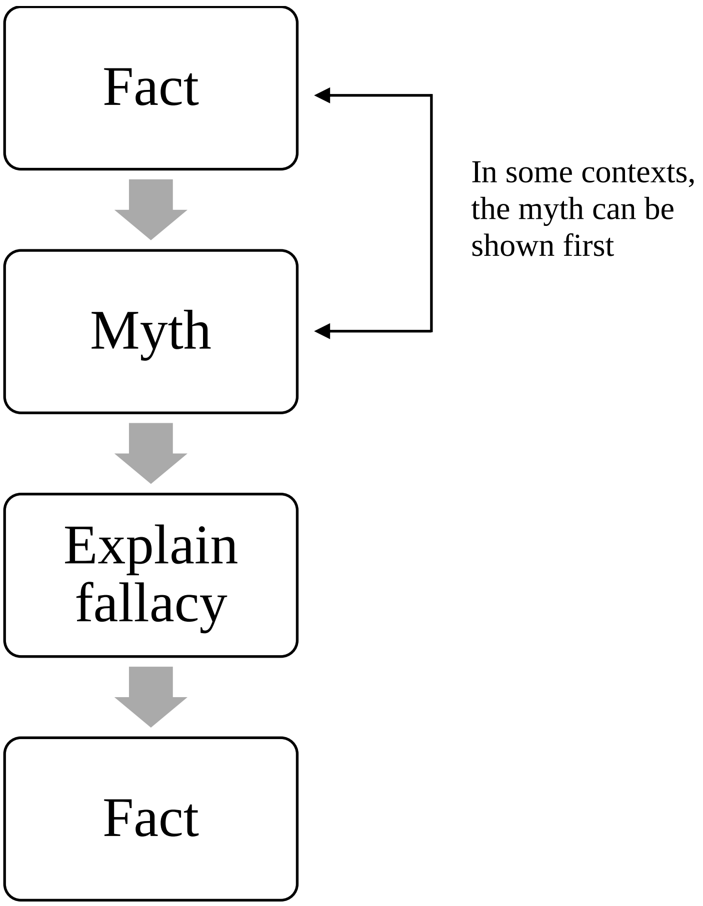
Swire-Thompson et al. (2021) conducted four experiments using multiple topics to test for the most effective correction method to lower beliefs in misinformation. Experiments 1 and 2 used misinformation related to the causes of climate change (e.g., the false claim that humans are not the cause of global warming). In Experiments 3 and 4, the topics of the materials were expanded to include the brain, alcohol, animals, hypnotism, and the influenza vaccine to increase the generalisability of Swire-Thompson et al.'s findings. In the first three experiments, misinformation belief ratings were measured immediately after correction. The authors found that all three correction formats (myth-first, fact-first, and fact-only) produced lower myth ratings compared to a control condition. Furthermore, all three correction formats performed similarly, there was no significant difference between them. In Experiment 4, however, the participants' beliefs were tested after a delay and a difference between the correction formats was found. After a delay, the myth-first format was better at lowering myth beliefs than the fact-first format. Nevertheless, the authors found that compared to control conditions, all three correction formats substantially reduced beliefs in misinformation. The authors proposed that providing a correction is more important than the format in which the correction is presented (Swire-Thompson et al., 2021).

4.4.1. Recommendations: Debunk often!

The most recent recommendations for correction format have been provided by Ecker et al. (2022). They propose that an effective debunking should prioritise the presentation of factual information and that presenting facts first is beneficial as it prioritises the fact and sets a factual frame for the problem (Figure 4.4). Nevertheless, they acknowledge Swire-Thompson et al. (2021)'s findings and propose the myth can be shown first (and even be more effective than presenting the fact-first) in some contexts.

Figure 4.4.

Recommendations from Ecker et al. (2022)



In terms of misinformation, Ecker et al. argue for its inclusion as it makes the correction salient and enables the debunker to demonstrate how the misinformation is incorrect. In line with previous advice, however, they encourage that the misinformation "should be prefaced with a warning and repeated only once in order not to boost its familiarity unnecessarily" (Ecker et al., 2022, p. 21). Ecker et al. stress that the most important component of a correction is the inclusion of factual information that ideally includes an alternative explanation for why the misinformation is incorrect and the fact is correct. They conclude by recommending that a correction should always finish with a factual statement as it reinforces the correction (Ecker et al., 2022).

4.5. Summary

When it comes to correcting misinformation, simply instructing an individual that their belief is incorrect is not 100% effective. Misinformation often continues to influence our beliefs and decision making (the continued influence effect). Historically, scientists have encouraged prioritising facts and even myth omission. In the Debunking Handbook 2011**,** the recommendation was that corrections should present the facts first and the myth (if it was presented at all) should be preceded by an explicit warning that the upcoming information is false (Cook & Lewandowsky, 2011). More recently, however, a series of studies have concluded that the backfire effects caused by repeating misinformation are elusive (e.g., (Ecker, Lewandowsky, et al., 2020; Swire-Thompson, DeGutis, et al., 2020; Wood & Porter, 2019). As a result of the new evidence, the old advice not to include the misinformation in corrections has been amended. Current advice suggests that the occurrence of the backfire effect may have been overestimated. The Debunking Handbook 2020 reflected these sentiments and in terms of correction format, advised debunkers to lead with the fact, warn about upcoming information before presenting the myth, explain why the myth is misleading and then finish the correction by reinforcing the fact (Lewandowsky et al., 2020). The handbook stated, "do not refrain from attempting to debunk or correct misinformation out of fear that doing so will backfire or increase beliefs in false information" (Lewandowsky et al., 2020, p. 9).

Correction format recommendations until this point were predominantly speculative and had not been experimentally tested. Therefore, Swire-Thompson et al. (2021) compared three correction methods (myth-first, fact-first and fact-only) against a control both immediately and after a delay to determine which correction format was the most effective. They found that all correction formats successfully reduced beliefs compared to a control and that the only significant difference was between myth-first and fact-first after a delay. With myth-first being the most effective. They recommended that simply providing a correction is more important than how the correction format is presented. The study also provided more support for the scarcity of the familiarity backfire effect. All three formats tested by Swire-Thompson et al. (2021) successfully reduced belief in misinformation. Swire-Thompson et al.'s recommendations were incorporated into the most recent debunking advice issued by Ecker et al. (2022) who noted that although they suggest leading with a fact, the myth can be shown first in some contexts. Nevertheless, no explanation of "some contexts" is provided. The current guidance provided by Ecker et al. (2022) is not based upon research designed to test public health campaigns. Corrections created using the recommended formats are long (e.g., see Figure 4.2). Although detail is beneficial for providing alternative explanations, Public Health campaigns often use posters which require fewer words. Therefore, Chapter 6 contains experiments in which I aimed to compare two influenza correction formats (myth busting and fact-only) against a control condition (healthy diet tips) to see if the presence of a myth helped or hindered influenza myth correction. Chapter 6 "Does correction format influence influenza myth agreement?" is the first of my experimental chapters. It contains work that I completed before the COVID-19 pandemic and therefore examines influenza misinformation and not COVID-19 misinformation. Additionally, in Chapter 7, I tested three COVID-19 correction formats (fact-myth, fact-only and question-answer) to determine 1) Which correction formats are effective immediately and after a delay? 2) Which is the most effective correction format?

Older people have been found to misremember previously negated statements as true following a delay (Wilson & Park, 2008). With regards to health misinformation, some have argued that "older adults are at increased risk for falling prey to quackery" (Ansburg & Heiss, 2012, p. 32). Research using American participants has found that older Americans are more likely to read and share misinformation than younger Americans (Grinberg et al., 2019; Guess et al., 2020). Another study using participants from the UK and Brazil found stronger misinformation beliefs amongst younger participants (aged 18-54 years old; Vijaykumar et al., 2021). Therefore, in Chapter 9 I examined misinformation's relationship with age.

SECTION 2: INFLUENZA MISINFORMATION

Chapter 5. Reasons for influenza vaccine non-acceptance amongst healthcare workers

In Chapter 3, I described how even when misinformation is corrected, it can linger and continue to influence an individual's memory and reasoning (Hamby et al., 2020; Lewandowsky et al., 2012). This phenomenon is referred to as the continued influence effect (Chan et al., 2017; Lewandowsky et al., 2012; Paynter et al., 2019) and it poses a challenge for public health as it makes misinformation difficult to correct.

In this chapter, I examined the reasons for influenza non-acceptance amongst healthcare workers from the Aneurin Bevan university Health Board (ABUHB). First, I examined whether reasons for influenza non-acceptance varied across influenza seasons before the arrival of the COVID-19 pandemic. Study 2 investigated the relationship between reasons influenza vaccine non-acceptance and COVID-19 status (pre-arrival and post-arrival of the COVID-19 pandemic).

5.1. Introduction

Influenza, colloquially referred to as "flu", is characterised by a high temperature, headache, chills, malaise, myalgia, cough, nasal discharge, sore throat, vomiting and diarrhoea (Cox & Subbarao, 1999; Pati et al., 2013). The influenza vaccination is the most effective tool to prevent both influenza and its secondary complications such as bacterial pneumonia (Ghebrehewet et al., 2016; Paules & Subbarao, 2017). It has been recommended in the UK to protect at-risk individuals since the late 1960s (GOV.UK, 2022e). Frontline healthcare workers are one of the populations recommended the influenza vaccination as it protects both the healthcare worker and patients against infection (Lorenc et al., 2017). A systematic review of four cluster randomised trials and four studies found that when healthcare workers were vaccinated against influenza, there was a 29% (95% CI, 15%–41%) reduction in patient deaths (Ahmed et al., 2014).

For the 2022-2023 influenza season, Public Health England have set a target for General Practices and school providers that 100% of eligible patients must be offered the influenza vaccination (PHE, 2022). Additionally, a target of 70-90% of frontline healthcare workers has been set for the NHS influenza programme 2022 to 2023 (GOV.UK, 2022c).

Targets throughout Europe are typically high at approximately 90% (Stead et al., 2019). High levels of vaccination coverage (>90% amongst high-risk patients) are needed to establish herd immunity against influenza viruses (Plans-Rubió, 2012). During the 2021/2022 influenza season, influenza uptake amongst frontline healthcare workers in the UK varied. In England, 61.4% of frontline healthcare workers (down from 76.8% in 2020/2021) were vaccinated against influenza (GOV.UK, 2022d). Difficulty attaining influenza vaccination targets isn't unique to the UK. Targets have been notoriously difficult to attain worldwide (Stead et al., 2019).

Within Aneurin Bevan University Health Board (ABUHB), where the data for this study was collected, the total number of staff (those with and without direct patient contact) increased over the four influenza seasons included in this study. In 2017/2018 56.9% of staff were vaccinated, this was below the Welsh Government's 60% target. During the 2018/2019, 2019/2020, and 2020/2021 influenza seasons, the ABUHB exceeded the Welsh government's target with 60.5%, 60.3% and 66.4% of staff receiving their influenza vaccination. The 60% target and vaccine uptake levels, however, remain well below the levels needed for herd immunity (Plans-Rubió, 2012). Broadly, the rationale behind this study is to identify the reasons for non-acceptance within the ABUHB to confirm whether influenza campaigns should include an educational component. By identifying reasons given by staff at the ABUHB and examining changes over time, we can identify 1) what interventions are needed, and 2) whether interventions are successful (this is something that has been notoriously difficult to measure).

5.1.1. Declination forms

The data for this study was routinely collected by occupational health and flu champion staff at the ABUHB. ABUHB was set up in 2009 and serves the following areas: Blaenau Gwent, Caerphilly, Monmouthshire, Newport, Torfaen and South Powys. Over 13,000 members of staff are employed by the health board and approximately 9,000 members of staff have direct patient contact.

Data was recorded by immunisers via an "Inactivated influenza vaccine no thank you form" (No thank you form). The studies in this chapter include data collected during four influenza seasons (2017/2018, 2018/2019, 2019/2020, 2020/2021). No thank you forms were anonymous and collected the following information about staff members: Gender, Job title, Division, Reason for non-acceptance. Once staff members had given the above information, immunisers were instructed to refer to the back of the No thank you form where a list of common responses and misconceptions about the influenza vaccination were listed. This information was present to encourage staff who may have been misinformed about the influenza vaccination. Immunisers recorded whether the member of staff changed their mind, along with their (the immuniser's) name, date, time, and signature.

Within the literature, declination forms have been used as a soft mandate to attempt to increase influenza vaccine acceptance (Lytras et al., 2016). The reasoning behind the forms is that healthcare workers who are undecided or have neutral views of the influenza vaccination may be persuaded to accept it if they cannot identify a good reason for non-acceptance (Stead et al., 2019).

Decliner forms are an advantageous method of data collection as they contain data that is routinely collected across multiple influenza seasons (unlike most cross-sectional questionnaires). This study is, to my knowledge, the first study to examine reasons for influenza vaccine refusal amongst healthcare workers across several influenza seasons. This method of data collection has several strengths. Firstly, the immunisers who completed the forms were located throughout the sites within ABUHB, therefore, the data is not limited to one clinical area (e.g., like (Ferragut et al., 2020). Secondly, the immunisers approached members from all staff groups (e.g., from medical and dental to administration and estates). Therefore, this method is inclusive as the immunisers did not discriminate between frontline and non-frontline staff. Thirdly, each reason for non-acceptance is collected in real time. Therefore, unlike questionnaires, participants are not asked to retrospectively recall their reason for non-acceptance.

5.1.2. Reasons for non-acceptance

A review of the self-reported reason amongst healthcare workers for vaccine acceptance found that the main reason for acceptance was self-protection (Hollmeyer et al., 2009). Self-protection is often cited more frequently than reasons such as the protection of patients or the protection of family and colleagues (Halpin & Reid, 2019; Haridi et al., 2017; Hollmeyer et al., 2009; Lorenc et al., 2017; Smedley et al., 2007).

A recent cross-sectional study collected questionnaire data from healthcare workers who worked within the clinical area of an acute London hospital and had direct patient contact (Ferragut et al., 2020). The most common reason for non-acceptance given by the healthcare workers who did not accept an influenza vaccine (n = 94), was “I got sick after the vaccine” (37, 39.36%). The next most common answer was “I do not want to have it” (18, 19.5%), followed by “I do not believe in the vaccine” (13, 13.83%), “I do not like needles” (11, 11.70%), “I never get flu” (9, 9.57%), and “It is contraindicated for me (4, 4.26%). Ferragut et al. noted that the primary reason for refusal was due to a previous bad reaction despite the flu vaccine having been delivered safely for half a century. The authors recommend that this finding should be explored further to understand why such a large proportion of healthcare workers cited a previous negative reaction. Commonly reported side effects of the influenza vaccination include soreness at the injection site, a slightly raised temperature and muscle aches (NHS, 2022b). A common influenza myth is that it can cause influenza. However, the Trivalent and Quadrivalent injections contain an inactivated form of influenza vaccination and therefore cannot cause influenza (Public Health Wales, n.d.-a). Furthermore, the “flu-like” symptoms reported following the influenza vaccination do not significantly differ to the symptoms reported following a placebo saline injection (Bridges et al., 2000; Nichol et al., 1995). In their conclusion, Ferragut et al. identified myths, fears and misinformation as the main barriers to increasing influenza vaccine acceptance.

The sample in Ferragut et al.’s study is quite small and therefore not representative. Nevertheless, other studies have found similar results. Common reasons for influenza vaccine non-acceptance amongst healthcare workers are concerns about side effects (Aguilar-Díaz et al., 2011; Lorenc et al., 2017; Smedley et al., 2007), the misperception that the individual does not need the vaccine (Halpin & Reid, 2019), concerns about vaccine efficacy (Aguilar-Díaz et al., 2011; Halpin & Reid, 2019; Smedley et al., 2007), the erroneous belief that the vaccine causes influenza (Halpin & Reid, 2019; Haridi et al., 2017; Smedley et al., 2007).

Hollmeyer et al. (2009) conducted a widely cited literature review of 25 studies examining self-reported reasons for influenza vaccine acceptance or non-acceptance amongst healthcare workers. They found that the most cited reason for vaccine refusal was “fear of adverse reactions”. This was followed by “lack of concern”, “inconvenient delivery”, “lack of perception of own risk”, and “doubts about vaccine efficacy” (Hollmeyer et al., 2009, p. 3937). Importantly, Hollmeyer et al. also identified that reasons for influenza vaccine non-acceptance are frequently due to erroneous beliefs about the vaccine (e.g., its efficacy or safety) or the disease. They reported that the reasons for non-acceptance could be split into two categories: 1) misconceptions or lack of knowledge of influenza and the influenza vaccine, and 2) lack of convenient access to the influenza vaccine. Thus, misinformation about influenza has been identified as an important variable in the non-acceptance of the influenza vaccine amongst healthcare workers. Hollmeyer et al. noted that erroneous beliefs about the influenza vaccine (e.g., that the vaccine causes influenza) were recorded in all 25 studies included in their review.

5.1.3. COVID-19 and influenza vaccination

To help relieve pressures on NHS services from seasonal influenza during the COVID-19 pandemic, the NHS increased the eligibility criteria from children aged 2-10 to 2-12 years (NHS, 2022a) and 65+ to 50+ years (NHS, 2022b). Bachtiger et al. (2021) conducted a cross-sectional study of UK participants who were eligible for a free NHS influenza vaccine during the 2020/2021 influenza season. They split the participants into two groups: 1) previously eligible bot not routinely accepted the influenza vaccine, and 2) newly eligible. They found that 56.7% of previously eligible participants intended to accept the influenza vaccine during the 2020/2021 influenza season. Of those who were newly eligible, 68.6% intended to accept their influenza vaccination. Bachtiger et al. conducted a subgroup analysis on healthcare workers. They found that amongst healthcare workers who continued to decline the influenza vaccination, the top three reasons for non-acceptance could be categorised as misinformation (gives me flu, vaccine doesn’t work, and unnecessary).

Furthermore, patients who intended to accept the influenza vaccine were most likely to report that they intended to accept the COVID-19 vaccine (Johnson et al., 2021).

5.1.4. Aims

The overall aim of this study is to examine whether the reasons for influenza vaccine non-acceptance varied across influenza seasons before (seasons 2017/2018, 2018/2019, 2019/2020) and after (2020/2021) the arrival of the COVID-19 pandemic. Data for the 2021/2022 influenza season was not collected by the ABUHB. The study has the following aims research questions:

Aim 1. What were the most reported reasons for non-acceptance given by healthcare workers pre-arrival of COVID-19?

Aim 2. Establish whether there is a significant difference in the reasons given by healthcare workers during the 2017/2018-2019/2020 influenza seasons. Aim 2 has the following question: Is there a difference between the reasons for non-acceptance given during each influenza season? That is, for example, did the number of "fear of adverse reactions" responses given during the 2017/2018 influenza season differ significantly from the 2018/2019?

Aim 3. What were the most reported reasons for non-acceptance post-arrival of COVID-19?

Aim 4. Determine whether reasons for non-acceptance changed post-arrival of COVID-19. It has the following research questions: Did reasons for non-acceptance change following the arrival of the COVID-19 pandemic?

5.2. Method

5.2.1. Design and Materials

5.2.1.1. Dependent variable

Reasons for non-acceptance. Reasons for non-acceptance were analysed and coded using an extended version of the categorisation method used by Hollmeyer et al. (2009). Categories 1-9 were the same as Hollmeyer et al. (see Table 5.1.) and categories 10 (Other), 11 (No) and 999 (missing) were added to fully capture responses given by the staff members from the ABUHB. If more than one reason was given, the first reason stated was coded. The forms were coded by two independent coders. The concordance, or agreement rate, was 98% (not including 999 responses). Disagreements were resolved through discussion.

Table 5.1.

Categorisation of reasons for vaccine non-acceptance among HCW.

Code	Category	Examples of identified reasons
1	Lack of concern	“Influenza is not a serious disease”, “I am not interested”
2	Lack of perception of own risk	“I don’t work with patients”, “don’t feel I need it”, “no history of flu”, “Never had it”, “Not needed if you have a diet that includes enough fruit, water and veg”, “I am young and healthy and don’t fell I need this”, “Fit and Well, never been sick, Not had a cough/cold in 10 years", “don’t need it”, “healthy enough”, “Prefer to use methods to improve immune system naturally”, “I don’t need it”
3	Doubts about vaccine efficacy	“The vaccine does not work”, “empirical data”, “not convinced by the evidence”, “pointless”
4	Fear of adverse reactions	“Fear of side effects”, “poorly after the last one”, “I don’t feel there has been enough research into the vaccine”, “heard bed stories”, “very sick previously
5	Self-perceived contra-indications	“Allergy”, “currently have a cold”, “Dr told never to have it again”, “currently have a chest infection”, “advised not to have it”, “Medical advice”, “strict vegan”, “pregnant”, “On COVID trial”
6	Dislike of injections	“Needle phobia”, “Too scared”, “phobia”, “it could hurt”, “needle phobic”
7	Avoidance of medications	“I avoid medications”, “does not believe in it”, “Not in agreement with the immunisation”, “I’m a conspiracy theorist”, “don’t think they are good

		for you", "Dislike the use of chemicals", "against my beliefs", "Prefer to adopt alternative forms of protection", "take Vitamin D"
8	Lack of availability	"Not offered vaccine"
9	Inconvenient delivery	"Not [at location] when clinic was arranged", "timing not convenient"
10	Other	"To think about it", "Not ready", "Appointment at GP surgery"
11	No	"No", sorry none I can think of", "don't want it", "I don't want it", "Don't want it", "Don't wish to receive it", "Personal beliefs", "Personal choice", "Prefer not to", "My decision", "Freedom of choice", "no", "no comment", "unwilling to share a reason", "no particular reason",
999	No response	"No response given", "unknown", "none", *blank space*, "

Note: Responses were categorised using categories 1-9 from Hollmeyer et al. (2009, p. 3936). Categories 10, 11 and 999 were added to capture additional reasons given by staff at ABUHB.

Table 5.2.

Staff groups and codes

Code	Staff Group	Examples of coded responses
1	Medical and dental	Consultant, Dentist, Doctor, Foundation Doctor, GP, Junior. Doctor, Medical Student, Obstetrician, Speciality Doctor
2	Nursing, midwifery and health visiting	Advanced Nurse Practitioner, Auxiliary Nurse, Clinical Nurse, Community Nurse, District Nurse, Health Visitor, Mental Health Nurse, Midwife, Nurse, Registered Nurse, School Nurse, Sister, Staff Nurse, Student Nurse
3	Scientific, therapeutic and technical	Best Interest Assessor, Clinical Psychologist, Dietician, Occupational Therapist, Pharmacist, Pharmacy Technician, Radiographer, Speech and Language Therapist, Technician
4	Administration and estates	Admin, Admin Assistant, Admin officer, Booking Clerk, Assistant Divisional Director, Business Manager, Business Support, Catering Staff, Cleaner, Clerical, Customer Services Officer, Domestic, Driver, Finance Analyst, Housekeeper, Laundry Assistant, Manager, Porter, Receptionist, Secretary, Supervisor, Works and Estates
5	Healthcare assistants and other support workers	HCA, HCSW, Healthcare Assistant, Healthcare Support Worker, Maternity Care Assistant, Support Staff, Support Worker,
6	Other	Band 2/3/4/5/6, Community. Social Worker, Storeman, Student
999	Unknown	

5.2.1.2. Predictor variable

Influenza season. Data collected during four influenza seasons was included in this study: 2017/2018, 2018/2019, 2019/2020, 2020/2021.

5.2.1.3. Covariates

Gender. The No thank you forms captured gender in a binary form (male/female).

Staff group. this variable (Table 5.2) was based upon the staff groups used by the NHS when reporting the number of directly employed NHS staff (NHS, 2022c).

Division. Division was included as a covariate because the experiences of staff from the same staff group would not be the same. For example, Nurses from the Families and Therapies division may experience different social norms or access issues to Nurses working in the Mental Health and Learning Disabilities division. Each response to the Division question was allocated to one of 11 categories: 1) Workforce & OD, 2) Complex Care, 3) Primary Care, 4) Facilities, 5) Unscheduled Care, 6) Mental Health & LD, 7) Community, 8) Families & Therapies, 9) Scheduled care, 10) Other, 11) Unknown. Division was entered into the analysis as a covariate.

5.2.2. Participants and Procedure

Participants were staff from the ABUHB, and the data was routinely collected as part of the influenza season. Overall, 2234 No thank you forms were returned. 707 (31.6%) were from the 2017/2018 influenza season, 629 (28.2%) were from the 2018/2019 influenza season, 574 (25.7%) were from the 2019/2020 and 324 (14.5%) were from the 2020/2021 influenza season (Table 5.3).

Most forms (1843, 82.5%) were completed by females (352, 15.8%, were completed by males). Most participants were from the Nursing, midwifery and health visiting staff group (752, 33.7%). This was followed by Administration and estates (615, 27.5%) and Healthcare assistants and other support workers (498, 22.3%). Many of the forms were not fully completed. Of the 2234 forms, 1283 did not contain a reason for non-acceptance and were therefore excluded from the analysis (57.4%). This left 951 (42.6) forms.

Table 5.3.

Participant characteristics overall and by influenza season (n = 833)

	All participants n (%)	2017/2018 n (%)	2018/2019 n (%)	2019/2020 n (%)
Gender				
Female	677 (82.6)	329 (83.3)	179 (79.2)	169 (84.9)
Male	143 (17.4)	66 (16.7)	47 (20.8)	30 (15.1)
Staff Group				
Medical and dental	36 (4.5)	12 (3.2)	10 (4.3)	14 (7.2)
Nursing, midwifery and health visiting	278 (34.6)	129 (34.0)	88 (38.3)	61 (31.4)
Scientific, therapeutic and technical	69 (8.6)	21 (5.5)	23 (10.0)	25 (12.9)
Administration and estates	238 (29.6)	126 (52.9)	60 (26.1)	52 (26.8)
Healthcare assistants and other support workers	81 (21.4)	43 (18.7)	37 (19.1)	161 (20.0)
Other	10 (2.6)	6 (2.6)	5 (2.6)	21 (2.6)

5.2.3. Analysis approach

Statistical analyses were completed using IBM SPSS Statistics 27 (IBM Corp, 2016). Statistical significance was set at $p < 0.05$.

Aim 1. This analysis was restricted to the 2017/2018-2019/2020 influenza seasons. The rationale behind excluding the 2020/2021 data from this analysis was to check whether reasons for influenza vaccine non-acceptance are consistent over time. First a Chi-square test was conducted to test for a significant overall relationship between influenza season and reasons for non-acceptance. Reasons for non-acceptance that had less than five responses were removed from the analysis. This resulted in "Lack of availability", "Lack of concern" and "Inconvenient delivery" being removed from analyses. The "Other" and "No" reasons for non-acceptance were also removed from both analyses as they were broad categories and didn't inform a potential intervention.

Aim 2. This analysis included all four influenza seasons (2017/2018-2020/2021). A Chi-square, again, examined the relationship between influenza season and reasons for non-acceptance.

5.3. Results

5.3.1. Aim 1. Pre-arrival of COVID-19: Most reported reasons for non-acceptance

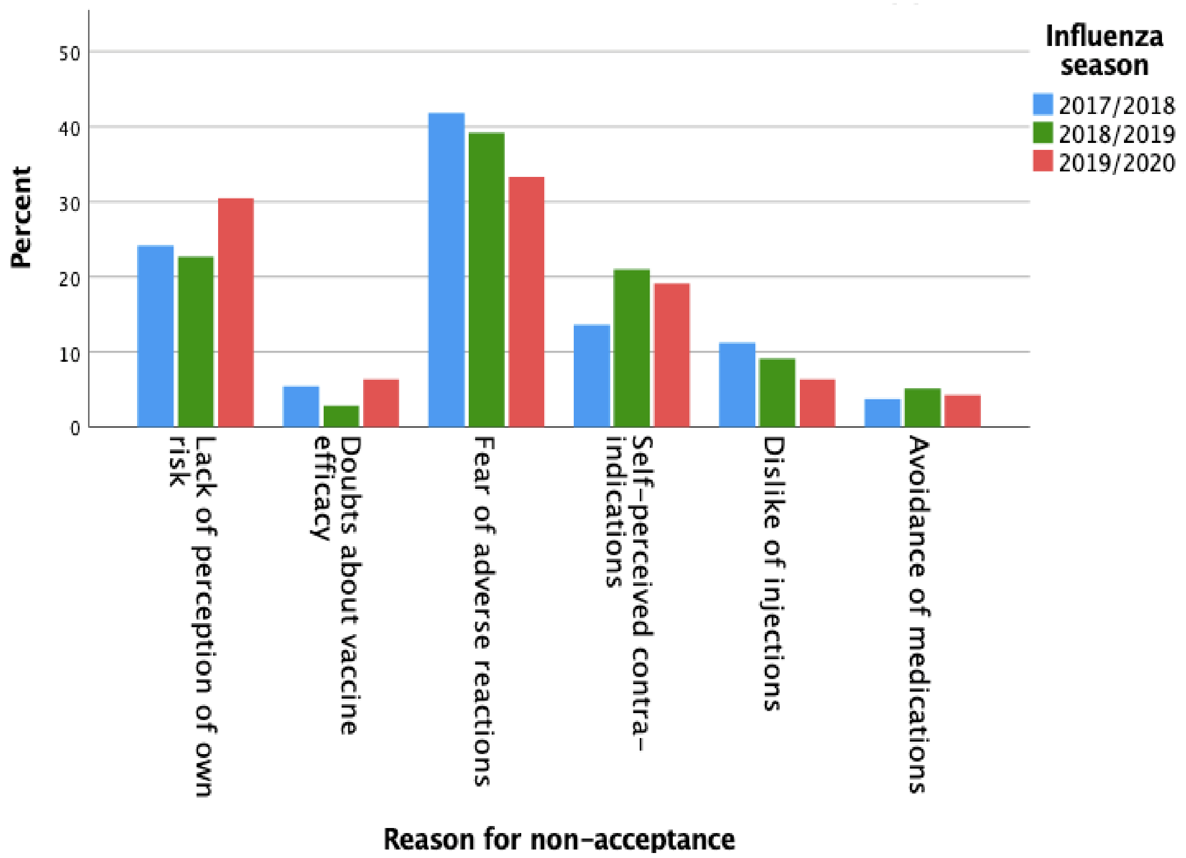
Fear of adverse reactions was the most cited reason for non-acceptance during the 2017/2018 (41.8%), 2018/2019 (39.2%), and 2019/2020 (33.3%) influenza seasons (Figure 5.1). This was followed by lack of perception of own risk (2017/2018: 24.1%, 2018/2019: 22.7%, 2019/2020: 30.5%), self-perceived contra-indications (2017/2018: 13.6%, 2018/2019: 21.0%, 2019/2020: 19.1%), dislike of injections (2017/2018: 11.2%, 2018/2019: 9.1%, 2019/2020: 6.4%), and avoidance of medications (2017/2018: 3.7%, 2018/2019: 5.1%, 2019/2020: 4.3%).

5.3.2. Aim 2. Reasons for non-acceptance pre-arrival of COVID-19

The Chi square test indicated that there was no significant relationship between influenza season and reasons for non-acceptance (X^2 (10, N = 611) = 13.14, p =.216). Thus, there were no significant differences between the influenza seasons for any of the reasons for non-acceptance.

Figure 5.1.

Reasons for non-acceptance by influenza season

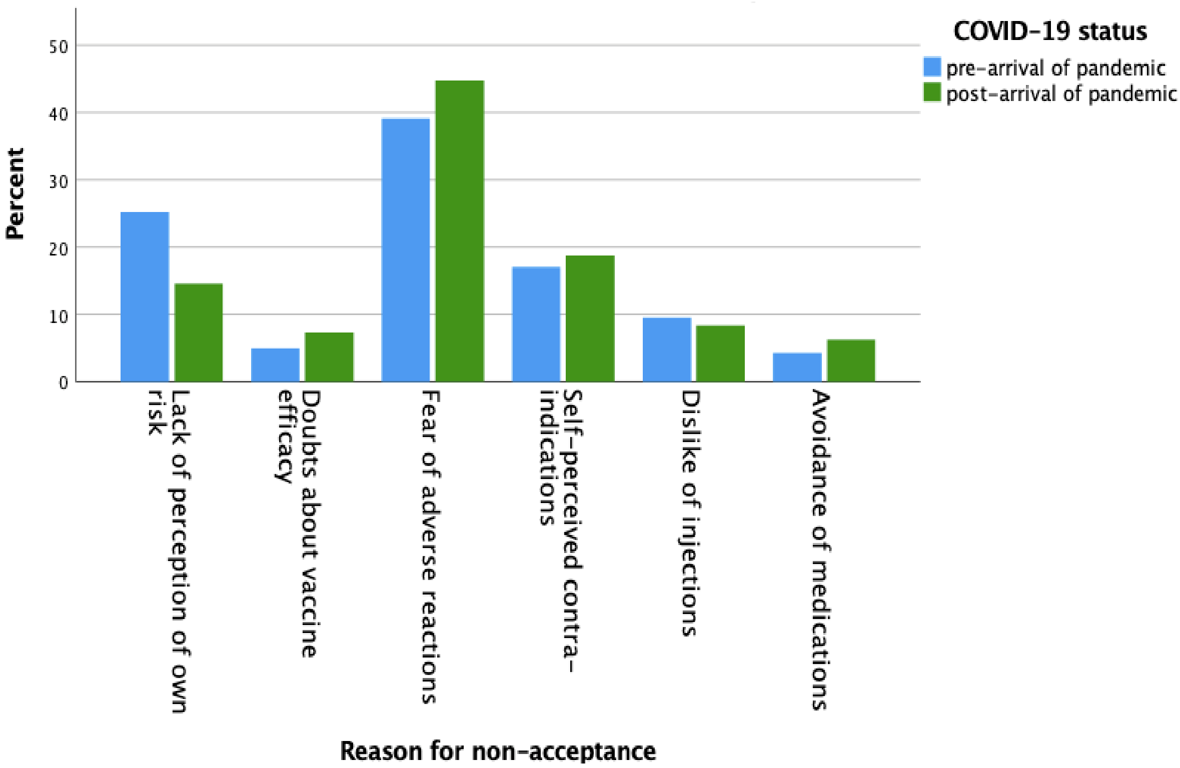


5.3.3. Aim 3. Post-arrival of COVID-19: Most reported reasons for non-acceptance

Fear of adverse reasons was the most cited reason both pre- and post-arrival of the COVID-19 pandemic (39.1% and 44.8% respectively, Figure 5.2). The second most reported reason pre-arrival of the pandemic was lack of perception of own risk (25.2%); however, the second most cited reason post-arrival of the pandemic was self-perceived contra-indications (18.8%). The third most common reason pre-arrival of the pandemic was self-perceived contra-indications (17.0%). Post-arrival of the pandemic, the third most common lack of perception of own risk (14.6%). The fourth most cited reason pre- and post-arrival of COVID-19 was dislike of injections (9.5%, 8.3%). This was followed by doubts of vaccine efficacy (4.9%, 7.3%) and avoidance of medications (4.3%, 6.3%).

Figure 5.2.

Reasons for non-acceptance by COVID-19 status



5.3.4. Aim 4. Reasons for non-acceptance post-arrival of COVID-19

A Chi-square test did not find a significant relationship between COVID-19 status and reason for non-acceptance (X^2 (5 N = 707) = 6.50, p = .261).

5.4. Discussion

I did not find evidence to support differences in the reasons for influenza vaccine non-acceptance between influenza seasons (both pre- and post-arrival of the COVID-19 pandemic). This, therefore, indicates that reasons for non-acceptance are consistent over time. From a public health campaign perspective, these results are promising as a strong, evidence-based campaign tailored to the main reasons for non-acceptance can be used for multiple seasons. We will consider each reason for non-acceptance in turn and situate it within the literature.

5.4.1. Fear of adverse reactions

We found that fear of adverse reactions was the primary reason for non-acceptance amongst healthcare workers. Fear of adverse reactions was also identified as the primary reason for influenza non-acceptance amongst healthcare workers by Hollmeyer et al. (2009). Hollmeyer et al. found that “Fear of adverse reactions” was cited in all 25 studies bar one and was the number one reason for non-acceptance in a third of the studies included in the review. Overall, 39.9% of our participants cited this reason. Thus, our findings are consistent with Hollmeyer et al.

To overcome the fear of adverse reactions it has been recommended that influenza campaigns contain educational information about potential side effects of the vaccine and their incidence (Hofmann et al., 2006). Following their review, Hofmann et al. (2006) stated that generally, the influenza vaccine is considered safe but “as with any vaccine, reactions do occur after vaccination: mainly local inflammatory reactions that are generally mild and short lived. Less frequently (< 15% of recipients) fever, myalgia, arthralgia or headache can occur” (p. 145).

5.4.2. Lack of perception of own risk

The second most cited reason for non-acceptance identified by this study, Lack of perception of own risk, was the fourth most common reason identified by Hollmeyer et al. Healthcare workers are at increased risk of influenza as they are exposed to the disease both at work (whilst treating patients) and within the community via household contact and socialising with others (Hofmann et al., 2006).

An education campaign highlighting healthcare workers’ increased risk of influenza may be an effective way to increase vaccine acceptance. Healthcare workers who feel at risk of influenza are 5.6 times more likely to accept the influenza vaccine (Van den Dool et al., 2008). Furthermore, self-protection is consistently cited as the primary reason healthcare workers accept an influenza vaccination (Hollmeyer et al., 2009).

5.4.3. Self-perceived contra-indications

Self-perceived contra-indications was the third most cited reason identified by this study. Some reasons, for example, self-reported allergies, cannot be changed by an intervention. There is, however, potential for an educational intervention to address other reasons within this category. For example, self-reported contraindications such as pregnancy and breastfeeding. The NHS recommends the influenza vaccine during all stages of pregnancy (NHS, 2022d). The Centers for Disease Control and Prevention (CDC) advise that the influenza vaccination is safe whilst breastfeeding if the infant is aged six months and older (CDC, 2021). Furthermore, the CDC states that there are benefits to obtaining an influenza vaccination whilst breastfeeding as the antibodies can be shared with the individual's infant via breastmilk (CDC, 2021, p. 14). The pregnancy and breastfeeding responses within this category were also identified by Hollmeyer et al. (2009) who noted that they are in fact reasons to accept an influenza vaccine. Another medical condition self-reported as a contra-indication by participants is Lupus. This was also mentioned by a participant in the Ferragut et al. (2020) study. Ferragut et al. explained that Lupus is not a contraindication for the influenza vaccine. Therefore, Public Health professionals should consider the inclusion of an educational segment surrounding contraindications and common misconceptions in influenza public health campaigns.

5.4.4. Dislike of injections

We found that 9.3% of healthcare workers declined their influenza vaccination because of a dislike of injections. A Canadian study examining the prevalence of needle fears in adults and children found that 24% of adults and 63% of children expressed a fear of needles (Taddio et al., 2012). Additionally, they found seven percent of adults and 8% of children reported that their fear of needles was the reason for their vaccine refusal. Thus, our findings are consistent with the literature.

Children are typically administered their influenza vaccination via a nasal spray. This is not, however licenced for people over the age of 17 years. For adults, however, Taddio et al., recommend several strategies for pain relief during vaccination. These include pharmacological (i.e., pain relief medications), physical (i.e., positioning), and psychological (i.e., distraction) interventions.

5.4.5. Doubts about vaccine efficacy

Doubts about vaccine efficacy has been identified as in the literature to have a strong association with vaccine non-acceptance (Aguilar-Díaz et al., 2011; Halpin & Reid, 2019;

Knowler et al., 2018). The influenza vaccine is an effective way to prevent influenza amongst healthcare workers. Unvaccinated healthcare workers are three times more likely to get influenza than vaccinated healthcare workers (Jenkin et al., 2019). Research has also found that when compared to healthy adults working in a non-healthcare setting, healthcare workers are at an increased risk of influenza infection (Kuster et al., 2011). Kuster et al. commented that healthcare workers' risk for asymptomatic influenza may be considerably higher. Reinforcing efficacy whilst affirming self-protection, the most frequently cited reason for vaccine acceptance identified by Hollmeyer et al. (2009), could form the basis of an educational intervention. Furthermore, when healthcare workers in long-term care are vaccinated against influenza, there is a large decrease in mortality amongst residents Kuster et al. (2011). This affirms the second most common reason for vaccine acceptance identified by Hollmeyer et al: to protect patients.

5.4.6. Avoidance of medications

The avoidance of medications reason for non-acceptance included answers such as "I avoid medications", "Not in agreement with the immunisation", and "I'm a conspiracy theorist". It therefore moved away from specific influenza vaccine-related reasons for non-acceptance towards a science denialism worldview. Current research into reducing science rejection has focused on science-related attitudes more broadly (Rutjens & Većkalov, 2022). For example, by highlighting the scientific consensus (van der Linden et al., 2015), improving how scientists are perceived without compromising perceived competence (e.g., by adding selfies, or self-portraits, to scientific communications; Jarreau et al., 2019), or considering the perceived psychological distance to science (Rutjens & Većkalov, 2022). For example, the abstractness of climate change has meant that scientists have had to work to decrease the psychological distance between climate change and individuals. This can be achieved by reducing uncertainty and making the consequences of climate change and actions to reduce it more concrete (Van Lange & Huckelba, 2021).

5.4.7. A note for public health practitioners

This study did not find a significant difference between the reasons for influenza non-acceptance pre- or post-arrival of the COVID-19 pandemic. One potential reason for this is that the reasons cited by healthcare workers reflect participants' general vaccine hesitancy towards all vaccines and not just the influenza vaccine. That is, participants who decline the

COVID-19 vaccine often cite the same reasons as those who do not accept the influenza vaccine. For example, Johnson et al. (2021) found that "concerns about the safety/side effects" and "fears of getting sick from the COVID-19 vaccine" are also amongst the most common reasons for COVID-19 vaccine refusal. Public health practitioners should therefore consider building a strong educational campaign centred around the safety of vaccines, their side effects and myths surrounding the vaccines causing the diseases they are aiming to prevent. This may not just help increase vaccine uptake for seasonal diseases such as influenza, it could also potentially improve uptake for the COVID-19 vaccine and uptake during future pandemics involving an infectious respiratory disease.

Furthermore, reasons for vaccine refusal are not the only similarities between influenza and COVID-19. They can both be prevented using similar behavioural measures. Mask wearing, hand washing, avoiding touching the mouth and nose, and social distancing (both by avoiding crowded places and by avoiding hugging, kissing, and shaking hands with others) have long been reported as effective strategies to prevent influenza infection (Aguilar-Díaz et al., 2011). These measures are identical to the behavioural measures implemented during the COVID-19 pandemic. Therefore, effective messaging within effective influenza campaigns may have potential spill over effects to other diseases.

5.4.8. Strengths and limitations

A strength of this study is that it considers reasons for non-acceptance and misinformation across multiple influenza seasons. This gives the results reliability (each influenza season found similar results). A limitation, however, is that it utilised a self-selected sample (participants must have declined the influenza vaccine and filled in the No thank you form". Therefore, the No thank you forms may not have captured a representative example of the reasons for non-acceptance. Additionally, more than half of the forms (57.4%) were returned with no reason for non-acceptance. Paired with a "no" response, this increases to 65.9%. That said, the reasons for non-acceptance given do reflect the reasons given within the literature on why healthcare workers do not accept the influenza vaccine.

5.4.9. Conclusion

Many of the reasons for non-acceptance stem from misperceptions (e.g., fear of adverse reactions). The finding that reasons for influenza vaccine non-acceptance are consistent over time, emphasises the importance of 1) educational campaigns to deliver correct information to patients, and 2) debunking campaigns to correct existing misinformation about the diseases and their associated vaccinations. The lack of significant differences between influenza seasons both pre- and post-arrival of COVID-19 should spur Public Health professionals as an evidenced based and well-designed campaign can be used year upon year to tackle the same misconceptions about influenza and the influenza vaccine.

The question is, what is the best way to debunk influenza misinformation? I will investigate this in Chapter 6.

Chapter 6. Does correction format influence influenza myth agreement?

In Section 1, I summarised the ways in which people make truth judgements and the ways in which our judgements can be led astray. Historically, fears that including the myth would make it become more familiar and therefore more likely to be remembered (and later believed) led to advice to omit misinformation during correction (Cook & Lewandowsky, 2011; Lewandowsky et al., 2012). More recently, however, this advice has been amended as backfire effects have been difficult to replicate. Current advice suggests that the myths can be included during correction *(Ecker et al., 2022)*. However, the current guidance is not based upon research focused on public health campaigns.

In Chapter 5, I examined the commonly cited reasons for influenza vaccine non-acceptance amongst healthcare workers. Many of the reasons cited, for example, lack of perception of own risk, doubts of vaccine efficacy, fear of adverse reactions stem from misinformation or misconceptions. To increase vaccine acceptance, these misconceptions can be corrected via an educational component within an influenza public health campaign. The question is, what is the best way to correct misinformation about influenza and the influenza vaccination? Therefore, in this chapter, I will test whether a myth-first format helps or hinder the correction of public health misinformation. In experiment 1, I will test whether presenting influenza myths first during correction results in stronger myth agreement. In experiment 2, I will test whether including the myths first (i.e., a myth-first, myth busting or myth-fact format) is more effective than a correction format that omits the myth (i.e., a fact only or fact-fact format).

6.1. Introduction

The more information is repeated, the more likely people are to believe it (i.e., the illusory truth effect, (Brashier et al., 2020; Cook & Lewandowsky, 2011; see Chapter 3 for review). This is true for true and false information and the phenomenon has been replicated in over 100 studies (Pillai & Fazio, 2021). When false information is encountered and corrected, the false information can continue to influence an individual's thoughts and beliefs (Lewandowsky et al., 2012). This led to debate in the literature about whether misinformation should be included during correction (Lewandowsky et al., 2012; Lewandowsky et al., 2020). The most recent advice is to include the myth (Ecker et al., 2022).

Alongside whether the myth should be included, there has also been debate about the structure or correction format. After noting that many of the recommendations for correction format had not been experimentally tested and that recommendations were predominantly speculative, Swire-Thompson et al (2021), identified and compared three correction formats. The first, a myth-first format, presented the myth before the fact. The reasoning behind presenting the myth first is that it allowed for the coactivation of the myth and correction in memory (Kendeou et al., 2014, 2019). The rationale behind coactivation is that by activating both the previously encoded misinformation and new correct information, the new information can be integrated with the misinformation. Over time, the correct information becomes activated more often, stronger links to it are formed and activation of the misinformation is diminished (Kendeou et al., 2014). The second condition, a fact-first format, presented the fact before the myth. It has been argued that presenting the myth first emphasises its content and gives the communicator more control over how the message is framed (Cook & Lewandowsky, 2011; Lewandowsky et al., 2020). The third condition, a fact-only format, only presented the fact. Some have argued that the fact-only approach is a superior correction method as repeating misinformation may make it more familiar and therefore more likely to be believed (i.e., the illusory truth effect; see Chapter 3.2 for a full discussion; Brashier & Marsh, 2020). It was also argued that a fact-only format should protect against familiarity backfire effects (Cook & Lewandowsky, 2011; Lewandowsky et al., 2012). Recently, however, calls to avoid mentioning the myth have been deemed overcautious (Ecker et al., 2022; Lewandowsky et al., 2020).

Swire-Thompson et al. (2021) compared the three correction methods (myth-first, fact-first and fact-only) against a control both immediately and after a delay. All three correction formats successfully reduced belief in misinformation compared to a control. The only significant difference was between myth-first and fact-first after a delay where myth-first was more effective. The authors concluded that simply providing a correction is more important than how the correction is presented. The study also provided more evidence that familiarity backfire effects are elusive. Swire-Thompson et al.'s recommendations were incorporated into the most recent debunking advice by Ecker et al. (2022). Ecker at al recommend leading with a fact but that the myth can be shown first in some contexts. However, Ecker et al. (2022) do not elaborate upon in which contexts the myth can be shown first.

Moreover, the current guidance is not based upon research focused on public health campaigns. This is problematic for several reasons. First, corrections created using the recommended formats are long (Cook & Lewandowsky, 2011). The recommended format should include the misinformation in order to debunk it, provide the factual information, and explain why the misinformation was wrong (i.e., explain fallacy). Although detail is beneficial for providing alternative explanations, public health campaigns often use posters which require fewer words. A recent study has tested the effectiveness of short-format refutations using fact checkable claims about topics such as crime and politics (Ecker, O'Reilly, et al., 2020). They limited the refutations to 140 characters (this was the maximum number of characters allowed by Twitter at the time). Ecker et al. (2020) found that short-format retractions were successful and did not find evidence of backfire effects. Although this finding is promising, it still doesn't provide clear guidance for public health professionals clear as the study did not use public health materials.

Second, the use of a myth-busting format is widespread within public health campaigns (e.g., influenza: WHO, n.d.; smoking: NHS, 2018). In this format, a myth (i.e., the misinformation) is presented first and then followed by a fact that refutes it. A potential problem with presenting misinformation during its correction is that the fact is often a negatively worded version of myth. For example, to counter the myth "flu vaccines cause the flu", the truth would state "flu vaccines *do not* cause the flu". Statements containing negations (i.e., *not*) are often more difficult to process than affirmative statements (Clark & Chase, 1972). In health research, negations have been shown to backfire with participants remembering the information without the negation tag. For example, Wilson and Park (2008) found that negatively phrased health information (e.g., do not use deodorant soaps if you have athlete's foot) has the potential to be misremembered, especially amongst older adults. A possible explanation for this is that the tag (e.g., not or myth) fades in memory faster than the original misinformation (Mayo et al., 2004). Pillai and Fazio (2021) reviewed whether corrections containing an evaluative or accuracy label (e.g., false) can override the effects of repetition on beliefs. They found that if an accuracy label is not closely related to a claim (e.g., a "true" or "false" label; Skurnik et al., 2005), the effect of repetition is stronger, and repetition increases belief in the claim even though it was labelled as false. However, strongly worded labels that are tailored to the misinformation can alleviate the effects of repetition (Ecker, Lewandowsky, et al., 2020). It is not clear from Ecker et al.'s advice whether public health campaigns are a context in which the myth can be presented first.

Thirdly, research is needed in the context of public health as within public health, the effect of accuracy labels on beliefs may be more complex or nuanced. For example, when presenting participants with information about risks associated with vaccination for a fictitious disease, Betsch and Sachse (2013) found that strong negations (e.g., no risk: absolutely impossible) resulted in higher risk perceptions. Weaker negations (e.g., some risk: extremely rare), on the other hand, produced lower risk perceptions. The differences between previous work and public health standards mean that it is difficult to generalise the results from previous work to public health. Thus, more research is needed.

In their correction format study, Swire-Thompson et al. (2021) used five topics. However, topic was not explored in the analysis. That is, the topic/items were not entered as a random factor in the analysis. This means that we cannot therefore infer anything about the effect of correction format on the individual topics used in Swire-Thompson et al.'s study. This is potentially problematic as beliefs in some topics are correlated with an individual's worldview (i.e., their personal ideology). For example, Lewandowsky (2021b) asked participants to rate their perceived scientific consensus on a range of topics. He found that the perceived scientific consensus and reasons for the consensus for some topics (e.g., HIV/AIDS) were not correlated. For other topics (e.g., climate change), however, worldview was a significant predictor. Therefore, if we consider the five topics from Swire-Thompson et al. (2021) the topic "animals" neutral whereas the "flu vaccines" topic is not.

The topic of influenza (i.e., flu) vaccines is not neutral as, as with most vaccinations, the influenza vaccine has not escaped the antivaccination movement and its associated misinformation. Despite being named as "one of the safest and most effective tools available in global efforts to control and prevent infectious diseases" (Hickler et al., 2015, p. 4155), many people are still hesitant to accept vaccines (World Health Organization, 2019b, see Chapter 2, section 2.3.3. for a more in-depth discussion of vaccine hesitancy). In the UK, influenza vaccination rates have been consistently low amongst at risk adults aged 16-64 years (Oakley et al., 2021). Many other countries have also struggled to reach the target influenza vaccine coverage rate (Kassianos et al., 2021). Reasons for influenza vaccine hesitancy include low risk perception of influenza, concerns about adverse effects or the safety of vaccination, and the erroneous belief that the vaccine is ineffective (Abbasi et al., 2022; Adeyanju et al., 2021).

Influenza misinformation is one of the primary reasons for vaccine hesitancy (Hollmeyer et al., 2009). A systematic review found that the most prevalent myth, reported by most studies as a significant barrier to vaccine acceptance, is the myth that "the influenza vaccination can cause the flu" (Schmid et al., 2017). Despite their medical training, healthcare workers are also susceptible to influenza misinformation. Following a review of 25 studies, misinformation was identified as one of the two reasons for vaccine refusal amongst healthcare workers (Hollmeyer et al., 2009). Misconceptions about the influenza vaccination include "the vaccine does not work, the vaccine can cause influenza" (Hollmeyer et al., 2009), and "the vaccine is unsafe during pregnancy" (Adeyanju et al., 2021). There is also a myth that increases uptake: "the influenza vaccine can protect against the common cold" (Schmid et al., 2017).

Research specifically addressing correction format and influenza misinformation have had mixed results. Skurnik et al. (2007)'s frequently cited yet unpublished study presented undergraduates with either a) a myth-first and fact-second flyer about influenza myths, b) a fact-only flyer, or c) no flyer (control group). Participants then answered questions about the influenza and indicated whether they intended to get the influenza vaccine. Skurnik et al. found that immediately after reading the flyers, participants in both conditions could correctly identify which statements were myths or facts. After a short delay of 30 minutes, however, participants who had viewed the myth-first correction format wrongly identified the myths as facts (Skurnik et al., 2007). The authors proposed that presenting the myth makes it more familiar and therefore more likely to be recalled because "people are more likely to remember the gist of the statement than the details of its presentation context" (Skurnik et al., 2007, p. 3).

Nyhan and Reifler (2015) also investigated the effect of correction upon influenza beliefs and vaccine intentions. They described their materials as "myth busting", however, instead of presenting the information in a traditional myth-fact format, they presented the myth as a question before proving the fact. They found that this correction format successfully lowered beliefs in the myth "you can get influenza from the influenza vaccination". When they examined participants with high and low concern about vaccine side effects individually. They found a that correction only significantly reduced myth agreement for the low vaccine concern group. Haglin (2017) conducted a replication of Nyhan and Reifler (2015). Again, Haglin found that correction effectively reduced participants' myth agreement. Unlike Nyhan and Reifler, however, Haglin found that correction reduced myth agreement in both the high and low vaccine concern participant groups.

Furthermore, Cameron et al. (2013) compared four message conditions. In three of the conditions, the myth was presented first. The fourth condition contained only the fact. They did not find evidence that debunking influenza myths using a myth-first format is ineffective.

Using two studies, this chapter aims to test the efficacy of the format most often used by Public Health campaigns: the myth-first format.

1. Experiment 1 compares the myth-first format to a control condition to test whether the myth-fact format is effective at reducing beliefs in misinformation within a public health context.
2. Experiment 2 compares the myth-fist format and a fact only format to a control condition. The rationale behind this is to test whether misinformation is required for effective correction to take place.

Together, these studies should help us to understand 1) whether misinformation should be present during public health campaigns, 2) whether public health campaigns are a context in which myths can be shown first, and 3) whether the shorter-style refutations used in public health campaigns are suitable for a myth-first format.

EXPERIMENT 1: MYTH-FACT CORRECTION FORMAT

In Study 1, we explored whether a myth-first correction format is effective at debunking myths about influenza. Participants were randomly assigned to view either influenza or control (healthy diet) myth busting statements before answering questions about their attitudes towards influenza and behaviour intentions. Participants were tested immediately after viewing the myth busting information and after a delay of one week. This delay was chosen as it had previously been used to demonstrate the presence of a backfire effect when using myth busting to correct information about the MMR vaccination (Pluviano et al., 2019). Furthermore, Swire-Thompson et al. (2021) found that the myth-first format was better at lowering myth beliefs than the fact-first format after a delay.

In this study we aimed to test whether a myth-first format is effective at debunking influenza misinformation. We had the following research question: Does the myth-first correction format result in lower influenza myth agreement 1) immediately and 2) after a seven-day delay?

Table 6.1.

Experiment 1: Influenza myth busting statements

	Flu Myth
1	**<u>Myth</u>** **Flu is not serious** Public Health England estimates that around 8000 people in England die from flu each year.
2	**<u>Myth</u>** **The flu vaccine does not work** Annual flu vaccine is the best way to protect against catching or spreading influenza.
3	**<u>Myth</u>** **Flu vaccines can give you the flu** No, they can't. Flu injections do not contain any live virus and the nasal spray for children contains very weakened viruses so they cannot give you flu.
4	**<u>Myth</u>** **I feel fine, I do not need a flu vaccine** Even if you feel fine, if you are pregnant, aged 65 or over, or in one of the clinical risk groups you are at increased risk of being very ill if you catch flu. You should get a flu vaccine to help make sure you stay well.
5	**<u>Myth</u>** **I won't spread flu because if I catch flu, I will avoid people who are high risk** Not everyone who catches flu is ill. Some people have no symptoms at all but can still pass the virus on.
6	**<u>Myth</u>** **Flu does not affect children** Yes, it does. Every year children in Wales need treatment in Intensive Care units because of flu.

Table 6.2.

Experiment 1: Diet myth busting statements

	Diet Myth
1	**<u>Myth</u>** **Frozen vegetables don’t count towards your recommended 5 a day** Vegetables can be fresh, frozen, canned dried or juiced. A portion of fresh, canned or frozen fruit and vegetables is 80g. A portion of dried fruit (which should be kept to mealtimes) is 30g.
2	**<u>Myth</u>** **Tea and coffee do not count towards your recommended 6-8 glasses of water a day** All non-alcoholic drinks count, but water, lower fat milk and lower sugar drinks, including tea and coffee, are healthier choices.
3	**<u>Myth</u>** **Skipping breakfast can help you to lose weight** A healthy breakfast high in fibre and low in fat, sugar and salt can form part of a balanced diet and can help you get the nutrients you need for good health.
4	**<u>Myth</u>** **All fat is bad** Try to cut down on your saturated fat intake and choose foods that contain unsaturated fats instead, such as vegetable oils and spreads, oily fish and avocados.
5	**<u>Myth</u>** **Only intensive exercise regimes count** The easiest way to exercise is to make activity part of everyday life, like walking or cycling instead of using the car.
6	**<u>Myth</u>** **We should avoid carbohydrates** Try to include at least 1 starchy carbohydrate food with each main meal. Some people think starchy foods are fattening, but gram for gram the carbohydrate they contain provides fewer than half the calories of fat.

6.2. Experiment 1: Method

Ethics for this study was granted by the School of Psychology, Cardiff University (EC.19.09.16.5653GR).

6.2.1. Participants

Participants were recruited from Prolific, an online participant panel. Experiment 1 had two timepoints. Timepoint 1 occurred immediately after the intervention and timepoint 2 occurred 1 week after timepoint 1. At timepoint 1, 266 participants were recruited, however, only 201 participants of these fully completed both timepoints. The participants who completed both timepoints ranged in age from 18 to 76 years (M = 34.96, SD = 11.18). 146 were female and 44 were male. Participants were randomly allocated to a condition. 101 participants were in the influenza condition and 100 participants were in the control condition.

In total, 57 participants completed timepoint 1 did not return to complete timepoint 2. Nevertheless, these participants did not significantly differ from the ones who did return in terms of their age (younger = 53, older = 3), gender (female = 41, male = 16), or the condition they were allocated (Influenza = 29, control = 28). Participants were reimbursed financially for their participation.

6.2.2. Study design and materials

Public Health Wales (PHW) is the national public health agency in Wales which aims to protect and improve health and well-being of people in Wales alongside reducing health inequalities (Public Health Wales, n.d.-b). In the influenza condition, participants read information about influenza presented in the same myth-first format that PHW recommended and used until October 2019 on their website (Table 6.1). In the control condition, participants read myth busting material related to diet (Table 6.2). This information was taken from the NHS' "8 tips for healthy eating" article on their website (NHS, 2019).

At baseline, each participant completed a pre-manipulation questionnaire. This questionnaire collected basic demographic information about the participants (age, gender) and was used to confirm that no significant differences in baseline attitudes existed between the two groups.

Table 6.3.

Experiment 1: Pre- and post-manipulation influenza attitude questions

	Pre-manipulation influenza attitude questions
1	Getting the influenza vaccination is a good way to protect myself from influenza.
2	Healthcare workers should be vaccinated to protect patients against influenza
3	You can have influenza but show no symptoms and still pass on the influenza virus
4	Influenza is a dangerous infectious disease
5	I am concerned about the side effects of the influenza vaccination
6	The influenza vaccination causes influenza in healthy recipients

	Post-manipulation influenza attitude questions
1	The influenza vaccination causes influenza in healthy recipients
2	The flu vaccine is the best way to protect ourselves against influenza
3	Influenza can be life-threatening
4	Even if you feel fine, you should get the influenza vaccination to ensure that you remain well

6.2.3. Measures

6.2.3.1. Influenza myth agreement questions

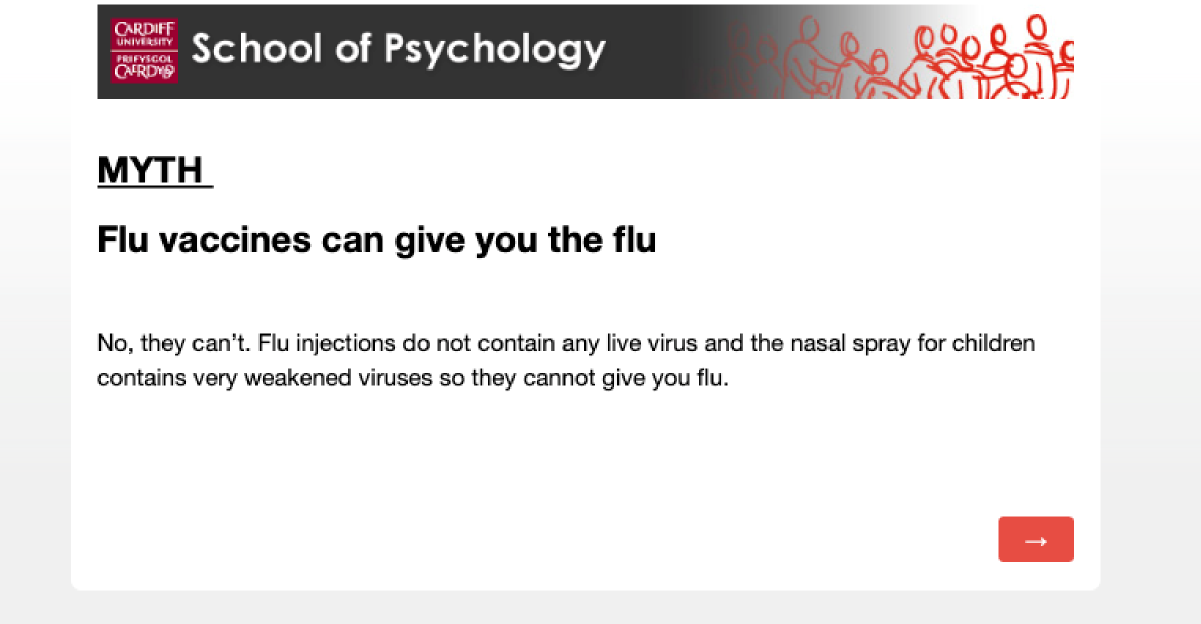
The myth agreement score was each participant's average score on the influenza attitude questions (Table 6.3). Participants rated their agreement with influenza myths on a seven-point scale from "very strongly disagree" to "very strongly agree". The higher the score, the more participants agreed with the influenza myths.

6.2.4. Procedure

Participants completed the study via a computer. Participants began by completing the pre-manipulation survey. The participants were then randomly assigned to the influenza myth-first or control condition. After viewing the statements one-at-a-time (Figure 6.1), participants completed the post-manipulation questionnaire. Once they had finished the post-manipulation questionnaire, participants were told that they had completed time point one and would be invited back in seven days to complete timepoint 2. At timepoint 2, the participants completed the same post-manipulation questionnaire as they did at timepoint 1. This was to assess changes in attitudes and behaviour intentions over time.

Figure 6.1.

Experiment 1: Example of how statements were shown to participants



6.2.5. Pre-processing and analysis overview

A linear regression analysis for Experiment 1 was completed in R.

6.2.5.1. Covariates

Research question 1.

The following variables were entered as co-variates into the linear regression:

Timepoint: Timepoint 1 or timepoint 2

Condition: control, fact-myth, myth-fact

Age: Participants were grouped into "younger" or "older" age groups using the same method as Vijaykumar et al. (2021). Vijaykumar et al. found stronger COVID-19 misinformation beliefs amongst younger participants (aged 18-54 years old) than older participants (aged 55+ years).

Gender: male or female

6.2.6. Experiment 1: Results

Influenza myth agreement score

There were no significant differences in baseline influenza myth agreement scores between conditions (p = .655).

Influenza myth agreement scores amongst participants in the influenza group were significantly lower than the participants' myth agreement in the control group (see Tables 6.4 and 6.5). There was no significant effect of timepoint and there was no significant interaction between timepoint and condition. Unlike Vijaykumar et al. (2021), younger people's myth agreement was not significantly different to older participants.

Table 6.4.

Experiment 1: Descriptive statistics

	Mean myth agreement (SD)	
	Timepoint 1	**Timepoint 2**
Condition		
Influenza	1.88 (.87)	1.99 (.92)
Control	2.85 (.99)	2.74 (1.00)
Gender		
Female	2.39 (1.08)	2.35 (2.07)
Male	2.29 (.98)	2.37 (.93)
Age group		
Older	2.15 (1.49)	2.13 (1.37)
Younger	2.37 (1.03)	2.37 (1.01)

7.

Table 6.5.

Experiment 1: Linear regression model for participants who completed both timepoints

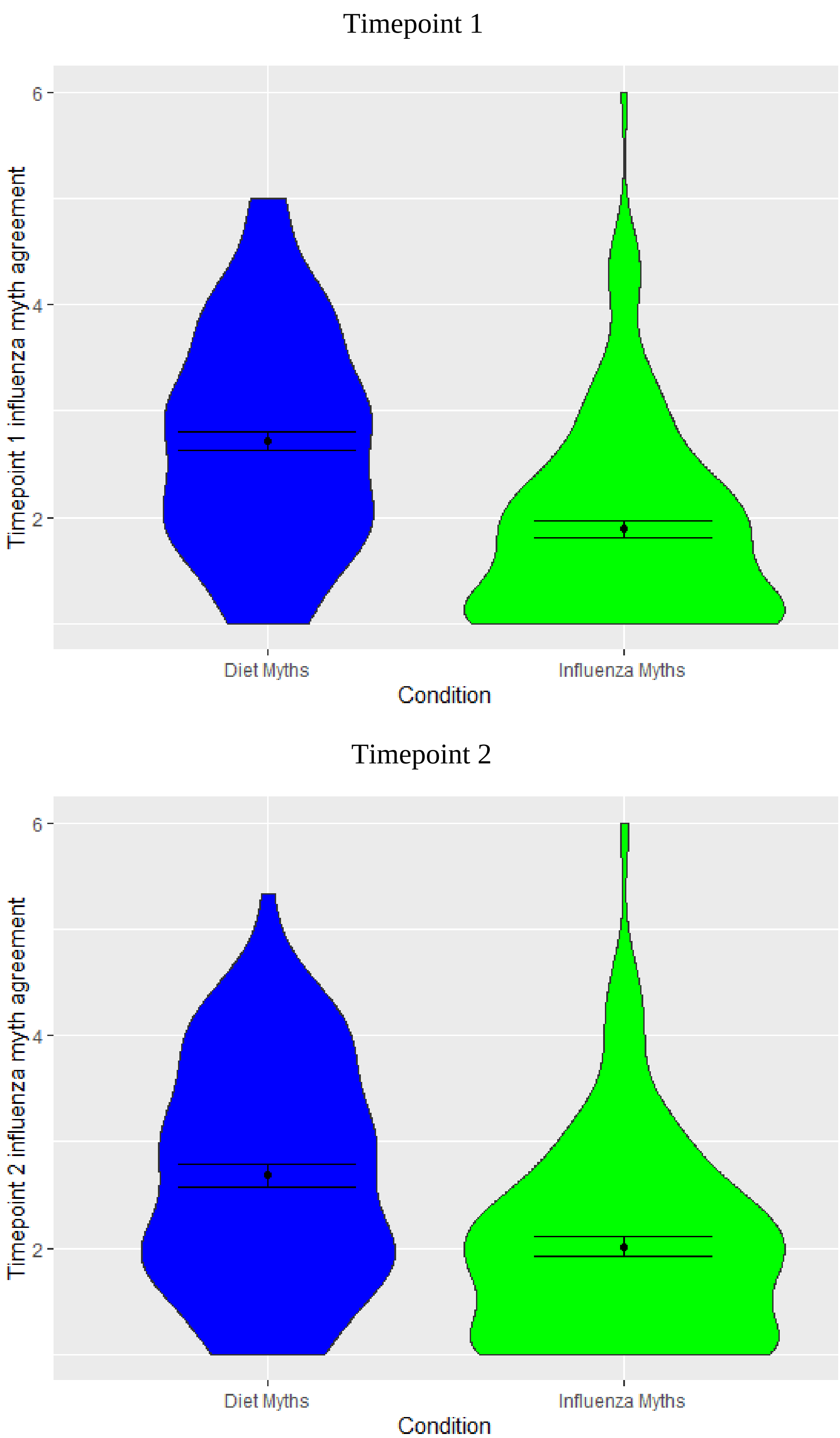
	Dependent variable: Myth Agreement			
	β	SE	*p* value	Standardised β
Timepoint	-.004	.095	0.969	-.002
Condition	.853	.095	< .001	.411
Age	-.151	.220	.494	-.032
Gender	.017	.107	.874	.007

R-squared: 0.171

Number of observations: 402

Figure 6.2.

Experiment 1: Influenza myth agreement at timepoint 1 and timepoint 2



6.2.7. Experiment 1: Discussion

In the UK, public health bodies encourage the use of myth busting to overcome misinformation during influenza campaigns. However, these recommendations have not been extensively tested within a public health context (Swire-Thompson et al., 2021). There have been mixed results in the literature surrounding the use of a myth-first correction format to debunk influenza misinformation. Some have reported that a myth-first format is ineffective and results in backfire effects for the full sample (Skurnik et al., 2007) whereas others have observed backfire effects amongst subgroups such as those with high concern about vaccine side effects (Nyhan & Reifler, 2015). Others, however, failed to observe any backfire effects (Cameron et al., 2013).

This study aimed to examine the influenza myth-first correction format within the context of an influenza public health campaign. We found that influenza myth-first correction format immediately lowered influenza myth agreement compared to controls. The lower influenza myth agreement was observed after a delay of seven days (timepoint 2).

EXPERIMENT 2: MYTH-FACT AND FACT-ONLY CORRECTION FORMATS

In experiment 1, influenza myth busting did not produce a backfire effect both immediately after correction and after a seven-day delay. In experiment 2, we aimed to compare two correction methods (myth-fact and fact only) and a control. We had the following research questions:

1. Does each myth correction format result in lower agreement with myths (i.e., effective correction) compared to a control group 1) immediately following correction, and 2) after a delay of seven days?
2. Is there a relationship between participants' baseline vaccine concern score and myth agreement?
3. Is there a relationship between participants' baseline protection score and myth agreement?

6.3. Experiment 2: Method

The project was approved by Cardiff University School of Psychology's Ethics Committee (EC.19.07.16.5653GR2A4). Participants consented at the beginning of the study and received payment and debrief after participation.

6.3.1. Participants

As with Experiment 1, participants were recruited from Prolific, an online participant panel. Again, the study was advertised generically as a "Health Information Study", and the participants were informed that we were "interested in how people use health related information."

This study had two timepoints. At timepoint 1, 429 were recruited from Prolific, an online participant panel. 395 participants' data were left after the participants with missing data had been removed and one non-binary participant was removed so that they could not be identified in the analysis. 278 participants were female and 117 were male. Participants' ages ranged from 18-75 years (M=37.20, SD=12.85). 130 participants were randomly allocated to the control condition, 132 to the fact-only condition, and 135 to the myth-fact condition.

Of the 395 participants, 95 did not return to complete timepoint 2. These participants did not differ significantly from the participants who completed both timepoints in their distribution of condition (control = 33, fact-only = 27, myth-fact = 35) or gender (female = 72, male = 23). The attrition rate, however, was higher amongst older participants (i.e., those aged 55+) than younger participants (p = .02). A potential reason for this is that COVID-19 disproportionately affected older adults and therefore the younger participants did not have the same motivation to continue. The higher level of attrition in younger participants should not affect the results as there are more younger participants than older participants in the study.

Subsequently, 300 participants completed both timepoints and were included in the analysis.

6.3.2. Study design and materials

6.3.2.1. Baseline

At baseline, pre-manipulation, the participants filled in demographic information (gender, age). They also answered the following vaccine attitude questions amongst other distractor questions (about the environment and exercise):

1. Concern: “I am concerned about side effects from vaccines”. The higher the score for this question, the higher a participant’s vaccine concern.
2. Protection: “Getting vaccines are a good way to protect myself from diseases”. The higher a participant’s score, the more misinformed they were.

Participants responded to the vaccine attitude questions on a seven-point scale ranging from “Strongly agree” to “Strongly disagree”. The vaccine attitude questions were motivated by Nyhan and Reifler (2015). As they found that participants who reported high concerns about the side effects from vaccines showed lower intentions to obtain the influenza vaccine after a myth-busting intervention.

6.3.2.2. Correction formats

There were two experimental conditions and one control conditions. Participants assigned to an experimental condition viewed corrections in a myth busting (e.g., Flu Myth: I won’t spread flu. If I catch it, I will avoid others. Flu Fact: Flu spreads quickly. Some people have flu without any symptoms, and they are still able to spread it to others) or fact-only format (e.g., Flu Fact: Flu spreads quickly. Flu Fact: Some people have flu without any symptoms, and they are still able to spread it to others). Participants in the control condition viewed information about healthy diets (e.g., Eat less sugar. Eating too much sugar can increase our risk of obesity and tooth decay). The information in all three conditions was presented in the style of a public health poster (see Figure 6.3) The influenza materials were produced in collaboration with the Public Health team at the Aneurin Bevan University Health Board (ABUHB) and were reviewed by the Public Health Wales Vaccine Preventable Disease Programme (VPDP) team (Table 6.4). The diet materials were based upon information on the NHS’s webpage “8 tips for healthy eating” (NHS, 2019). This topic was selected as a control because it is unrelated to vaccinations but is still focused on public health. All posters showed information split across three sections: two containing text and one containing an image. The font type and size were standardised across all conditions. Each poster contained a reference providing the source of the information on the poster and displayed the NHS and BEAT FLU logos. The logos were kept consistent across the posters to ensure that they didn't influence responses.

6.3.2.3. Influenza myth agreement

Influenza myth agreement was computed by averaging participants scores across six flu attitude questions. Agreement was scored so that the higher a participant's score, the higher their agreement with the myth.

Each myth agreement question was related to a myth presented in the six influenza posters. The participants were randomised to view these questions in a positive-negative or a negative positive format. In the positive-negative format, the first three questions were phrased positively (e.g., The influenza vaccination is safe for pregnant people) and the last three questions were phrased negatively (e.g., The influenza vaccination is not safe for pregnant people). In the negative-positive format, the presentation order was reversed, the first three questions were negative and the last three were positive.

6.3.3. Procedure

Participants completed the study via an electronic device (i.e., computer/tablet/mobile). Participants began by completing the pre-manipulation survey. The participants were then randomly assigned to the influenza vaccination or diet myth busting condition. They were then randomly assigned to complete the positive-negative or negative-positive post manipulation questionnaire. Once they had finished the post-manipulation questionnaire, participants were told that they had completed time point one and would be invited back in seven days to complete time point two. After a delay of seven days, participants were invited to complete time point two. At time point two, the participants completed the same post-manipulation questionnaire as they did at time point one.

Figure 6.3.

Experiment 2: Example materials for a) myth -fact, b) fact-only and c) control

a) b) c)

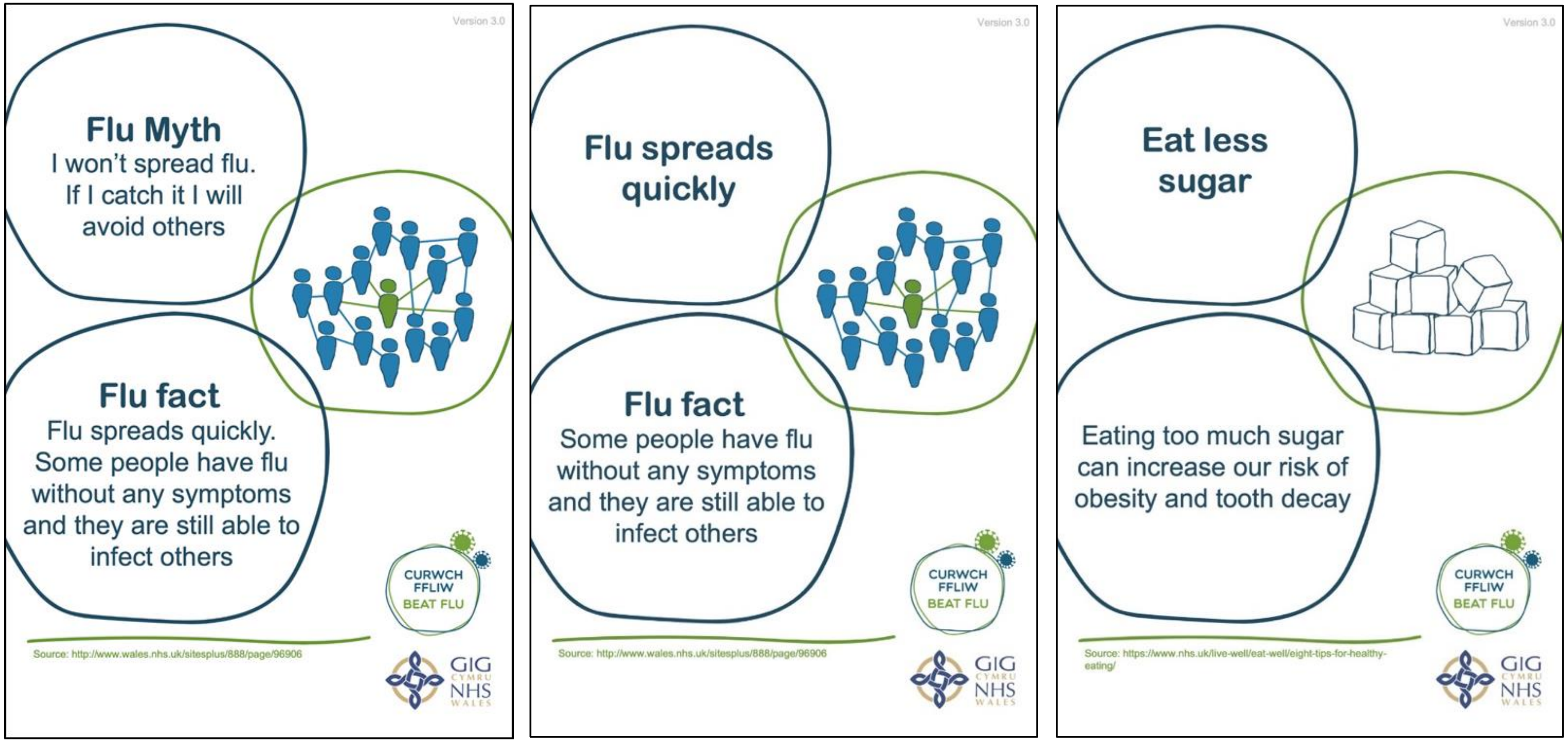


Table 6.6.

Experiment 2. Myths used in the study.

	Myth
1	Flu is not a dangerous disease
2	The flu vaccine is not an effective way to protect myself from flu
3	You can get the flu from the flu vaccine
4	Flu is only contagious when symptoms show
5	I am not at risk of catching flu
6	The influenza vaccination is not safe for pregnant people

6.3.4. Pre-processing and analysis overview

All analyses for Experiment 2 were completed in R. Research question 1 was completed using a linear regression as this is the same method used in Experiment 1. Research questions 2 and 3 were answered using a linear mixed effect (LME) model in R.

6.3.4.1. Covariates

Research question 1.

The following variables were entered as co-variates into the linear regression:

Timepoint: Timepoint 1 or timepoint 2

Condition: control, fact-myth, myth-fact

Age: Participants were grouped into “younger” or “older” age groups using the same method as Vijaykumar et al. (2021). Vijaykumar et al. found stronger COVID-19 misinformation beliefs amongst younger participants (aged 18-54 years old) than older participants (aged 55+ years).

Gender: male or female

Research questions 2 and 3

Data was analysed using a linear mixed effect (LME) model in R using lme4 (Bates et al., 2015), lmerTest (Kuznetsova et al., 2017) and lmer_alt() (afex package (Singmann et al., 2022)). Random effects for participants and influenza myths were included in the models. *P*-values were obtained using the Satterthwaite approximation**.** Model convergence was obtained by starting with a model that had a maximal random effects structure design (as per advice of (Barr et al., 2013)). If that did not converge, correlations between intercepts and slopes items were removed (Bates et al., 2015; Singmann & Kellen, 2019).

Responses to baseline vaccine attitude questions (vaccine concern and protection) were entered as covariates in our analyses. This was motivated by Nyhan and Reifler's (2015) finding that for participants with high vaccine concern, myth corrections resulted in lower intentions to obtain an influenza vaccination. The two variables were only moderately correlated (r = .41). Therefore, we analysed the two variables separately.

Research question 2: Is there a relationship between participants' baseline vaccine concern score and myth agreement?

```
Model 1a: Myth_agreement ~ correction*concern + (1|participant) +
(1+correction*concern|item)
```

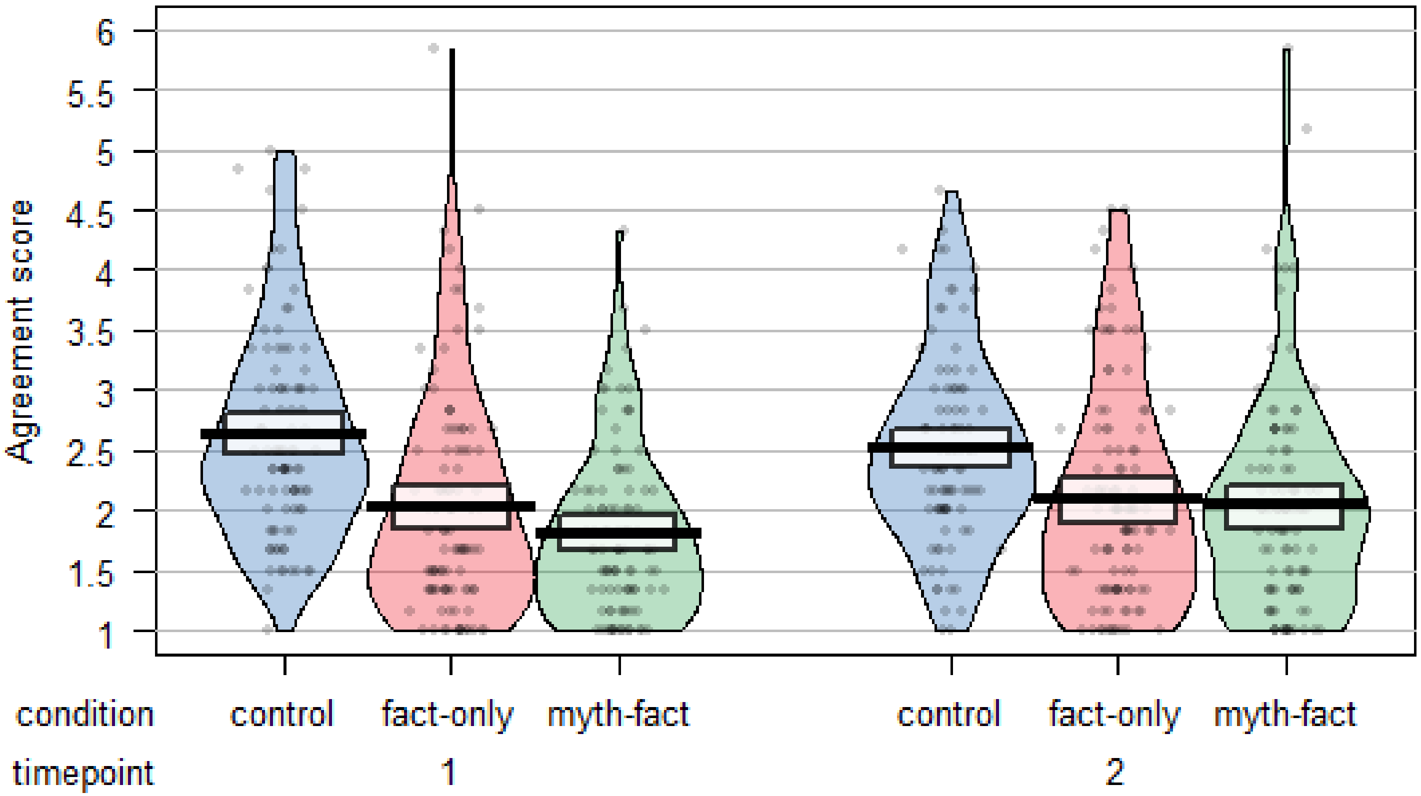
Research question 3: Is there a relationship between participants' baseline protection score and myth agreement?

```
Model 1b: Myth_agreement ~ correction*protection + (1|participant) +
(1+correction*protection|item)
```

Where Myth_agreement is the outcome variable, correction is a fixed factor with three levels (myth-fact, fact-only, control). Concern (Model 1a) is a continuous covariate corresponding to each participant's answer to the "I am concerned about side effects from vaccine" question). Protection (Model 1b) is a continuous covariate corresponding to each participant's answer to the "I am concerned about side effects from vaccine" question. The * strings include all main effects and interactions for the listed factors. The model includes all main effects and interactions for fixed and random effects.

Figure 6.4.

Experiment 2: Influenza myth agreement at timepoint 1 and timepoint 2



6.3.5. Experiment 2: Results

Research question 1: Does myth correction result in lower myth agreement?

Myth agreement was significantly lower at timepoint 1 than timepoint 2 (see Tables 6.7 and 6.8). Fact-only and myth-fact produced myth agreement scores that were significantly lower than the control condition. Myth agreement was significantly higher amongst males than females . Younger people were significantly more likely to agree with the myths than older participants. This reflects the findings of Vijaykumar et al. (2021).

Table 6.7.

Experiment 2: Descriptive statistics

	Mean myth agreement (SD)	
	Timepoint 1	**Timepoint 2**
Condition		
Fact-only	2.04 (.93)	2.10 (.90)
Myth-fact	1.81 (.70)	2.04 (.90)
Control	2.64 (.86)	2.54 (.83)
Gender		
Female	2.05 (.84)	2.16 (.85)
Male	2.36 (.98)	2.33 (.98)
Age group		
Older	1.92 (.73)	1.99 (.75)
Younger	2.20 (.92)	2.26 (.92)

Table 6.8.

Experiment 2: Linear regression model for participants who completed both timepoints

	Dependent variable: Myth Agreement			
	β	SE	*p* value	Standardised β
Timepoint	.064	.070	.354	.036
Condition	-.313	.043	< .001	-.281
Age	.293	.097	.003	.117
Gender	.182	.076	.016	.094
R-squared: 0.107		Number of observations: 600		

6.3.6. Research questions 2: Is there a relationship between participants' baseline vaccine concern score and myth agreement?

At timepoint 1, the fact-only and myth-fact correction methods produced myth agreement ratings that were significantly lower than the control (p's < .001; Figure 6.4). There was a significant interaction between fact-only and baseline vaccine concern (p = .024) whereby the fact-only format resulted in higher myth agreement scores for participants with high baseline vaccine concerns (a score over 4) compared to those with low baseline vaccine concern scores (a score less than 4; Figure 6.5). At timepoint 2, there was no significant interaction between the correction methods and vaccine concern (Figure 6.7) or vaccine protection (Figure 6.8).

Figure 6.5.

Experiment 2. Means of timepoint 1 flu myth agreement (post intervention) as a function of baseline Concern (pre-intervention) and correction format

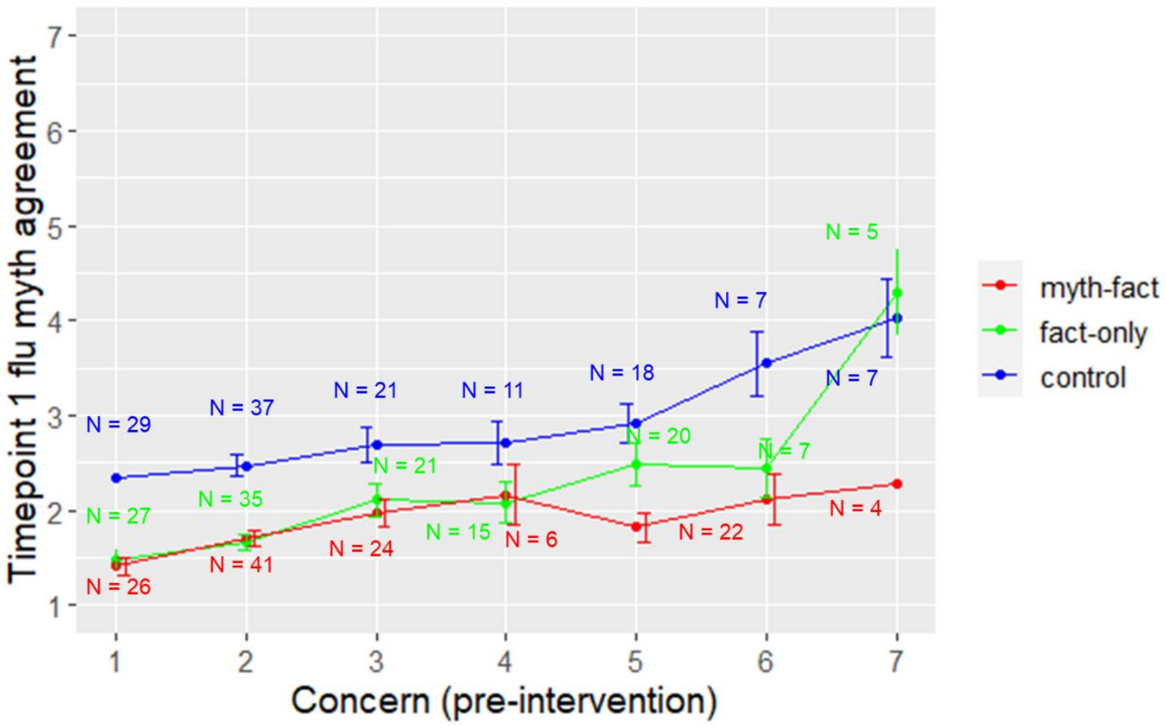
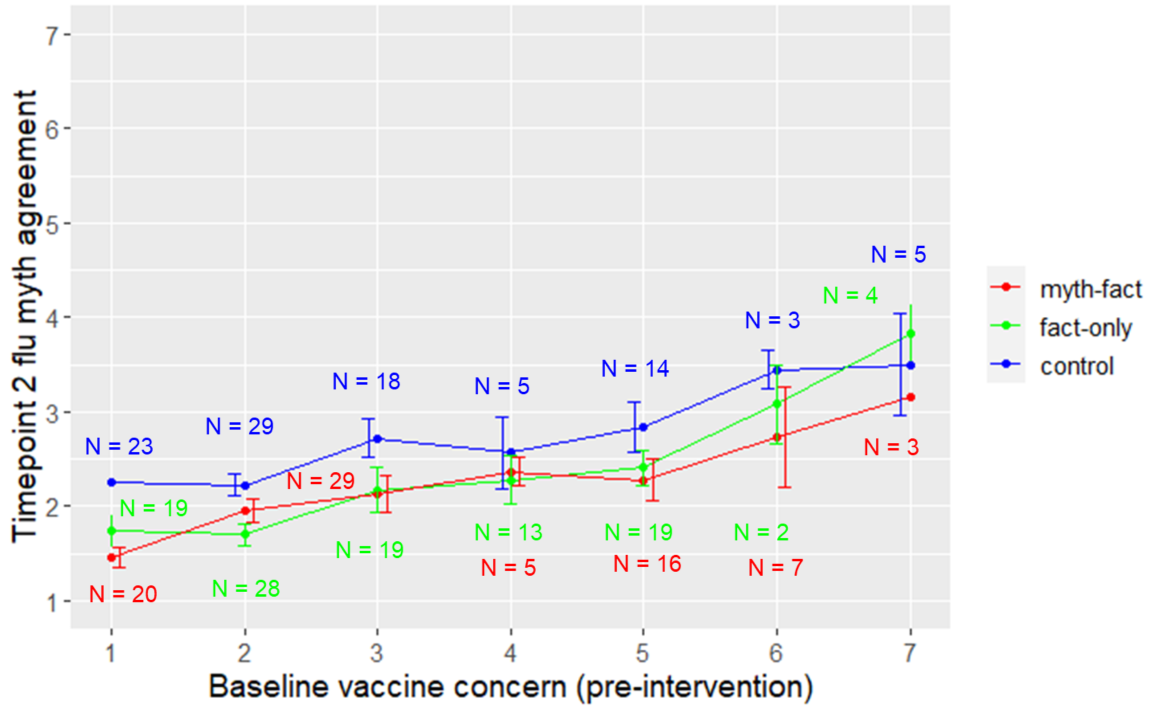


Figure 6.7.

Experiment 2. Means of timepoint 2 flu myth agreement (post intervention) as a function of baseline Concern (pre-intervention) and correction format



6.3.7. Research question 3: Is there a relationship between participants' baseline protection score and myth agreement?

At timepoint 1, there was no significant interaction between any correction methods and vaccine protection (Figure 6.6). At timepoint 2, there was no significant interaction between the correction methods and vaccine concern (Figure 6.7) or vaccine protection (Figure 6.8).

Figure 6.6.
Experiment 2. Means of timepoint 1 flu myth agreement (post intervention) as a function of baseline Protection (pre-intervention) and correction format.

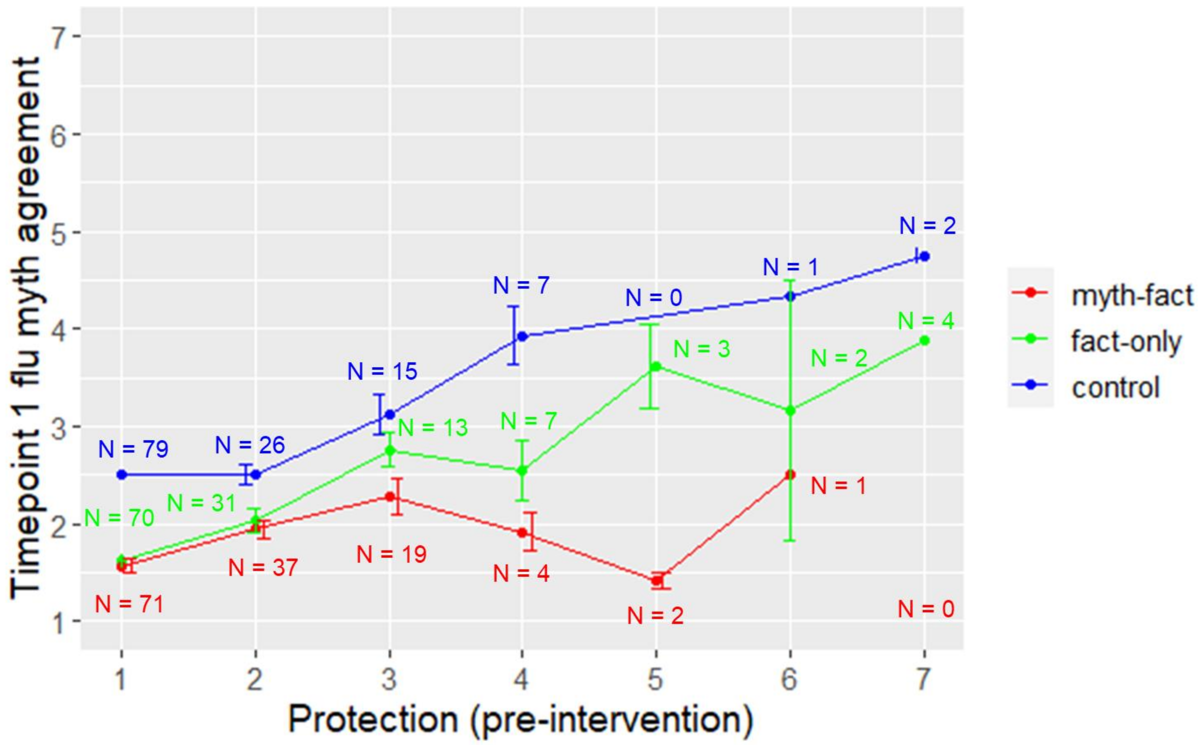
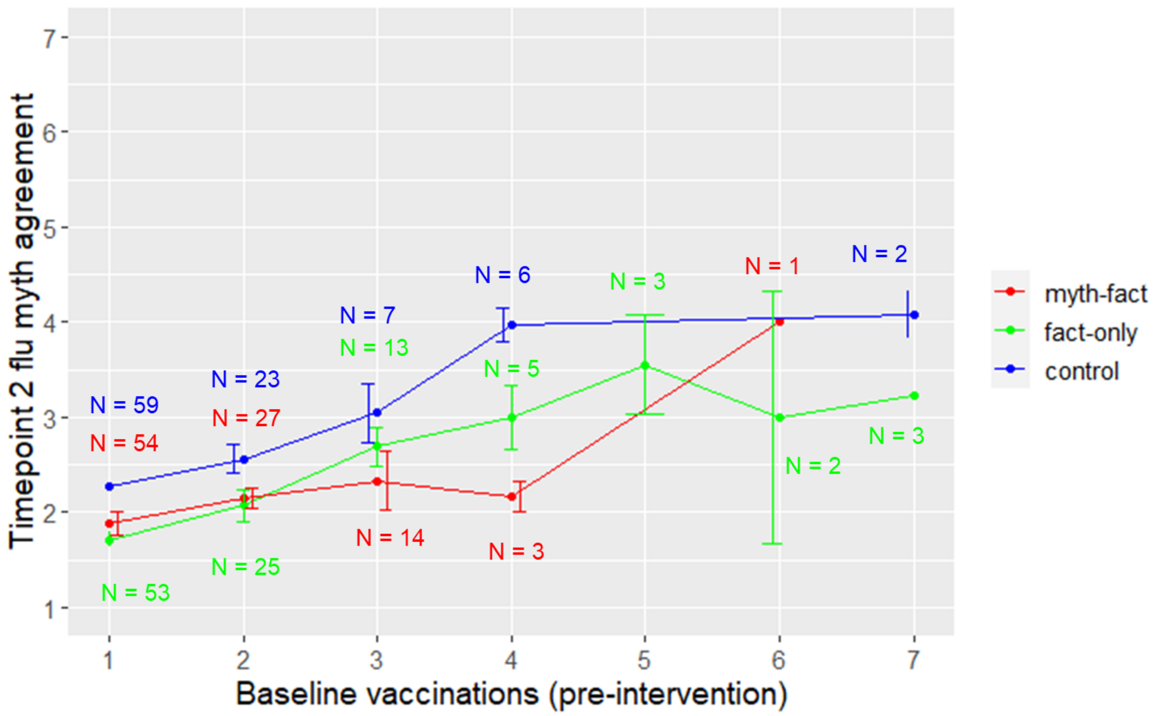


Figure 6.8.
Experiment 2. Means of timepoint 2 flu myth agreement (post intervention) as a function of baseline Protection (pre-intervention) and correction format.



6.4. General Discussion

Using two experiments, I aimed to test whether an influenza myth-first correction format results in lower myth agreement. In both experiments we found that a myth-fact debunking format was effective at reducing myth agreement compared to a control both immediately and after a delay. These results, again, do not find support for backfire effects and add further evidence to their elusive nature (Wood & Porter, 2019; Swire-Thompson et al., 2020). In experiment 2, the fact-only format also produced myth agreement scores that were lower than controls immediately and after a delay.

Influenza vaccinations are not a neutral topic due, in part, to the antivaccination movement. Therefore, at baseline in experiment 2, we asked participants to rate how concerned they are about vaccine side effects. When we considered vaccine concern, we found a significant interaction between the fact-only debunking condition and baseline. For participants with high baseline vaccine concerns, the fact-only format resulted in higher myth agreement scores compared to those with low baseline vaccine concern scores. Thus, the fact-only correction format was not as effective at lowering the myth agreement scores of participants with high baseline vaccine concerns. This interaction was not present for the myth-first debunking method. Therefore, a myth-first correction format appears to be the better approach when correcting influenza myth agreement amongst people who have high vaccine concern. The myth-first approach reduced myth agreement consistently across levels of vaccine concern.

Each of our debunking posters contained a statement explaining why the myth is wrong. Refutation texts containing a refutation and an elaboration statement supporting the refutation and providing extra information are an effective way to correct misinformation (Will et al, 2019). Research using such refutation texts has found that when asked to explain the information they have read, participants are more accurate, less likely to use circular arguments, are more likely to use causality and generate more explanations (Will et al., 2019). Nyhan et al (2015) also used refutation and elaboration when they found their corrective information about influenza vaccines to be effective at correcting the misinformation that flu vaccines cause the flu.

We developed our materials alongside ABUHB to tackle some of the most common reasons for vaccine refusal that are misinformed. To further support the inclusion of these myths, in Chapter 5 we found that healthcare workers gave five of the six myths used in study one and six out of six myths included in study 2 as reasons for non-acceptance. In other words, most of the myths included in these studies were cited as reasons for non-acceptance by healthcare workers at the ABUHB. The reasons for non-acceptance (and myths) that were captured by the myths were 1) Lack of concern (Flu is not serious), 2) Doubts of vaccine efficacy (The flu vaccine does not work), 3) Fear of adverse effects (Flu vaccines can give you the flu), 4) Lack of perception of own risk (I am not at risk of catching flu/flu is only contagious when symptoms show/I won't spread flu), 5) Self-perceived contra-indications (the influenza vaccination is not safe for pregnant people). Thus, the myths addressed in this study are ones that are believed by healthcare workers and cited as reasons for vaccine non-acceptance.

We tackled key misconceptions such as "flu is not serious", "I'm not at risk, I won't catch the flu", and "flu vaccines can give you the flu". However, we did not examine the use of a myth-first correction format when communicating risk of side effects. A myth-first correction format may have a different effect on attitudes when used to communicate risk of harm, for example, "the risk of having a serious adverse reaction to a flu vaccine is less than one in a million". People are typically poor at interpreting numbers and risk (Gigerenzer et al., 2007). We did communicate risk of getting the disease in this study, for example, "Unvaccinated healthcare workers are three times more likely to get the flu than vaccinated healthcare workers" (Jenkin et al., 2019). However, future research might examine differences in attitudes when using different correction formats to communicate risk of harm.

I note that attention checks, or screeners, were not used in the influenza studies. Future studies may wish to include them to filter out inattentive respondents.

The participants were recruited from Prolific, and we didn't screen participants to identify who met the NHS' influenza risk criteria. Most participants were young and under the age of 65, therefore, one could argue that the influenza vaccine may not be very relevant to them, and they would not know much information about influenza or its vaccine. Thus, the myths would be unfamiliar to them. One of the concerns associated with a myth-first approach is that it makes the myth more familiar and therefore more likely to backfire (Cook &

Lewandowsky, 2011). Incorrect information must be encoded prior to the presentation of the corrective information before the backfire effect can take place. Therefore, future studies should consider replicating these results within additional populations (e.g., those aged over 65 years or those who have a chronic health problem). Additionally, a potential avenue of future research is to manipulate the familiarity of the myths before the debunking material is presented.

Our study makes important contributions to Public Health literature: 1) A myth-first correction method is an effective way to dispel myths surrounding the influenza and the influenza vaccine. 2) Public health professionals commonly use posters to correct misinformation. These posters contain less text than the corrections produced using current recommendations. This study shows that misinformation can be corrected using a shorter poster-like debunking. 3) A myth-first correction format reduces myth agreement immediately and after a delay of seven days 4) A myth-first correction method as effective as a fact-only campaign. The fact-only campaign struggled to reduce myth agreement in participants who had high baseline vaccine concerns. Our findings support the decision by Public Health England and Public Health Wales to include myth busting as one of the "Seven elements of running a successful flu campaign".

6.4.1. Conclusion

The flu vaccination is recommended for all healthcare workers annually. Uptake rates are often sub-optimal, and misinformation is cited one of the main reasons for vaccine refusal. Myth busting is recommended by Public Health bodies as a key element of running a successful flu campaign. However, some research has argued that myth busting results in a backfire effect whereby after a delay people forget the fact and remember the erroneous information in the myth. Our experiment did not find evidence to support the presence of a backfire effect for flu myth busting. In fact, myth busting was arguably a more effective method of information correction than the recommended fact only method in participants with high vaccine concern.

6.4.2. Impact

Our materials were used in the ABUHB 2019/2020 Staff Flu Vaccination Programme. Approximately 300 posters in Welsh and English were displayed across health board sites. Influenza myth-first messages were posted on the health board's intranet, news and social media platforms (e.g., Facebook, Twitter and Instagram). Flu champions and divisional flu leads also used our resources to display posters in staff areas. The content of the posters was also used within staff communication.

SECTION 3: COVID-19 MISINFORMATION

Chapter 7. COVID-19 myth busting: An experimental study

> In Chapter 1 I explained that the COVID-19 pandemic was accompanied by an "infodemic". The abundance of misinformation within the infodemic successfully spread across the globe. Thanks in part to the phenomenon I introduced in Chapter 2: the post-truth era, populism, science denialism and social media. These factors created a perfect storm for the dissemination of COVID-19 misinformation.
>
> In this Chapter, I aim to test two debunking methods that adhere to the debunking guidelines described in Chapter 4 (myth-fact format and fact-only format) alongside a novel debunking format (question-answer format). The aim of this chapter is to is to test whether the three formats reduce beliefs in COVID-19 misinformation immediately following debunking and after a delay.

7.1. Introduction

The COVID-19 pandemic has spawned an abundance of misinformation (Brennan et al., 2020; Kouzy et al., 2020; Mian & Khan, 2020; Motta et al., 2020), described by the WHO as an 'infodemic' (World Health Organization, 2020d). In many countries, misinformation preceded the outbreak of COVID-19 infections and posed a serious threat to public health (Gallotti et al., 2020). False statements such as "prolonged use of face masks cause health problems" (Full Fact, 2021c), "over 90% of positive COVID-19 tests are false" (Full Fact, 2021a) and "the new COVID-19 vaccine will alter your DNA" (Full Fact, 2020d) reduce compliance with health advice (Freeman et al., 2020) and oblige health teams to compete with science denialism groups. For this reason, the WHO identifies COVID-related misinformation 24 hours a day (World Health Organization, 2020d) and provide 'myth-busting', as do many WHO member countries, such as the UK (GOV.UK, 2020b) and Brazil (Ricard & Medeiros, 2020), and prominent online platforms (e.g. The Guardian (Devlin, 2020), BBC (BBC News, 2020b), and fact checker websites (AFP Fact Check, n.d.; Full Fact, n.d.; Snopes, n.d.).

But correcting misinformation is difficult. Misinformation can sway reasoning long after attempts have been made to correct it (Chan et al., 2017; Hviid et al., 2019b; Johnson & Seifert, 1994; Lewandowsky et al., 2012; Paynter et al., 2019; Rich & Zaragoza, 2016;

Walter & Tukachinsky, 2019; Wilkes & Leatherbarrow, 1988). Health campaigns must therefore optimise their materials to maximise belief change. This requires successfully linking the correction with misinformation in the mind of the reader (Kendeou et al., 2014). Traditionally, myth-busting campaigns have done this explicitly by naming the myth as well as providing a rebuttal ("Myth: the COVID-19 vaccine is mandatory. Fact: the COVID-19 vaccine is not mandatory…"). This approach is used extensively in public health (e.g., influenza (World Health Organization, n.d.), smoking (NHS Inform, 2022) and has been applied to COVID-19 myths (BBC News, 2020b; Full Fact, n.d.; King's College London, 2020; Reynolds & Weiss, 2020; Snopes, n.d.; World Health Organization, 2022a).

However, there have been fears that repeating the myth makes the misinformation more familiar and therefore more likely to be considered true (Lewandowsky et al., 2012). This phenomenon could lower campaign effectiveness (Lewandowsky et al., 2012), and more recent campaigns, such as those by the WHO, have used approaches that either avoid repeating the myth entirely (*fact-only*, "The new COVID-19 vaccine will not alter your DNA") or implicitly link the myth with the correction using a question-answer format (*question-answer*, "Does the new COVID-19 vaccine alter your DNA? No…"). In contrast to these approaches, recent studies question the need to omit the myth (Ecker, Lewandowsky, et al., 2020; Swire et al., 2017; Swire-Thompson, DeGutis, et al., 2020), although current guidance recommends placing the myth after, rather than before, the rebuttal (Ecker et al., 2022). Indeed, including myths can sometimes have positive effects on belief change (Reynolds & Weiss, 2020; Wahlheim et al., 2020).

In this study I compared three approaches to myth-busting to establish whether health campaigns might be most effective when they include the myth, omit the myth, or use a question-answer format. I used a randomised trial with a representative sample.

7.1.1. Facts and myths vs only facts

A central question in myth-busting is whether to repeat myths in the myth-busting materials or to present only correcting facts. Early studies suggested that repeating myths had a detrimental effect (Lewandowsky et al., 2012). It was argued that they risked making the myths more familiar (Skurnik et al., 2007), and that they promoted shallow processing of the material (Yeh & Jewell, 2015). For example, Skurnik, Yoon & Schwarz (2005) found that after a 30-minute delay, participants in a flu myth-busting condition mistakenly mislabelled myths as facts. They also found that intention to obtain the influenza vaccine was lowered following corrective information that included statements of the myth (a ‘backfire’ effect). Such backfire effects led to advice not to make explicit reference to myths, but present only facts (Cook & Lewandowsky, 2011; Lewandowsky et al., 2012).

But recent work presents a more muted conclusion. Familiarity effects have proven elusive (Ecker, Lewandowsky, et al., 2020; Swire et al., 2017; Swire-Thompson, DeGutis, et al., 2020) and difficult to replicate (Haglin, 2017). For example, Swire et al. (2017) presented participants with a series of true and false claims (myths) that were subsequently affirmed or corrected. They measured the corresponding change in belief and found no evidence of backfire effects at short or long delays, or in older people (whose ability to recall information using strategic memory processes is typically less efficient than younger people’s).

Recent studies have also found advantages for restating the myth during correction, both immediately and after a delay (Ecker, Lewandowsky, et al., 2020; Ecker, O’Reilly, et al., 2020; Swire et al., 2017). A limitation of these studies, however, is that they were not designed with Public Health interventions in mind. Instead, they focused on fake news headlines or stories, or general claims that were then fact-checked, e.g. “The national animal of Scotland is the unicorn” (true). For example, the study generally cited to support inclusion of the myth is Ecker, Hogan & Lewandowsky (2017), who used a continued influence paradigm modelled on misinformation retraction in news media. Participants read novel news stories (e.g., about a wildfire) that included crucial information (e.g., how the fire started) that was later retracted. Retractions that explicitly stated the original information (e.g., ‘It was originally reported that the fire had been deliberately lit, but authorities have now ruled out this possibility. After a full investigation and review of witness reports, authorities have concluded that the fire was set off by lightning strikes’) were more effective than retractions that did not (‘After a full investigation and review of witness reports, it has been concluded that the fire was set off by lightning strikes’). The materials in health campaigns and social media generally contain much less information than the whole news stories used in continued influence paradigms, are aimed at familiar myths rather than novel news, correct myths after a much longer delay, and have a more diverse audience than Ecker et al.’s participants (n=60 per condition, Psychology students).

In summary, the prevailing view is that including myths as well as facts is more effective at changing beliefs than including only facts. Nonetheless, the variability in findings, and differences between health campaigns and experimental investigations motivated our dedicated COVID-19 study designed with the specific purpose of providing advice for health campaigns.

7.1.2. Question-answer

Explicitly including the myth in a correction provides a cue that there is a conflict between the facts and pre-existing beliefs. An alternative approach to myth-busting is to use a question format that implicitly cues the myth ("Will the new COVID-19 vaccine alter your DNA? No…"). This format prompts the reader to internally retrieve the answer to the myth question. Conflict is potentially generated between the retrieved and the provided answer and resolved by belief revision.

It is unknown whether implicitly cueing the myth, as in question-answer, produces greater correction of the myth than explicitly doing so. Greater correction might arise because interrogatives yield more engagement or intrinsic motivation than declarative statements (Senay et al., 2010). For example, "Will I ….?" motivates more goal directed behaviour than "I will ….", and rhetorical questions are more effective at encouraging elaborative processing of material than declaratives (Petty et al., 1981; Yeh & Jewell, 2015). On the other hand, implicitly cueing the myth risks the reader failing to access relevant representations. For example, the reader may not expend sufficient processing time to retrieve the correct answer to the question (Bott et al., 2016). If this happens, there would be no coactivation of the myth and the correction, and so belief revision would not arise (Kendeou et al., 2014).

The question-answer format is currently deployed by the WHO, amongst others, to combat coronavirus misinformation (World Health Organization, 2022a). One study has used this approach, using a WHO infographic to correct the myth that garlic is a cure for coronavirus (Vijaykumar et al., 2021), with mixed results: there was no significant overall effect on misinformation belief, and there was a backfire effect for older adults (55+) (although it was not the authors' purpose to compare question-answer format to any other approach; they were comparing age groups in UK and Brazil).

7.1.3. Study rationale and outline

In sum, question-answer, fact-only and fact-myth formats are all currently deployed in an attempt to correct COVID-19 misinformation. There are reasons to favour each. Fact-myth presents an explicit link between pre-existing beliefs and corrective material and so may facilitate the detection of conflict, but risks making the myth familiar. Fact-only avoids making the myth more familiar, but risks failing to link pre-existing beliefs and corrective material. Question-answer invites an implicit link between myth and correction that may be more engaging and could yield better recall, but for the same reason it could boost myth familiarity.

To identify which format is most effective at generating belief change in COVID-19, I compared their effectiveness using a randomised trial with a representative UK sample. Participants read myths/facts and appropriate corrections and then answered inference questions testing their agreement with the myths.

There were three between-subject conditions (i) *Question-answer*, (ii) *Fact-only*, (iii) *Fact-myth* (Fig. 7.1). The materials were designed to be useable and relevant to public health but also follow the most recent advice (Lewandowsky et al., 2020). When including the myth, traditional public health myth-busting typically present a myth first and then a correction (myth-fact), but the current advice (Lewandowsky et al., 2020) is to place the fact first and then the myth (fact-myth). We followed this advice.

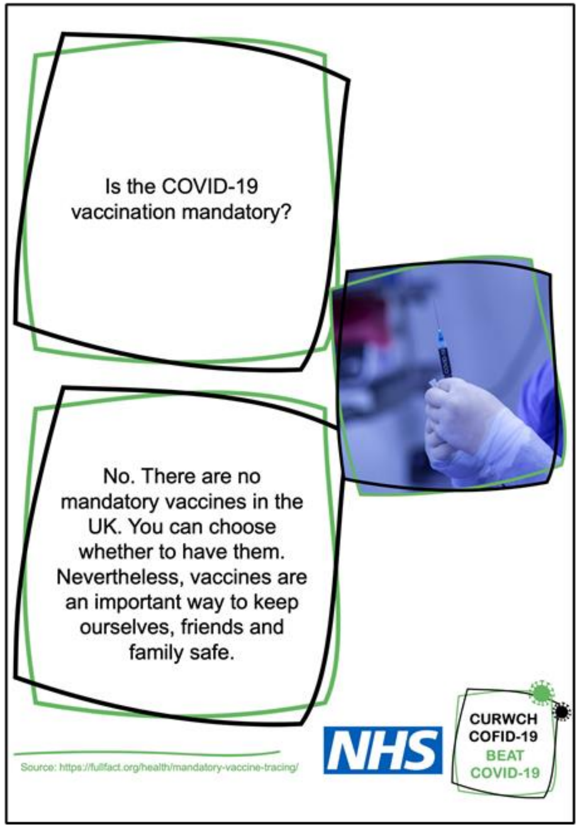
Participants were tested prior to correction (baseline) to establish baseline beliefs to act as a (repeated measures) control condition. Participants were then tested immediately after correction (timepoint 1) and after a delay of at least six days (timepoint 2). This enabled us to answer the following main research questions:

1. Which formats are effective immediately and after a delay? That is, does each format lower agreement with myths (effective correction), increase agreement (a backfire effect), or neither?
2. What is the most effective myth correction format?

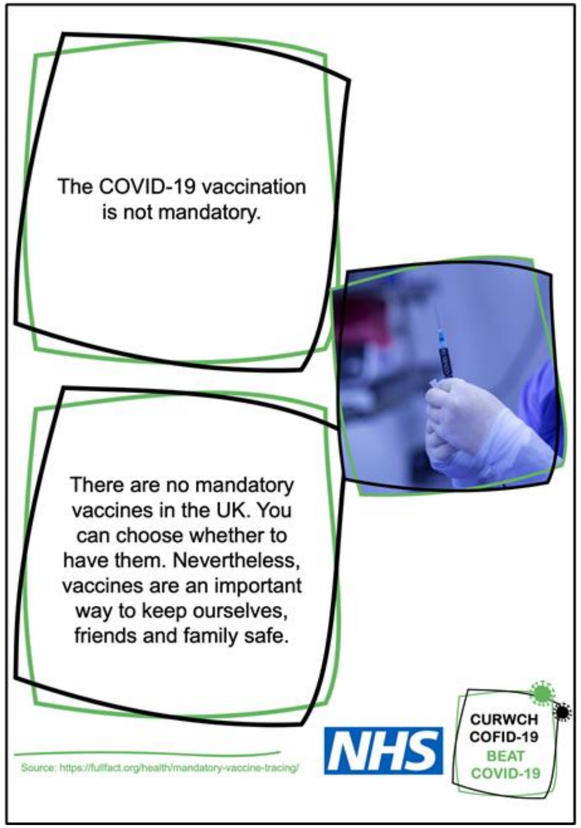
Figure 7.1.

Example correction graphics for a) question-answer, b) fact-only, c) fact-myth

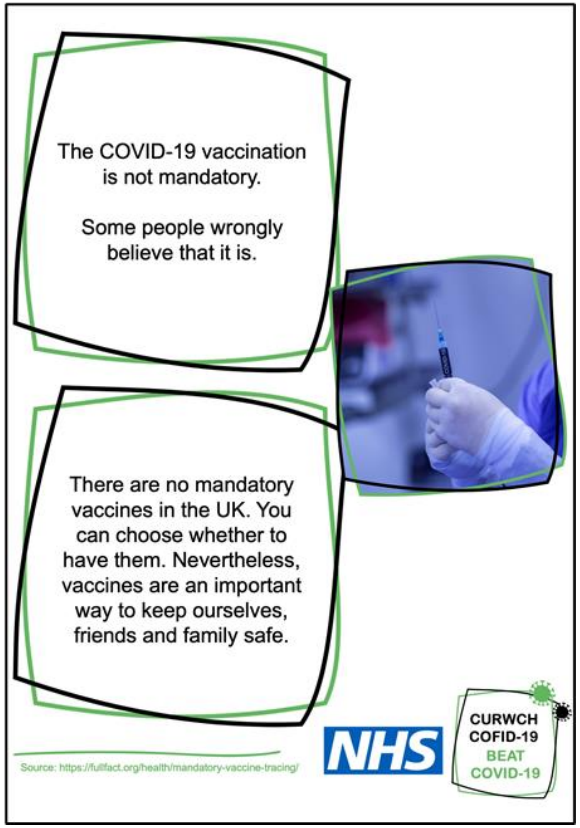
a)



b)



c)



Note: Each graphic had two boxes. The first contained the intervention material, the second the supporting explanation statement (and the answer, i.e., yes/no, in the case of question-answer).

7.2. Method

7.2.1. Ethics information and pre-registration

The project was approved by Cardiff University School of Psychology's Ethics Committee (EC.19.07.16.5653GR2A4). Participants consented at the beginning of the study and received payment and debrief after participation. The study was pre-registered at https://osf.io/huz4q/.

Table 7.1.

COVID-19 myths

	Myth
1	Seasonal colds and flu are wrongly being counted as COVID-19 cases
2	If your symptoms are mild, you can self-isolate and don't have to take a test
3	Lockdowns don't work
4	Thermal scanners can detect people who have COVID-19 but aren't showing symptoms
5	The flu is more deadly than COVID-19
6	The COVID-19 vaccination is mandatory
7	Lockdowns are due to healthy people getting tested
8	Ultra-violet lamps should be used to disinfect hands
9	Face masks do not reduce the transmission of infection
10	Wearing a face mask can lead to increased levels of carbon dioxide in the blood
11	As soon as you have had the vaccine, you can go back to your normal life

7.2.2. Design and materials

Myth selection: I ran two short surveys to select real-world COVID-19 myths as materials. Together these surveys yielded 11 myths for the main study (Table 7.1). The first survey tested a list of 39 myths sourced from the WHO's COVID-19 myth-busters list (World Health Organization, 2022a) and fact checker websites (AFP Fact Check, n.d.; Full Fact, n.d.). Myths were included if they had potential to influence readers' behaviour. For example, the myth that "500 lions were released into the streets to prevent people from leaving their houses during lockdowns in Russia" (Full Fact, 2020e) was not included as it was unlikely to affect behaviour in the UK. The myth that "gargling with salt water can prevent COVID-19" (Full Fact, 2020b) was included as it had the potential to change behaviour.

Table 7.2.
COVID-19 study materials.

	Fact-myth	Fact-only	Question-answer	Explanation	Agreement Question
1	A COVID-19 test will not show a positive result if you only have a cold or flu. A common COVID-19 myth is that seasonal colds and flu are wrongly being counted as COVID-19 cases.	A COVID-19 test will not show a positive result if you only have a cold or flu.	Will a COVID-19 test show a positive result if you only have a cold or flu? No.	The COVID-19 swab (PCR, antigen) test has been specifically developed to detect the presence of COVID-19 only. It has a proven accuracy rate of 99.91%. A cold or the flu won't cause positive tests for coronavirus, even though symptoms can be similar.	If I have the flu, I will be included in the number of COVID-19 cases
2	If you have any COVID-19 symptoms, however mild, you should take a test and stay at home. A common myth is that if your symptoms are	If you have any COVID-19 symptoms, however mild, you should take a test and stay at home.	If you only have mild COVID-19 symptoms, do you still have to take a test and stay at home? Yes.	Even if your symptoms are mild, you can still pass COVID-19 on to others. Symptoms include a high temperature, a new continuous cough and a loss or change to your sense of smell or taste.	If my symptoms are mild, I don’t need to take a test and can just stay at home.

	mild, you can self-isolate and don't have to take a test.				
3	Lockdowns can slow COVID-19 transmission. Some people wrongly believe that lockdowns don’t work.	Lockdowns can slow COVID-19 transmission.	Do lockdowns slow COVID-19 transmission? Yes.	Lockdowns limit contact between people which is important to slow the spread of the disease. The first lockdown, which resulted in a very large reduction in mobility, was followed by a reduction in COVID-19 cases.	I do not believe that lockdowns are effective.
4	Thermal scanners measure a person’s temperature and not whether they have COVID-19. A common myth is that thermal scanners can detect people who have	Thermal scanners measure a person’s temperature and not whether they have COVID-19.	Can thermal scanners detect people who have COVID-19 but aren’t showing symptoms? No.	Thermal scanners detect people whose temperatures are higher than normal. If you think your temperature is higher than normal, you should book an NHS swab test.	Thermal scanners can detect whether I have COVID-19 even if I am not showing symptoms

	COVID-19 but aren't showing symptoms.				
5	COVID-19 is more deadly than the flu. Some people wrongly believe that COVID-19 is just like the flu and causes no more deaths.	COVID-19 is more deadly than the flu.	Is COVID-19 more deadly than the flu? Yes.	Despite the numerous restrictions on public movement (which aren't enforced during flu seasons), COVID-19 deaths have been higher than flu deaths during recent bad flu seasons.	I do not believe that COVID-19 causes more deaths than the flu.
6	The COVID-19 vaccination is not mandatory. Some people wrongly believe that it is.	The COVID-19 vaccination is not mandatory.	Is the COVID-19 vaccination mandatory? No.	There are no mandatory vaccines in the UK. You can choose whether to have them. Nevertheless, vaccines are an important way to keep ourselves, friends and family safe.	It is mandatory for me to have my COVID-19 vaccination
7	Avoiding a COVID-19 test to keep official numbers down will not stop lockdowns.	Avoiding a COVID-19 test to keep official numbers down will not stop lockdowns.	Will avoiding a COVID-19 test keep official numbers	You should get a test if you have symptoms. The number of tests and positive cases are used to	If I avoid taking a COVID-19 test I can help prevent

	Some people wrongly believe that the lockdowns are due to healthy people getting tested.		down and stop lockdowns? No.	measure the scale of an outbreak in a certain area. A lack of testing might lead to an extended pandemic.	lockdowns from happening
8	Ultra-violet lamps should not be used to disinfect hands. Some people wrongly believe that they can.	Ultra-violet lamps should not be used to disinfect hands.	Should ultra-violet lamps be used to disinfect hands? No.	UV radiation should not be used to disinfect hands as UV radiation can cause skin irritation and damage your eyes. You should use soap and water (or hand sanitiser gel if soap and water are not available).	It is safe for me to disinfect my hands using an ultra-violet lamp
9	Face masks reduce transmission of COVID-19. Some people wrongly believe that face masks do not reduce the	Face masks reduce transmission of COVID-19.	Do face masks reduce the transmission of COVID-19? Yes.	Face masks reduce the spread of respiratory droplets and small aerosols that carry COVID-19 from an infected person into the air. They also provide	I believe that face masks will not reduce the spread of my respiratory droplets and transmission of COVID-19

	transmission of infection.			some protection for the wearer against droplets.	
10	Wearing a face mask does not lead to increased levels of carbon dioxide in the blood. Some people wrongly believe that wearing a mask makes you breathe in too much carbon dioxide and so makes you ill.	Wearing a face mask does not lead to increased levels of carbon dioxide in the blood.	Does wearing a face mask lead to increased levels of carbon dioxide in the blood? No.	Some people may find face masks uncomfortable, but they are not harmful if you are fit and well.	I believe wearing a face mask will lead to higher levels of carbon dioxide in my blood
11	After you have had the vaccine, you cannot immediately return to the life you had before COVID-19.	After you have had the vaccine, you cannot immediately return to the life you had before COVID-19.	After I have had the vaccine, can I immediately return to the life I had before COVID-19? No.	Even when COVID-19 vaccines are rolled-out, it will take a while to reach everyone. You will still be asked to follow other public health measures such as socially	I can return to normal life immediately if I have had my COVID-19 vaccine.

Some people wrongly believe that as soon as they have had the vaccine, they can go back to their normal life.		distancing, wearing a mask and limiting social mixing.

Note: Participants saw text from one of fact-only, fact-myth, question-answer columns, and also the explanation statement.

Fifty participants recruited from the online participant panel Prolific (Prolific, n.d.) rated how much they agreed with each myth, alongside four COVID-19 facts, in a random order, using a pointer on a visual analogue scale from “Strongly disagree (0)” to “Strongly agree (100)”. I selected myths with above 20% average agreement to be included in this study. This process yielded five myths.

I repeated the study with a new set of 18 myths (again those with behavioural relevance) from the WHO (World Health Organization, 2022a) and fact checker websites (AFP Fact Check, n.d.; BBC News, 2020a; FactCheck.org, n.d.; Full Fact, n.d.) and an additional 50 participants (Prolific). One participant was removed for giving the same response (50) to all questions. Again, I selected all myths with above 20% average agreement, except for one because there was subsequent scientific debate about whether it was partially true (the effects of Vitamin D). This yielded six myths.

Conditions: There were three between-subject conditions (i) *Question-answer*, (ii) *Fact-only*, (iii) *Fact-myth.* Other conditions were considered. Firstly, a myth-fact format was considered. This condition would have presented the myth before the fact. It therefore would have been the opposite of the fact-myth condition. Secondly, a pure control condition whereby participants did not view any corrective material was considered. The addition of these two conditions was not possible due to the limited funds available for this study. The conditions that were selected prioritised the most current guidance (fact-myth) and novelty (question-answer).

Correction graphics: Graphics were designed to conform to current myth-busting advice (Lewandowsky et al., 2020). Each graphic (Fig. 7.1) therefore contained source information, including an NHS and COVID-19 logo, and a supporting explanation statement that gave an alternative to the myth (Table 7.2). I also included a non-probative image (an image that is related to the claim but does not give extra information about the claim’s veracity), since such images are often included in Public Health Campaigns (Public Health England, n.d.). The same image was used in each format because engagement can be increased even by non-informative images (Fenn et al., 2019; Newman et al., 2012).

Agreement questions. Participants rated their agreement with myths in response to questions that differed in style to the correction graphics to avoid pattern matching between the two. Agreement ratings were made on a six-point Likert scale ranging from “Strongly agree” to “Strongly disagree”. I also included 4 fact statements, to encourage participants to use the full scale (Table 7.3).

Catch questions. I used two catch questions to eliminate participants who did not read the questions. Berinksy, Margolis and Sances (2014) recommend the use of multiple items to measure attention. The questions I included were “There are seven days in the week” and “The first letter of the alphabet is ‘T’”. Participants answered “True” or “False”.

Demographics questions. Participants were asked about age, education, ethnicity, vaccine concern, vaccine intentions and COVID-19 experiences (Table 7.4).

Table 7.3.
Fact and catch questions

Type	**Question**
Fact agreement questions	1. I can protect others by regularly washing my hands with soap and water. 2. To help stop the spread of COVID-19, I can wash my hands with hand sanitiser gel. 3. Symptoms of the coronavirus include a new continuous cough and/or a high temperature. 4. I should not touch my eyes, nose or mouth if my hands are not clean.
Catch questions	1. There are seven days in the week. 2. The first letter of the alphabet is ‘T’.

7.2.3. Procedure

Baseline: Participants completed a short set of questions measuring demographic information and personal experiences with COVID-19. They then answered the 15 agreement questions (11 myths, 4 facts), in a random order. Participants used a six-point Likert scale.

Intervention: Immediately following the agreement questions, participants were randomly assigned to one of three correction formats (question-answer, fact-only or fact-myth). They then viewed the corresponding 11 correction graphics.

Timepoint 1: Immediately following the correction phase, participants again rated agreement with the 15 statements plus two catch trials in a random order.

Timepoint 2 (delay): Participants completed timepoint 2 6-20 days later (*M* = 8.9 days), in which they again rated agreement in a new random order.

Table 7.4.

Demographic, COVID-19 experiences and vaccine intentions questions

Section	Question
Demographic information	1. Please enter your age 2. Please enter your gender 3. Please enter the highest level of education you have completed. e.g., if you have completed your A-levels and are currently doing a degree, you would select "A-levels"
COVID-19 experiences	1. Are you a healthcare worker? 2. According to the NHS advice, are you in a higher risk group for the coronavirus? (This group includes older people, people with health conditions and pregnant women) 3. Have you had symptoms of the coronavirus?
Vaccine concern	1. How concerned are you about serious side effects from vaccines?
Vaccine intentions	1. How likely is it that you will get a COVID-19 vaccine? 2. How likely is it that you will get a flu vaccine for the seasonal flu during the upcoming flu season (autumn 2021–spring2022)?

7.2.4. Participants

I recruited participants representative for age and gender across the UK, via Qualtrics, an online participant platform. To achieve a representative sample, I applied age and gender quotas. Age 18-24: 12%, 25-34: 19%, 35-44: 18%, 45-54: 20%, 55-64: 17%, 65+: 14%. Gender male: 49%, female: 51%. Power calculations are described in the pre-registration.

The main dataset consisted of 2215 participants who completed baseline and timepoint 1. There was an attrition rate of 36.2% (n = 733) between timepoints 1 and 2. There was no difference in the distribution of conditions or gender for participants who only completed timepoint 1 and those who completed both timepoints. However, there was a significant difference for age. Older people were significantly less likely to drop out than younger participants (X^2 (1, N = 2026) = 140.13., p < .001).

36 (2.7%) participants were excluded for failing the attention checks. A further 2 participants were excluded for not meeting the minimum age requirement (18 years, n=2). This left 1293 participants in the analysis.

Therefore, the *n* for main analysis was 1291. Of these, 440 participants were randomly assigned to the question-answer condition, 435 to fact-only and 416 to fact-myth. 47% identified as “man”, 52% identified as “woman”. Age ranged from 18 to 89 years; 5% were 18-24 years, 16% were 25-34 years, 18% were 35-44 years, 24% were 45-54 years, 19% were 55-64 years, and 18% were aged above 65 years. 6% identified as Asian, 1.5% as Black, 89.6% as White and 2.9% as Mixed/multiple ethnic groups.

The study was advertised as a “Coronavirus study” and participants were informed that we were interested in “how the general public use COVID-19 related information”.

Replication data for timepoint 1: I also collected a partial dataset where timepoint 2 was not collected (due to an error). This data was collected three weeks prior to the main dataset (January 2021, the main dataset was collected in February 2021), and I use it to test for replication of the main results for timepoint 1. 2275 participants were recruited and 191 were excluded for not meeting the inclusion criteria described above. 691 participants were randomly assigned to the question-answer condition, 687 to fact-only and 704 to fact-myth. 48% identified as “man”, 51% identified as “woman”. Participants ranged in age from 18-91 years; 14% 18-24 years, 21% 25-34 years, 19% 35-44 years, 19% 45-54 years, 15% 55-64 years, and 13% above 65 years. 7.7% identified as Asian, 2.2% as Black, 0.3% as Middle Eastern, 86% as White and 2.8% as mixed/multiple ethnic groups. 24% reported they were in a COVID-19 risk group, 6.6% had had a positive COVID-19 test; 8.5% reported they were healthcare workers.

7.2.5. Analysis approach

Linear mixed effect (LME) models were used to analyse the data. Analysis was conducted in R using lme4 (Bates et al., 2015), lmerTest (Kuznetsova et al., 2017) and lmer_alt() (afex package (Singmann et al., 2022)). Random effects for participants and myths were included in the models, allowing us to generalise across both. Effects are reported as treatment contrasts with reference level according to the reported comparison (e.g., reported effect of question-answer *vs* fact-myth assumes question-answer as the reference level). *p*-values were obtained via the Satterthwaite approximation**.**

I obtained model convergence by starting with a model that had a maximal random effects structure design (as per advice of Barr, Levy, Scheepers, & Tilley Tilley (Barr et al., 2013)), and if that did not converge, removing correlations between intercepts and slopes items (see (Bates et al., 2015; Singmann & Kellen, 2019)). Model 1 (see below) converged with the maximal random effects structure but Models 2 and 3, which had many more parameters, required suppression of correlations between intercept and slopes. This led to successful model convergence in all cases. Thus, all models included slopes and intercepts for all factors where the design allowed, but not necessarily the correlations between intercepts and slopes.

Even with convergence there remained singularity warnings. I therefore tried simplifying the models by removing further random effects structure. However, this led to models that either failed to converge or were over-simplified (i.e., ignored obvious structure in the data) and consequently risked being anti-conservative (e.g., Barr et al. (2013)). Moreover, wherever I obtained a simplified model that both converged and was absent of singularity warnings, significant effects present in the more complex models were also present in the simpler models. I therefore report the results of the most complex models that converged, as described by the models below.

Research Question 1: To test whether each correction format lowered agreement scores at each timepoint, I used:

```
Model 1: Myth_agreement ~ timepoint + (1+timepoint|participant) +
(1+timepoint|myth)
```

Where `Myth_agreement` is the outcome variable, and timepoint is a fixed factor (baseline, timepoint 1, timepoint 2). Random effects (identified to the right of the pipe symbol, |) include intercepts (identified by 1 left of |) and slopes (identified by named factors after 1+), and correlations between the two. Model 1 was applied to each correction format separately (one model to question-answer, one to fact-only etc.)

Research Question 2: To compare the correction formats I used:

```
Model 2: Myth_agreement ~ correction*baseline*timepoint +
(1+timepoint|participant) + (1+correction*baseline*timepoint||myth)
```

Where `correction` is a fixed factor with three levels (question-answer, fact-only, fact-myth), baseline is a continuous covariate corresponding to baseline scores for each participant and myth, and timepoint is a fixed factor with two levels (timepoint 1 and timepoint 2). The * strings include all main effects and interactions for the listed factors. The model includes all main effects and interactions for fixed and random effects. Correlations between intercepts and slopes were supressed for myth random effects (identified by double pipe, ||, using lmer_alt(); see Analysis Approach above).

`Baseline` was included as a covariate to resolve problems associated with variable degrees of belief in the myths. Myths that were not believed by participants (low baseline scores) could not be corrected (agreement scores lowered) by the intervention, and myths believed too much (high baseline scores) could not exhibit a backfire effect (agreement scores raised). Including baseline as a covariate meant that I could understand effects of the intervention at different levels of baseline belief.

To replicate the results for timepoint 1 with the secondary set of participants, I simply restricted Model 2 to timepoint 1 only:

```
Model 2(a): Myth_agreement ~ correction*baseline + (1|participant) +
(1+correction*baseline||myth)
```

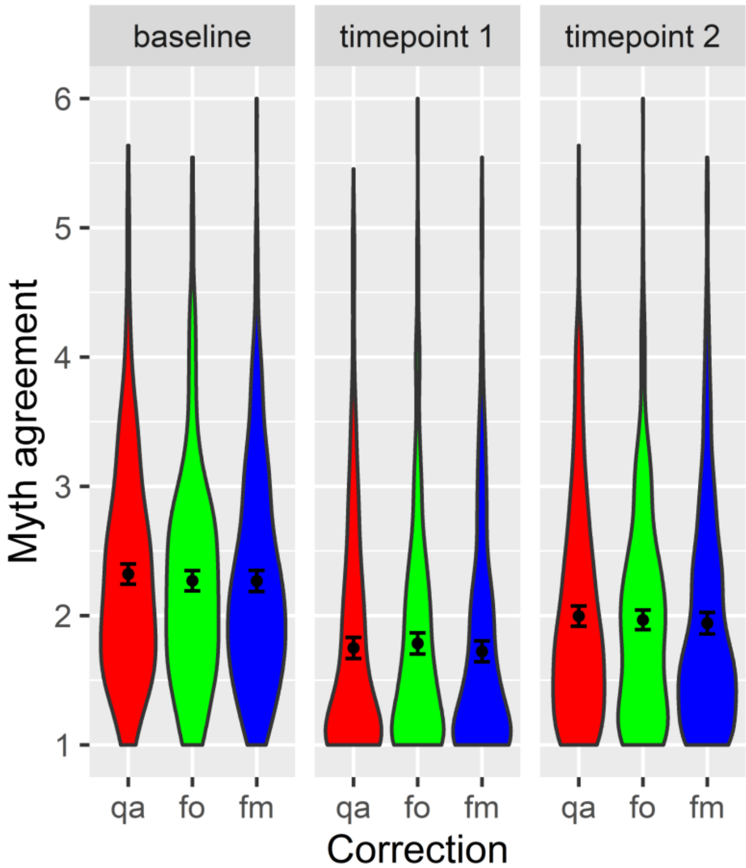
7.3. Results

7.3.1. Research question 1: Which formats are effective immediately and after a delay?

Timepoint 1 and timepoint 2 myth agreement ratings were significantly lower than baseline for all correction formats (Figure 7.2, see Table 7.5 for means and Table 7.6 for model parameters), all β's > 0.30, *SE*'s < 0.092, *df*'s > 11, *t*'s > 5.95, *p*'s $< .001$ (replication set: all β's < 0.43, *SE*'s < 0.076, *df*'s > 11, *t*'s < -6.95, *p's* $< .001$). That is to say, each format was effective and did not backfire.

Nonetheless, ratings partially returned towards baseline at timepoint 2, as shown by significant timepoint 1 to timepoint 2 differences, all β's > 0.18, *SE*'s < 0.045, *df*'s > 13, *t*'s > 4.6, *p*'s $< .001$ (although still falling short of baseline).

Figure 7.2.
Means of COVID-19 myth agreement ratings



Note: 1 denotes low agreement, 6 denotes high agreement with by-participant standard errors and violin distributions. Ratings were reduced at both timepoints 1 and 2 for all correction formats (question-answer, qa, fact-only, fo, fact-myth, fm) relative to baseline. At timepoint 2, myth agreement was higher than at timepoint 1, but stayed below baseline for all formats.

Table 7.5.

Means and Standard Deviations (SD) from the Main and Replication data sets

		Baseline		Timepoint 1		Timepoint 2	
Data Set	**Condition**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Main	Question-answer	2.320	1.439	1.751	1.269	1.996	1.327
	Fact-only	2.269	1.446	1.785	1.305	1.970	1.357
	Fact-myth	2.268	1.424	1.723	1.222	1.941	1.318
Replication	Question-answer	2.623	1.567	2.090	1.510	n/a	
	Fact-only	2.583	1.562	2.152	1.526		
	Fact-myth	2.637	1.586	2.119	1.539		

Table 7.6.

Final models for Main and Replication data sets

Correction format	**Data set**	**Comparison**	**β**	**SE**	**df**	***t***	***p***
Question-answer	Main	Timepoint 1 vs baseline	-0.57	0.084	10.69	-6.83	< .001
		Timepoint 2 vs baseline	-0.32	0.055	11.98	-5.95	< .001
		Timepoint 1 vs Timepoint 2	0.25	0.045	13.00	5.47	< .001
	Replication	Timepoint 1 vs baseline	-0.53	0.076	10.63	-6.95	< .001
Fact-only	Main	Timepoint 1	-0.48	0.059	10.90	-8.26	< .001
		Timepoint 2	-0.30	0.046	16.13	-6.62	< .001
		Timepoint 1 vs Timepoint 2	0.18	0.040	14.99	4.59	< .001
	Replication	Timepoint 1 vs baseline	-0.43	0.047	10.92	-9.13	< .001
Fact-myth	Main	Timepoint 1 vs baseline	-0.55	0.061	11.11	-8.93	< .001
		Timepoint 2 vs baseline	-0.33	0.040	14.77	-8.19	< .001
		Timepoint 1 vs Timepoint 2	0.22	0.038	14.64	5.67	< .001
	Replication	Timepoint 1 vs baseline	-0.52	0.066	11.00	-7.88	< .001

7.3.2. Research Question 2: Which is the most effective correction format?

There was no overall difference between correction formats, but there were interactions with baseline agreement and timepoint (Fig. 7.3 & Fig. 7.4). The main pattern of interest was that differences between formats became evident where the myths were more strongly believed (i.e., where baseline myth agreement was high compared to when it was low; Fig. 7.3 & Fig. 7.4). These differences are considered in detail below.

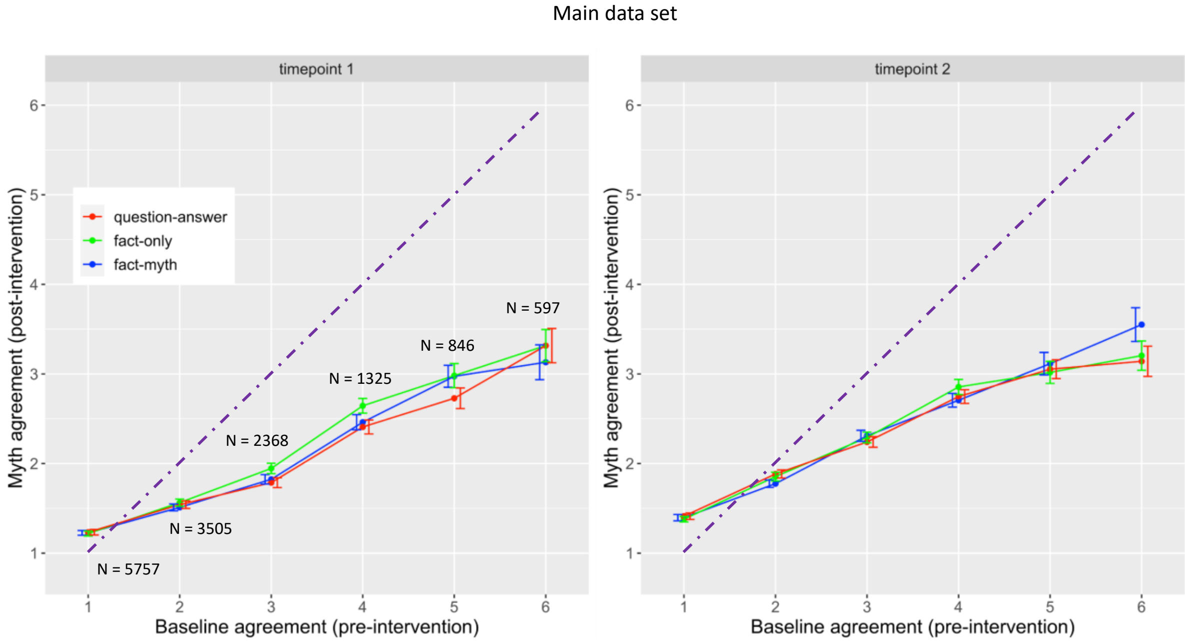
First, for question-answer *vs* fact-only, there was a marginal interaction with baseline and time, $\beta = 0.032$, SE = 0.018, df = 1272, $t = 1.79$, $p = .073$, such that differences were greater at higher baselines and at timepoint 1. Simple effects confirmed (and replicated) that question-answer was more effective at reducing myth agreement than fact-only for higher baselines at time point 1, $\beta = 0.040$, SE = 0.018, df = 28, $p = .022$ (replication set: $\beta = 0.053$, SE = 0.018, df = 19, $p = .0075$), but not at timepoint 2, $\beta = 0.0075$, SE = 0.019, df = 26, $t = 0.39$, $p = 0.70$.

There was also a marginal effect of question-answer vs fact-myth by baseline and time, $\beta = -0.020$, SE = 0.010, df = 5341, $t = -1.93$, $p = .053$, with effects smaller at timepoint 1 than timepoint 2. This was also confirmed by simple effects: there was a significant effect at timepoint 2, $\beta = 0.040$, SE = 0.018, df = 28, $p = .031$, such that question-answer was more effective than fact-myth at higher baselines compared to lower baselines. There was no significant question-answer vs fact-myth by baseline interaction at timepoint 1, $\beta < .001$, SE = 0.018, df = 35, $t = 0.040$, $p = 0.97$ (replication set: $\beta = -0.0028$, SE = 0.013, df = 24, $p = .84$).

Finally, there was a fact-only vs fact-myth by baseline and time interaction, $\beta = -0.038$, SE = 0.010, df = 15990, $t = -3.70$, $p < .001$. This was reflected as a significant simple effect at time 1 for the fact-only vs fact-myth by baseline interaction, $\beta = -0.051$, SE = 0.017, df = 42, $t = -2.91$, $p = .0059$ (replication set: $\beta = -0.061$, SE = 0.016, df = 19, $t = -3.91$, $p < .001$), such that fact-myth was more effective than fact-only at higher baselines than lower baselines. At timepoint 2 the difference between fact-only and fact-myth was no longer significant $\beta = .025$, SE = 0.015, df = 23340, $t = 1.63$, $p = 0.10$.

Figure 7.3.

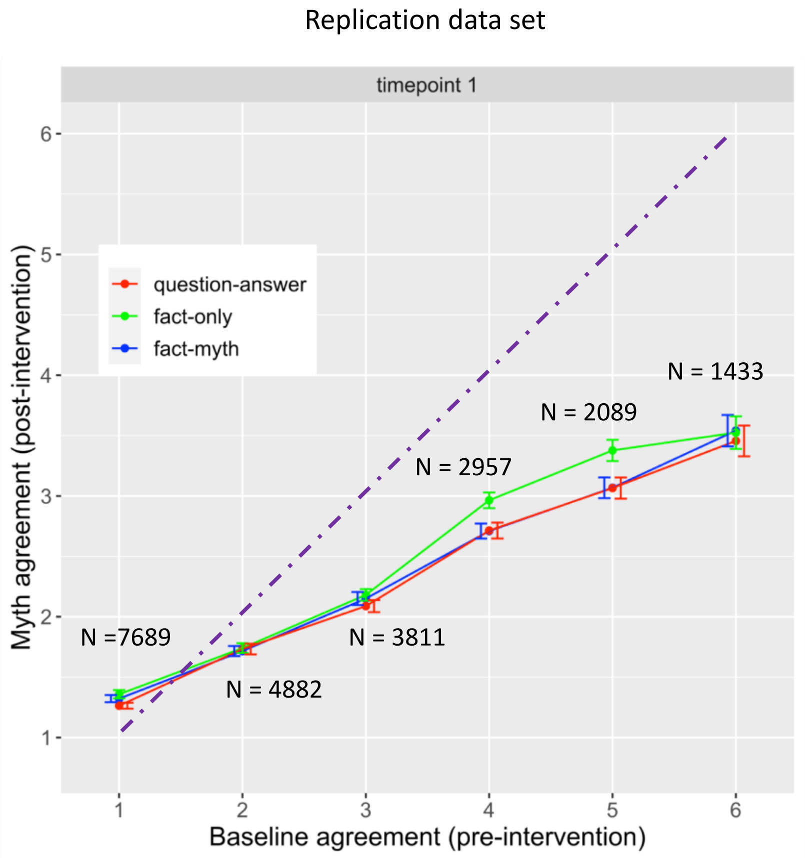
Main data set. Means of COVID-19 myth agreement (post intervention) as a function of baseline agreement (pre-intervention), correction format and timepoint



Note: responses at timepoint 1 in the question-answer condition that were 2 at baseline (pre-intervention) had an average of 1.5 post-intervention. N's indicate the number of responses in each data point e.g. there were 3505 responses that had baseline 2. No N's are included for timepoint 2 because the same number of responses were used for timepoint 1 and timepoint 2. Dashed line shows equivalence between baseline and myth agreement (post-intervention) so that data below the line indicates correction. In both timepoints there was a strong positive correlation between baseline agreement and post-intervention agreement (post-intervention agreement was high when baseline agreement was high). Differences between correction formats were more apparent at higher levels of baseline agreement than at lower levels, hence interactions between baseline and correction format. At timepoint 1, no differences between correction formats were visible when baseline was low, but at higher levels fact-only was less effective at lowering agreement than question-answer or fact-myth. At timepoint 2, again no differences were visible at low baselines, but fact-myth was less effective than question-answer when baseline was very high.

Figure 7.4.

Replication data set. Means of myth agreement (post-intervention) as a function of baseline agreement (pre-intervention) and correction format.



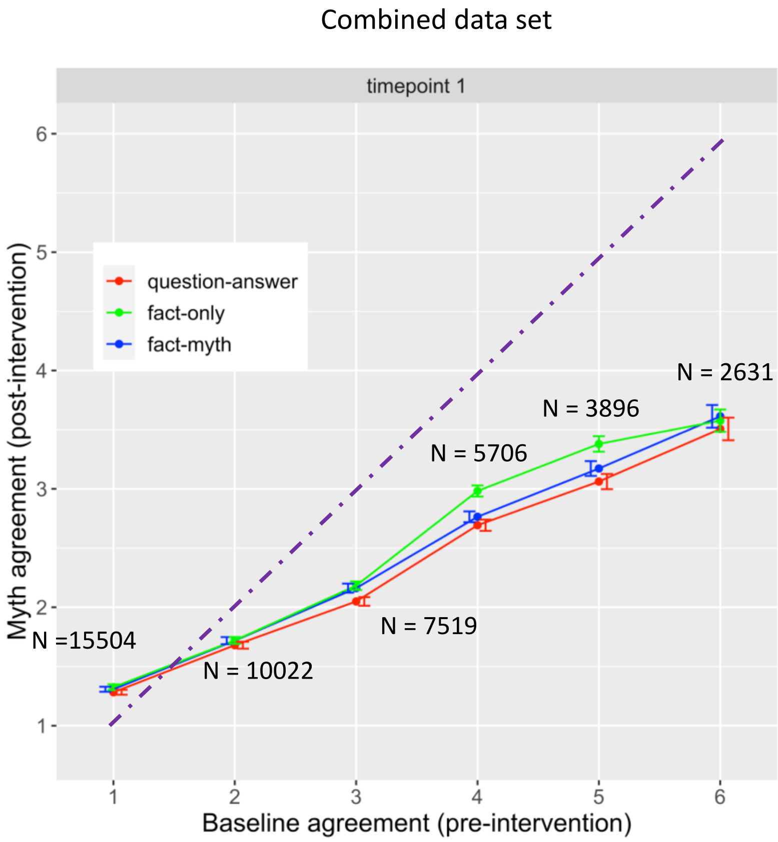
Note: Data from replication set. N's indicate the number of responses in each data point. Dashed line shows equivalence between baseline and myth agreement (post-intervention) so that data below the line indicates correction. Data pattern replicates main data set in that fact-only is less effective than other correction formats at higher baselines.

Analysis of timepoint 1 with combined data set

The analyses above used data from the main set that included only those participants who completed both timepoints. This was necessary to allow comparison between timepoint 1 and timepoint 2. However, the consequence was a substantial loss in power when considering timepoint 1 alone (N = 2177 *vs* N = 1291). Furthermore, the main data set (Fig. 7.3) and the replication data set (Fig. 7.4) set were analysed separately whereas as a combined analysis would have maximised power. I therefore I combined the complete main data set, N = 2177, and the replication set, N = 2084, to yield the largest possible data set (Fig. 7.5).

The results replicated the individual analyses above. There were no main effects but there were interactions with baseline (Fig. 7.5). For question-answer *vs* fact-only, there was an interaction with baseline agreement, $\beta = .039$, SE = 0.012, df = 16, $t = 3.32$, $p = 0.0044$, such that question-answer was more effective at reducing myth agreement than fact-only for higher baselines. Similarly, for fact-myth *vs* fact-only, there was an interaction with baseline, $\beta = .033$, SE = 0.012, df = 16, $t = 2.75$, $p = 0.015$, such that fact-myth was more effective at reducing myth agreement than fact-only. There was no interaction of question-answer *vs* fact-myth by baseline, however, $\beta = 0.0086$, SE = 0.011, df = 16, $t = 0.75$, $p = 0.46$.

Figure 7.5.
Means of myth agreement (post-intervention) as a function of baseline agreement (pre-intervention), correction format and timepoint.



Note: Data combined from complete main and replication data set. Dashed line shows equivalence between myth agreement (post-intervention) and baseline. There are interactions of correction format by baseline such that fact-only is less effective than other formats at higher baselines.

7.4. Discussion

This study demonstrates that simple, poster-like images, of the style used in public health campaigns, can reduce COVID-19 myth agreement both immediately post-intervention and after a delay. This efficacy applied across a UK representative sample for age and gender, across a range of myths, and was replicated in a partial study.

All formats proved effective at reducing myth agreement. Nonetheless, there were differences between formats where baseline (pre-intervention) myth agreement was high. Immediately post-intervention, question-answer and fact-myth were more effective correction formats than fact-only, and after a delay, question-answer was more effective than fact-myth. I therefore recommend question-answer as the preferred format for myth-busting COVID-19, all else being equal.

7.4.1. No backfire effects

Misinformation researchers have sometimes observed “backfire” effects, whereby attempted correction leads to elevated belief in the myths (Gigerenzer et al., 2007; Pluviano et al., 2017, 2019). While such effects have not been consistent in myth-busting research (Ecker et al., 2017; Swire et al., 2017; Swire-Thompson, DeGutis, et al., 2020; Wahlheim et al., 2020), backfire was recently observed for older people when attempting to correct a COVID-19 myth about garlic (Vijaykumar et al., 2021) in a similar study to ours. I found that common COVID-19 correction formats did not cause backfire effects.

7.4.2. Correction formats

I found no main effect differences between correction formats but there were interactions with baseline agreement. These were such that differences were visible when baseline agreement was high (i.e., only when people believed the myths pre-intervention). Immediately post-intervention, fact-myth was more effective than fact-only. This is consistent with prior studies (Ecker et al., 2017; Wahlheim et al., 2020) demonstrating that reminding participants of misinformation facilitated correction. This could be because restating the myth allows improved coactivation of the myth and the correction (Kendeou et al., 2014). Another possibility is that restating the myth makes the fact more familiar relative to fact-only. Informing people that a proposition is a myth communicates that the negation of the proposition is a fact. For example, the utterance, “Some people incorrectly believe that the COVID-19 vaccine will change your DNA," is logically equivalent to saying that the COVID-19 vaccine will not change your DNA. Thus, the advantage of fact-myth might arise because the fact is communicated more often than in fact-only.

Question-answer was also more effective than fact-only immediately post-intervention. One potential explanation is that the question-answer image motivated readers to search for a relevant myth, much like an internally motivated myth restatement. However, effects after the delay provide some evidence that this account is incorrect. Here, question-answer was more effective than fact-myth; if question-answer participants benefitted from an internal myth restatement, I should not have observed differences between the external (fact-myth) and internal (question-answer) myth restatement conditions. Note, however, that the statistical differences between question-answer and fact-myth after the delay were weak ($p = .03$) and differences were only visible at very high baseline scores (Figure 7.3). Further evidence is required to confirm the advantages of question-answer at longer intervals.

Another possibility is that the question-answer advantage arose from facilitated retrieval and/or encoding. Retrieval might have been facilitated in a similar way to the testing effect seen in educational settings (Roediger & Karpicke, 2006). In educational research, it is well known that self-testing (questioning oneself about the to-be-learnt material) produces better long-term recall than repeated reading of the to-be-learnt material, one explanation being that testing enhances learning by producing elaboration of existing memory traces and their cue-target relationships (McDaniel & Masson, 1985). However, it is unclear whether immediately providing the answer, as in the question-answer format used here, is equivalent to providing the answer after a delay, as is typical in educational research.

The discourse structure was different in question-answer than fact-myth or fact-only. This could have contributed to encoding differences. First, question-answer was pragmatically more felicitous that fact-only. Fact-only lacked an obvious "question-under-discussion" (Roberts, 1996), a reason why the fact was presented, and so participants were obliged to expend effort in search of one. Second, question-answer provided a clear statement about the veracity of the queried fact. The answer ("yes" or "no") told participants whether the statement was true and might have acted as a memory "tag" (Lewandowsky et al., 2012; Mayo et al., 2004). In other conditions, the veracity of the fact had to be inferred from the experimental context.

In summary, question-answer and fact-myth conferred advantages relative to fact-only immediately post-intervention. After the delay, there was some evidence that question-answer was more effective than fact-only. These findings lead us to recommend question-answer as the preferred format for COVID-19 myth correction campaigns (in contrast to the format used by some current campaigns, e.g., WHO (World Health Organization, 2022a), which use fact-only formats). However, it is important to emphasise that the effects of correction format were small compared to the effects of correction more generally (compare differences across correction formats in Fig. 7.2 with differences between baseline and post intervention), especially after the delay. It is thus better to include correction in any format than to avoid doing so for fear of causing harm with an ineffective myth-busting campaign.

7.4.3. Attrition and attention checks

The only significant difference between the participants who only completed timepoint 1 and those who completed both timepoints 1 and 2 was age. Older participants were more likely to return to complete timepoint 2 than younger participants. One possibility is that COVID-19 had more sever outcomes for older participants, and therefore they were more motivated to take part in the study.

Approximately three percent of the participants failed the post-manipulation attention checks, or screeners, used in this study. Following the advice of Berinsky et al. (2014), I included two attention checks as single screeners do not effectively improve data quality. The aim of the attention checks was to identify participants who were carelessly reading the questions and/or information in this study. I note that the failure rate in my study (2.7%) is a lot lower than the rates identified by Berinsky et al. (2014; 24.9% and 38.3%). Attention checks are frequently used in research to test for inattentiveness. However, their measurement quality has been tested by very few (e.g., Berinsky et al., 2014; Shamon & Berning, 2019) and it has been noted that many participants who notice the checks may intentionally fail them (61%; Silber, Roßmann & Gummer, 2022).

7.4.4. Limitations and future studies

Our study comes with a number of caveats and opportunities for further research. The first relates to the myths I tested. The level of belief in our myths was low overall, around 40% at baseline, which meant that there was only limited room for correction (although much room for backfire effects). The consequence was that the power of the study was reduced relative to a study with more strongly believed myths (Swire et al., 2017) and this may have contributed to our failure to find differences between some conditions. Nonetheless, the loss in power was accompanied by a gain in validity. The materials I used were genuine COVID-19 myths, recruited from fact-checker websites, rather than the everyday narratives used in continued influence paradigms (Ecker et al., 2017). The results of this study are therefore more likely to generalise to COVID-19 myth-busting campaigns than if I had used non-COVID materials.

By limiting our materials to myths found in current COVID-19 health information, I not only limited the pre-existing myth belief, I also limited the range of myths. The myths I tested could all be considered *rumours* (Islam et al., 2021), in that they were factually verifiable and designed not to inflame political beliefs. Our conclusions are thus limited to these forms of misinformation. Other types of misinformation, such as conspiracy theories, tend to be much more difficult to correct (Lewandowsky, 2021b) and may respond differently to the correction formats I tested.

The second limitation relates to the degree of engagement with the materials. Our findings are the result of participants reading each correction image when told to do so, independently of whether they found the topic or format engaging. In real health campaigns, people will only process material they are drawn to engage with, and the danger is that engagement and memory will dissociate so it remains possible that, for example, question-answer produces the most effective memory correction, but fact-myth is more engaging.

Relatedly, I did not test the effects of partial engagement. Many readers outside of an experiment will only shallowly process posters or social media content, perhaps just reading the title (Gabielkov et al., 2016) or initial sentences, or their attention might be divided between reading the correction and other tasks, impairing memory (Craik et al., 1996) and even the processing of corrections specifically (Ecker et al., 2010). Correction under these conditions may be weaker than effects reported here (Ecker, O'Reilly, et al., 2020) and may differ according to correction format. For example, were people to read the question of a question-answer format poster without reading the answer ("Does the COVID-19 vaccine change your DNA?"), the myth may become more familiar than if the question had not been read at all. This would be more likely when the answer was separated from the question by large chunks of intervening material.

Finally, there were subtle differences between the formats I tested, and the materials used in health campaigns. These differences may influence the extent to which our findings generalise. The first is that where I included myths, I did do *after* stating the fact, in line with current guidance. However, health campaigns, fact checkers, and previous studies have often presented the myth first and then the fact (Full Fact, n.d.; Pluviano et al., 2019). From a partial engagement perspective putting the fact first reduces the probability that the myth is read without the correcting fact. Second, I did not use the word “myth”, as in the traditional myth-busting format (“Myth: The COVID-19 vaccine changes your DNA”). Instead, I used synonymous text strings (“Some people wrongly believe that…”) that fitted better with the structure of the materials and is widely employed in campaigns (Pickles et al., 2021). It is possible that using the more concise, lexical form would be easier for people to process and so lead to greater correction.

7.4.5. Conclusion

Our results imply that COVID-19 myths can be effectively corrected using materials and formats typical of health campaigns. Health campaigns can also use our results to select the optimum correction formats. While myth-busting in any of the three formats I tested was effective, question-answer format and fact-myth were more effective than fact-only, and there was some evidence that question-answer was more effective than fact-myth in the longer term. Further research needs to widen the range of myths tested from the verifiable rumours considered here to conspiracy theories, and to consider how different formats behave under partial engagement conditions.

Chapter 8. Does debunking increase behaviour intentions?

In Chapter 6 and Chapter 7, I demonstrated that debunking can successfully correct beliefs in misinformation within a public health context. Specifically, debunking decreased myth agreement both immediately and after a delay. These findings are in line with the wider literature on debunking (Swire-Thompson et al., 2021).

What is less clear within the literature is whether debunking produces downstream effects on vaccine intentions. Some have argued that debunking has a negative effect (Nyhan & Reifler, 2015), other have found no effect of debunking on behaviour intentions (Pluviano et al., 2019). In this chapter, I use data collected during the studies mentioned above to test for an effect of debunking on behaviour intentions. Study 1 and Study 2 uses a between-subjects design and compare debunking methods to a control (who did not receive an influenza correction). Study 3 uses a within-subjects design to compare COVID-19 vaccine intentions before and after debunking.

8.1. Introduction

When pandemics and health emergencies arise, public health organisations employ campaigns promoting health knowledge. These help communities to respond appropriately to risk factors and to contain infection outbreaks (Uribe et al., 2021). During the current COVID-19 pandemic, Governments (GOV.UK, n.d.), Health services (NHS, 2020), and the World Health Organization (World Health Organization, 2022c) have all provided free materials promoting health knowledge. It is commonly believed that beliefs based upon accurate information foster helpful, or health promoting, behaviours whereas beliefs based on misinformation produce unhelpful behaviours (Freeman et al., 2020).

The COVID-19 pandemic was accompanied by an “infodemic” which, in part, consisted of an abundance of misinformation (World Health Organization, 2020d). Misinformation is a serious threat to public health. For example, if misinformation spreads about a disease’s treatments, people may take ineffective and/or dangerous remedies (Pennycook et al., 2020). Anecdotally, during the current COVID-19 pandemic, a man in Arizona died after consuming chloroquine phosphate. He had allegedly heard false claims that chloroquine can cure the coronavirus (Edwards & Hillyard, 2020). Experimentally, Loomba et al. (2021) found that exposure to COVID-19 misinformation lowered participants' intent to vaccinate. Furthermore, Jolley & Douglas (2014) found that when participants were exposed to information in support of anti-vaccine conspiracy theories, their vaccine intentions were significantly lower than participants who viewed anti-conspiracy information and those in the control condition. The most harmful consequences of misinformation, therefore, are their effects on behaviour (MacFarlane et al., 2021).

To counteract the potential damage of misinformation, fact checking organisations (Full Fact, n.d.; Snopes, n.d.; World Health Organization, 2022a) have provided myth busting services during the COVID-19 pandemic. Public health campaigns commonly employ an information deficit model to correct misinformation. This model reasons that erroneous beliefs can be easily corrected by supplying relevant facts (Simis et al., 2016). Subsequently, public health campaigns often correct misinformation via debunking, that is addressing and correcting specific myths (Ecker et al., 2022). In the literature, debunking has been found to be effective at correcting attitudes regardless of the correction format used (Swire-Thompson et al., 2021). If we consider that exposure to misinformation decreases intentions to vaccinate, shouldn't correct information increase vaccine intentions? Although this question may make sense logically, there have been mixed results for the effects of debunking on behaviour intentions. Therefore, in this chapter, I aim to test effects of debunking on influenza and COVID-19 vaccine intentions.

8.1.1. Health knowledge and its effects on behaviour during pandemics

Uribe et al. (2021) conducted a systematic review of health knowledge, health behaviours and attitudes during pandemics. Thirteen cross sectional studies conducted during three pandemics (Mers-CoV, Influenza A H1N1, and COVID-19) were included in the review. Health knowledge was self-reported in all thirteen studies. Ten studies reported that health knowledge was significantly associated with protective behaviours. One study reported that health knowledge about Influenza A (H1N1) moderately predicted engagement in protective health behaviours such are wearing a facemask, hand washing, and reporting symptoms. One study found that health knowledge about Influenza A (H1N1) was a partial mediator between confidence in formal information and personal hygiene practices. The thirteenth study did not consider behaviours, it only considered attitudes.

Uribe et al. (2021) concluded that health knowledge was positively associated with protective behaviours such as hand washing, mask wearing, temperature monitoring and social distancing during pandemics (Uribe et al., 2021). These results are in line with Freeman et al. (2020): accurate information and health knowledge is important during pandemics to foster protective behaviours.

8.1.2. Health knowledge and behaviour: the wider literature

Within the wider literature, the relationship between knowledge (or interventions to increase knowledge) and behaviour (or behaviour intentions) has not been as clear. Some studies have found that interventions to increase knowledge can have positive effects on behaviour or behaviour intentions. For example, MacFarlane et al. (2021) found that correcting false knowledge about Vitamin E capsules and their "ability to treat COVID-19", successfully reduced participants' intentions to buy the ineffective vitamin E capsules. Other studies, however, have failed to find an effect of knowledge correction on behaviours or behaviour intentions. For example, Tay et al (2022) used prebunking and debunking interventions for implied versus explicit misinformation about fair trade products and found no differences between the intervention groups and a control for the behavioural measure "willingness to pay".

Additionally, some studies have found that knowledge correction interventions can backfire amongst the whole sample or subgroups and decrease the likelihood of participants engaging (or intending to engage) in a behaviour. For example, Skurnik et al. (2007) found that participants who had viewed debunking information had lower intentions to obtain an influenza vaccination. Similarly, Nyhan & Reifler (2015) found that debunking successfully lowered belief in influenza vaccine misinformation. However, for participants with high levels of concern about vaccine side effects, myth busting significantly decreased their intent to vaccinate themselves against influenza. However, researchers have failed to replicate the findings of these studies (Haglin, 2017). Haglin (2017) found no effect of knowledge correction upon behaviour intentions.

Similarly, studies by Pluviano et al. (2019, 2020) have also failed find an effect of knowledge correction on vaccination intentions. Furthermore, a recent randomised controlled trial conducted by Helfers & Ebersbach (2022) using a real-world COVID-19 debunking (i.e., knowledge correction) campaign found no significant difference between the debunking group and control group for intentions to get vaccinated against COVID-19. Although, like Nyhan and Reifler (2015), when they considered pre-test misinformation beliefs, they found evidence that the correction decreased vaccine intentions amongst participants with high pre-test misinformation beliefs.

Backfire effects, whereby interventions fail and inadvertently strengthen beliefs in misinformation or decrease behavioural intentions (Cook & Lewandowsky, 2011) have proved difficult to replicate (Wood & Porter, 2019). Following an in-depth review of backfire effects, (Swire-Thompson, DeGutis, et al., 2020) concluded that backfire effects do not occur consistently and named them non-robust phenomena. Researchers have also failed to find backfire effects when introducing misinformation to previously naïve audiences (Ecker, O'Reilly, et al., 2020). In terms of COVID-19, MacFarlane et al. (2021) failed to find evidence of a backfire effect on behavioural intentions. Debunking successfully reduced participants' willingness to pay for Vitamin E supplements to "treat" COVID-19.

There appears, therefore, to be a paradox in the literature. Why on one hand is an individual's knowledge associated with positive behaviours and behavioural intentions, but on the other hand, is not associated with a change in behaviour intentions following knowledge correction? It is unclear why intentions to increase knowledge are effective for attitudes but not for behaviours (or behaviour intentions). One possible explanation is that behaviour is difficult to predict. Older theories of behaviour such as the Theory of Planned Behaviour only account for a small proportion of behaviour. For example, for health behaviours, the Theory of planned behaviour was better at predicting physical activity and diet behaviour than risk detection, safe sex and abstinence from drugs (McEachan et al., 2011). However, even for the better predicted behaviours, only approximately 23% of the variance was explained by the Theory of Planned Behaviour (McEachan et al., 2011).

As a result, contemporary theories have become more complex and incorporated both the mechanisms that underly behaviour change and factors that may moderate an intervention's success. For example, whether an environment aids the behaviour change (Davidson & Scholz, 2020). Regarding health behaviour change, successful interventions typically have modest effects (Davis et al., 2015). A potential reason for this is that interventions are grounded in theory less than a quarter of the time (Davis et al., 2015), and when theories are referenced, they are referred to loosely (Hagger et al., 2020). Furthermore, there is an overwhelming number of behaviour-change theories and each use different terminology for the same phenomena which can obscure trends within the field (Davis et al., 2015; Hagger et al., 2020).

Another possibility is that the success of an intervention on behaviour change relies on the ease at which the behaviour can be achieved. For example, Uribe et al. (2021) found that health knowledge was both a predictor and mediator of behaviour. They found that the interaction between health behaviour could be explained by the practicality of behaviours, how easy they were to access and how easy they were to perform. Many of the behaviours included in Uribe et al.'s systematic review were personal hygiene behaviours that could easily be performed (e.g., hand washing). Pluviano et al. (2019, 2020) and Helfers & Ebersbach (2022) failed to find an effect of a knowledge intervention on behaviour intentions, however, they all studied vaccine intentions. Acquiring a vaccine is a behaviour that is not as easily accessible, practical, or easy to perform as washing your hands. For example, if an individual wants to vaccinate themselves against COVID-19, the vaccine must be easily accessible or available to them, they must also have the resources to book an appointment at the doctors, negotiate time off work, travel to the appointment, and manage any common side effects (e.g., feeling tired, sick, or having a high temperature).

8.1.3. The present study

The difference between attitudes/knowledge and behaviours is important to address. Many public health interventions that correct knowledge are primarily motivated to change behaviours (e.g., counteracting misinformation about face masks to increase their use during the COVID-19 pandemic). It is vital to understand the gap between knowledge and behaviour as the failure of such public health interventions can mean that risky or unsafe behaviours are continued (e.g., purchasing ineffective health products, failure to comply with social distancing measures, or the consumption of dangerous or ineffective substances; Tay et al., 2022).

In Chapter 6 (Does correction format influence influenza myth agreement?) and Chapter 8 (COVID-19 myth busting: an experimental study), I demonstrated that debunking can be successfully used to correct people's knowledge about influenza and COVID-19. The data for this chapter was collected alongside the myth agreement data in chapters 6 and 8. In this chapter, I aim to test whether the same debunking interventions are also successful at changing behaviour intentions. Specifically, this chapter looks at the effects of debunking on influenza and COVID-19 intentions both immediately following the interventions and after a delay.

This study has the following research questions:

1. What are the immediate and delayed effects of debunking on vaccine intentions?
2. What are the effects of debunking on vaccine intentions for a subgroup of participants with high vaccine concern?

Research question 1 was motivated by the mixed findings for the differences between attitudes (or knowledge) and behaviour intentions. Research question 2 was included because some studies have found that interventions aimed at debunking misinformation have backfired and decreased vaccine intentions (Nyhan & Reifler, 2015; Skurnik et al., 2007).

8.2. Method and analysis approach

This chapter contains data from two influenza debunking experiments (Influenza Experiment 1 and Influenza Experiment 2) and one COVID-19 debunking experiment. The COVID-19 experiment contained two datasets: Wave 1 only and Wave 1 & Wave 2. The two datasets were collected separately and did not include the same participants.

8.2.1. Influenza Experiment 1

8.2.1.1. Participants and materials

The participants in this analysis are the same participants described in Chapter 6. Participants were recruited from Prolific. The two timepoints in this study were separated by a seven-day delay. At timepoint 1, 266 participants were recruited, however, only 201 participants of these fully completed both timepoints. The participants who completed both timepoints ranged in age from 18 to 76 years (M = 34.96, SD = 11.18). 146 were female and 44 were male. Participants were randomly allocated to a condition. 101 participants were in the influenza condition and 100 participants were in the control condition.

In total, 57 participants completed timepoint 1 did not return to complete timepoint 2. Nevertheless, these participants did not significantly differ from the ones who did return in terms of their age (younger = 53, older = 3), gender (female = 41, male = 16), or the condition they were allocated (Influenza = 29, control = 28). Participants were reimbursed financially for their participation.

8.2.1.2. Behavioural intention measure

Participants indicated their intentions to get vaccinated by answering the following question: "How likely is it that you will have an influenza vaccination this year?". The higher the vaccine intention score, the more likely the participant was to perform the behaviour. For example, a score of "0" indicated that a participant was "very unlikely" to obtain their influenza vaccination and a score of "6" indicated that they were "very likely" to obtain their influenza vaccination.

8.2.1.3. Research question and analysis approach

Influenza Experiment 1 compared a flu myth correction intervention to a control (healthy eating). It did not collect baseline influenza knowledge or myth agreement scores. Therefore, for Influenza Experiment 1 we are only able to answer Research question 1: What are the immediate and delayed effects of debunking on vaccine intentions?

Statistical analyses were completed using IBM SPSS Statistics 27 (IBM Corp, 2016). Statistical significance was set at $p < 0.05$. Influenza Experiment use a between-subjects study design. Therefore a 2 (correction format) by 2 (timepoint) ANOVA was used to answer Research question 1.

8.2.2. Influenza Experiment 2

8.2.2.1. Participants

As with Experiment 1, the participants in this analysis are the same participants from Chapter 6. These participants were also recruited from Prolific. This study had two timepoints separated by a seven-day delay. At timepoint 1, 429 were recruited from Prolific, an online participant panel. 395 participants' data were left after the participants with missing data had been removed and one non-binary participant was removed so that they could not be identified in the analysis. 278 participants were female and 117 were male. Participants' ages ranged from 18-75 years (M=37.20, SD=12.85). 130 participants were randomly allocated to the control condition, 132 to the fact-only condition, and 135 to the myth-fact condition.

Of the 395 participants, 95 did not return to complete timepoint 2. These participants did not differ significantly from the participants who completed both timepoints in their distribution of condition (control = 33, fact-only = 27, myth-fact = 35) or gender (female = 72, male = 23). The attrition rate, however, was higher amongst older participants (i.e., those aged 55+) than younger participants ($p = .02$). A potential reason for this is that COVID-19 disproportionately affected older adults and therefore the younger participants did not have the same motivation to continue. The higher level of attrition in younger participants should not affect the results as there are more younger participants than older participants in the study. 300 participants completed both timepoints and were included in the analysis.

8.2.2.2. Behavioural intention measure

I asked each participant "If you were offered the flu vaccine this year, how likely would you be to accept it?". Responses were scored so that the higher the score, the more likely participants were to accept the influenza vaccine.

8.2.2.3. Research question and analysis approach

Influenza Experiment 2 compared two debunking interventions (myth-fact, fact only) to a control condition. Again, baseline influenza attitudes were not collected, therefore this study answered research question 1. Influenza Experiment 2 also used a between-subjects study design. Therefore, a three (condition) by 2 (timepoint) ANOVA was computed.

8.2.3. COVID-19 experiment: Wave 1 only

Participants were recruited via Qualtrics. Participants in both COVID-19 datasets completed Wave 1 (i.e., baseline and timepoint 1) but only participants in the Wave 1 & 2 dataset completed timepoint 2.

8.2.3.1. Participants

Wave 1 was completed by 4108 participants. The majority identified as "woman" (2083, 50.7%), 48.5% identified as "man" (n=1994). There were three debunking conditions: question-answer (n = 1362), fact-only (n = 1368), and fact-myth (n = 1378). The ages of the participants ranged from 18-91 years; 13.3% were 18-24 years, 21.2% 25-34 years, 18.6% 35-44 years, 19.1% 45-54 years, 15.1% 55-64 years, and 12.6% 65+ years.

8.2.3.2. Behavioural intention measure (both COVID-19 datasets)

To assess vaccine acceptance, Nyhan and Reifler (2015)'s influenza vaccine question "How likely is it that you will get a flu vaccine for the seasonal flu during the upcoming flu season (fall 2012–spring 2013)?" (p. 463) was adapted so that it was relevant to COVID-19. Participants were asked "How likely is it that you will get a COVID-19 vaccine?" and responded on a six-point scale from "Very unlikely" to "Very likely".

8.2.3.3. Research questions and analysis approach

Before the analyses for any of the COVID-19 experiments were completed, the participants who scored the maximum baseline vaccine intention score (i.e., those who answered, "Very likely" to the question "How likely is it that you will get a COVID-19 vaccine?") at baseline were removed from the main analyses. These participants had already reached the maximum score for vaccine intentions and therefore would not display an improvement effect. A separate analysis was conducted on these participants to account for potential backfire effects.

The Wave 1 only dataset did not contain timepoint 2 data, therefore it could only answer "what are the immediate effects of debunking on vaccine intentions?"

Baseline misinformation agreement was collected at baseline during the COVID-19 experiment. Therefore, when answering research question 1 (What are the immediate and delayed effects of debunking on vaccine intentions?), I tested for an interaction between baseline myth agreement and behaviour intentions. A 3 (correction format) X 2 (timepoint) or 3 (correction format) repeated measures ANOVA was completed with baseline myth agreement was entered into both ANOVAs as a covariate.

To answer research question 2 (What are the effects of debunking on vaccine intentions for a subgroup of participants with high vaccine concern?), the participants who scored the two highest vaccine concern scores were selected from the dataset. This criterion was consistent with Nyhan & Reifler (2015). A 3 (correction format) X 2 (timepoint) ANOVA was then completed with baseline myth agreement entered as a covariate.

8.2.4. COVID-19 experiment: Wave 1 and 2 dataset

8.2.4.1. Participants

The analysis included 1291 participants. Again, there were three debunking conditions: question-answer (n = 440), fact-only (n =435) fact-myth (n = 426). 47% identified as "man", 52% identified as "woman". Age ranged from 18 to 89 years; 5% were 18-24 years, 16% were 25-34 years, 18% were 35-44 years, 24% were 45-54 years, 19% were 55-64 years, and 18% were aged above 65 years.

8.2.4.2. Research questions and analysis approach

The Wave 1 and 2 dataset contained both timepoint 1 and timepoint 2 data and could therefore answer "what are the immediate and delated effects of debunking on vaccine intentions?" As with the Wave 1 only dataset, Research question 1 could be answered two ways: the first examining each debunking condition separately and the second combining the three interventions to form a single "debunking" condition. When comparing the three debunking conditions, a 3 (correction format) X 3 (timepoint) ANOVA repeated measures ANOVA was used with baseline myth agreement entered as a covariate. For those with the highest vaccine concern, a 3 (correction format) X 3 (timepoint) ANOVA was completed with baseline myth agreement was entered into both ANOVAs as a covariate.

8.3. Results

8.3.1. Influenza Experiment 1

8.3.1.1. Debunking and myth agreement

Influenza myth busting in the myth-first format successfully decreased myth agreement compared to a control at timepoint 1 and timepoint 2.

8.3.1.2. What are the immediate and delayed effects of debunking on vaccine intentions?

There was no significant between-subjects effect of correction format on vaccine intentions (F (1, 199) = 3.458, p = .064, η_p^2 = .017, observed power = .457).

There was a significant timepoint by correction format interaction (F (1, 199) = 4.25, p = .041, η_p^2 = .021; Table 8.1). Participants in the influenza myth-first format condition had higher vaccine intentions at timepoint 1 than participants in the control condition (p = .020). However, there was no difference between vaccine intention scores at timepoint two between the two conditions (p = .211).

Table 8.1.

Influenza experiment 1: Means and Standard Deviations

	Mean	Std. Dev
Timepoint 1		
Control	2.21	2.26
Influenza myth-first	2.97	2.33
Timepoint 2		
Control	2.35	2.35
Influenza myth-first	2.76	2.31

8.3.2. Influenza Experiment 2

8.3.2.1. Debunking and myth agreement

Influenza myth busting in the myth-first format successfully decreased myth agreement compared to a control at timepoint 1 and timepoint 2.

8.3.2.2. What are the immediate and delayed effects of debunking on vaccine intentions?

There was no significant between-subjects effect of correction format on vaccine intentions (F (2, 297) = .601, p = .549, η_p^2 = .004, observed power = .150).

There was a significant interaction between timepoint and correction format interaction (F (2, 297) = 3.79, p = .024, η_p^2 = .025; Table 8.2). Simple effects analyses found that there was a significant difference between timepoints 1 and 2 for the influenza myth-first condition (p < .001). For those in the myth-first condition, vaccine intentions were significantly higher at timepoint 1 than timepoint 2. This pattern was not found for the fact-only (p = .206) or control (p = .552) conditions.

Table 8.2.

Influenza experiment 2: Means and Standard Deviations

	Mean	Std. Dev
Timepoint 1		
Control	5.67	1.97
Influenza myth-first	6.04	1.63
Influenza fact-only	5.96	1.82
Timepoint 2		
Control	5.62	2.01
Influenza myth-first	5.68	1.85
Influenza fact-only	5.86	2.81

8.3.3. COVID-19 Experiment: Wave 1 only

8.3.3.1. Debunking and myth agreement

For the Wave 1 only participants, debunking successfully reduced myth agreement at timepoint 1.

8.3.3.2. What are the immediate effects of debunking on vaccine intentions?

To test for an interaction between baseline misinformation and behaviour intentions, I entered baseline myth agreement as a covariate. There was no significant interaction between time and baseline myth agreement (F (1, 1641) = 3.28, p = .070, η_p^2 = .002), or time and correction format (F (2, 1641) = 3.28, p = .720, η_p^2 = .000).

There was, however, a main effect of time (F (1, 1641) = 25.13, p = <.001, ηp2 = .015; see Table 8.3). Vaccine intentions were higher at timepoint 1 than at baseline (p < .001) and this was the case for all three experimental conditions (all p's < .001). There was no significant difference, however, between the three correction formats (F (2, 1641) = 1.19, p = .304, η_p^2 = .001).

Table 8.3.

COVID-19 Wave 1 data set Means and Standard Deviations

	Mean	Std. Deviation
Baseline		
Fact-myth	3.65	1.44
Fact-only	3.75	1.41
Question-answer	3.60	1.41
Timepoint 1		
Fact-myth	3.93	1.58
Fact-only	3.99	1.53
Question-answer	3.88	1.60

According to G*Power, a paired t-test would require a sample size of n = 326 to have 95% power to detect a small effect size (.20). Thus, with 1660 participants, I had >99% power to detect the small effect size observed in this analysis.

8.3.3.3. What are the effects of debunking on vaccine intentions for a subgroup of participants with high vaccine concern?

For this analysis, the participants with the highest vaccine concern scores, as in Nyhan & Reifler (2015), were analysed using a 3 (correction format) X 2 (timepoint) ANOVA with baseline myth agreement entered as a covariate (fact-myth n = 105, fact-only n = 99, question-answer n = 124).

I did not find a significant effect of time (F (1, 324) = .146, p = .703, η_p^2 = .000, Table 8.4). I also did not find a significant time by baseline myth agreement interaction (F (1, 324) = .651, p = .420, η_p^2 = .002), nor a significant time by correction format interaction F (2, 324) = .601, p = .549, η_p^2 = .004). Furthermore, there was no significant difference between the correction formats F (2, 324) = 174, p = .840, η_p^2 = .001). Therefore, I did not find evidence of a worldview backfire effect amongst a subgroup of participants with high concerns about vaccines. Debunking was therefore unsuccessful at changing vaccine intentions of participants with the highest vaccine concern scores.

Table 8.4.

COVID-19 Wave 1 data set: Highest vaccine concern participants' Means and Standard Deviations

	Mean	Std. Dev
Baseline		
Fact-myth	2.84	1.69
Fact-only	2.68	1.69
Question-answer	2.87	1.58
Timepoint 1		
Fact-myth	3.02	1.91
Fact-only	2.98	1.88
Question-answer	3.03	1.89

8.3.4. COVID-19 Experiment: Wave 1 and 2

8.3.4.1. Debunking and myth agreement

For the Wave 1 and 2 dataset, debunking resulted in significantly lower timepoint 1 and timepoint 2 myth agreement ratings than baseline for all correction formats

8.3.4.2. What are the immediate and delayed effects of debunking on vaccine intentions?

Within the Wave 1 & 2 dataset, there was a significant interaction between baseline myth agreement and time (F (2, 802) = 6.78, p < .001, η_p^2 = .017. The participants who agreed with the myths the most at baseline demonstrated the biggest changes in their vaccine intention scores at timepoints 1 and 2 (Figure 8.1). However, this result should be interpreted with caution due to the low number of participants who agreed with the myths at baseline (n = 18). Furthermore, the participants who believed the myths a medium amount at baseline (i.e., a score of 3 or 4) had lower vaccine intentions at all timepoints. There was not, however, a significant interaction between time and correction format (F (4, 802) = .402, p < .808, η_p^2 = .002).

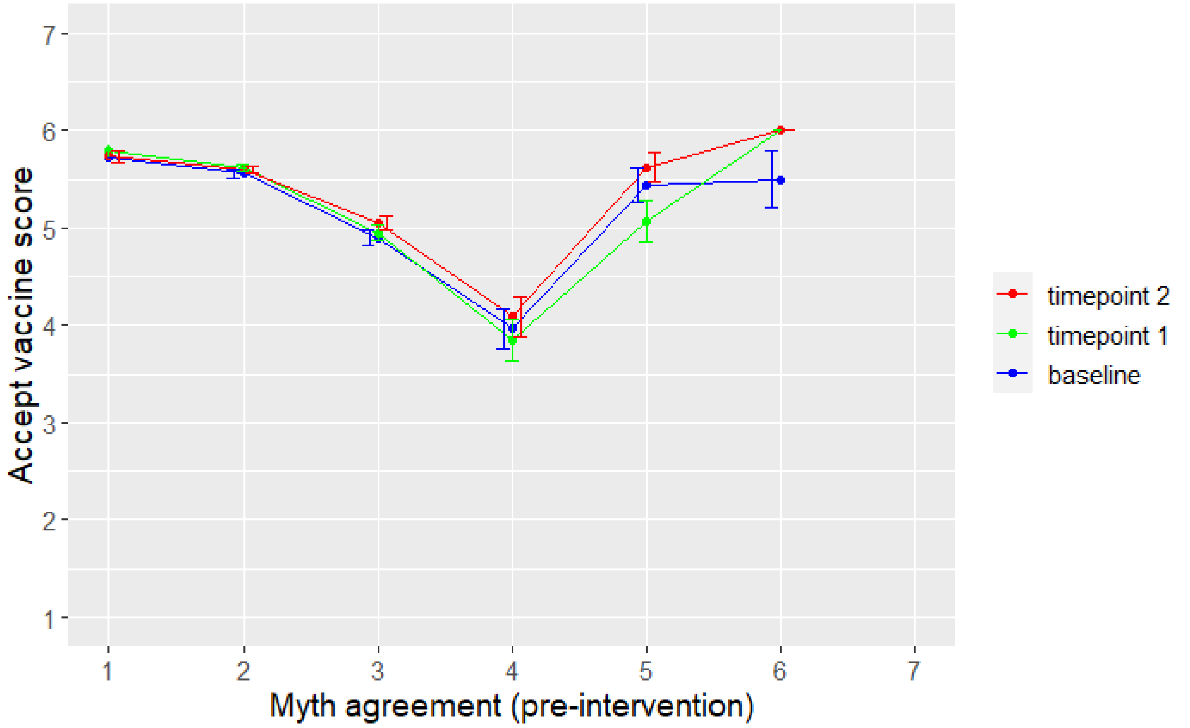
There was a significant within-subjects effect of time on vaccine intentions (F (2, 802) = 19.27, $p < .001$, $\eta_p^2 = .046$). Using pairwise comparisons, I found that vaccine intentions were higher at timepoints one ($M = 4.02$) and two ($M = 4.24$) compared to baseline ($M = 3.76$; *p's* < .001). Participants also had significantly higher vaccine intentions at timepoint 2 than timepoint 1 ($p < .001$). There was no significant difference between the correction formats (F (2, 401) = 2.02, $p = .134$, $\eta_p^2 = .01$; Table 8.5).

8.3.4.3. What are the effects of debunking on vaccine intentions for a subgroup of participants with high vaccine concern?

When only the participants with the highest vaccine concern scores (Table 8.6) there was no significant main effect of time (F (2, 148) = .594, $p = .553$, $\eta_p^2 = .008$). Similarly, there was no significant time by baseline myth agreement interaction (F (2, 148) = .107, $p = .898$, $\eta_p^2 = .001$). Thus, debunking did not have a significant effect on vaccine intentions amongst those with high vaccine concern, and a backfire effect was not found.

Figure 8.1.

Means of accept vaccine score (post-intervention) as a function of baseline myth agreement (pre-intervention), and time. The participants who agreed with the myths the most at baseline demonstrated the biggest changes in their vaccine intention scores at timepoints 1 and 2. Error bars are participant standard errors by correction format and baseline. There was a significant time by baseline myth agreement interaction.



Note. Myth agreement scores were rounded for the figure. N's at each myth agreement were the same at each timepoint (1 = 217, 2 = 628, 3 = 332, 4 = 90, 5 = 16, 6 = 4).

Table 8.5.

COVID-19 Wave 1 & 2 data set Means and Standard Deviations

	Mean	Std. Deviation
Baseline		
Fact-myth	3.81	1.40
Fact-only	3.90	1.37
Question-answer	3.56	1.40
Timepoint 1		
Fact-myth	4.08	1.62
Fact-only	4.13	1.55
Question-answer	3.86	1.59
Timepoint 2		
Fact-myth	4.37	1.64
Fact-only	4.32	1.57
Question-answer	4.05	1.67

Table 8.6.

COVID-19 Wave 1 & 2 data set: Highest vaccine concern participants' Means and Standard Deviations

	Mean	Std. Dev
Baseline		
Fact-myth	3.08	1.79
Fact-only	2.29	1.74
Question-answer	2.87	1.52
Timepoint 1		
Fact-myth	3.23	2.03
Fact-only	2.52	1.91
Question-answer	2.90	1.78
Timepoint 2		
Fact-myth	3.42	2.02
Fact-only	2.57	1.81
Question-answer	3.10	1.80

8.4. Discussion

Misinformation is at its most harmful when it affects behaviour. This study aimed to test the immediate and delayed effects of debunking on vaccine intentions. The effect of debunking on behaviour intentions is important to address as many public health interventions use debunking as part of their health campaigns to address health misinformation. For example, in response to COVID-19 misinformation, public health organisations have used debunking to correct specific myths about the coronavirus. Although an aim of the interventions may be to correct knowledge/attitudes about health, the primary aim of many health interventions is to change behaviour (e.g., increase participation in health screening). Many campaign interventions work on the premise that beliefs based upon accurate information foster positive behaviours whereas beliefs based on misinformation produce unhelpful behaviours (Freeman et al., 2020). Failure of such campaigns to change behaviour can result in delayed diagnoses or the purchasing ineffective health products (Tay et al., 2022).

Using influenza and COVID-19 debunking interventions, this study found that debunking can *sometimes* successfully increase vaccine intentions both immediately and after a delay. Although both Influenza Experiments 1 and 2 found a significant effect of debunking of myth agreement, only one influenza experiment found a significant difference between the debunking conditions and control condition for behaviour intentions. In Influenza Experiment 1, the debunking condition (i.e., the influenza myth-first condition) produced higher vaccine intentions than the control condition immediately following debunking. This effect, however, was not persistent over time and there were no significant differences between participants' vaccine intentions at timepoint 2. Debunking, however, failed to increase vaccine intentions in experiment 2. There was no significant difference between the correction formats either immediately following debunking or after a delay. Nevertheless, there was a significant difference between the vaccine intention scores of participants in the influenza myth-first condition at timepoints 1 and 2. The scores were higher at timepoint 1 than timepoint 2. This appears to reflect a regression to the mean rather than a backfire effect.

Conversely, both COVID-19 datasets found that debunking (no matter which format) successfully increased vaccine intentions compared to baseline. This finding is in line with Uribe et al.'s (2021) systematic review of the relationship between health knowledge and behaviours during pandemics and Freeman et al, (2020) who both found that health knowledge is positively related to protective behaviours during pandemics.

Furthermore, the positive effect of debunking on vaccine intentions persisted over a delay, timepoint 2 vaccine intentions were significantly higher than timepoint 1. The data was collected in February 2021 with UK participants at a time where the UK COVID-19 vaccination programme was described as a global frontrunner (Baraniuk, 2021). Thus, it is very likely that the participants would have been exposed to many pro-vaccination communications during the seven-day delay. This outside (or prolonged) exposure to positive COVID-19 vaccination messaging explains the significant difference between timepoints 1 and 2.

There was a significant interaction between baseline myth agreement and timepoint. The participants who believed the myths a medium amount at baseline (i.e., a score of 3 or 4) had lower vaccine intentions at all timepoints. Further research should consider unpicking this relationship as those who were ambivalent demonstrated lower vaccine intentions than those who weakly or strongly believed the myths before the corrective information was presented.

There was no significant difference between the vaccine intentions of participants in any of the correction format groups. Therefore, during pandemics, the act of debunking (rather than the format of the debunking message) should be prioritised. This finding is in line with Swire-Thompson et al. (2021) who, after comparing several debunking formats, proposed that providing a correction is more important than the format in which the correction is presented Moreover, my finding is in line with the most recent debunking guidelines by Ecker et al. (2022) which state that the myth can be shown before the fact in some contexts.

There is an exception, however, amongst participants with high vaccine concern, the debunking intervention had no significant effect on vaccine intentions. I found this in both the Wave 1 only and Wave 1 & 2 datasets. The participants in the COVID-19 study were representative for age and gender within the UK. Antivaxxers form a small amount of the population. Most people agreed that vaccines are important (90%), safe (82%), and effective (88%; Larson et al., 2018). Reasons cited for vaccine refusal are diverse and often personal, therefore the people who deny vaccines are a very heterogenous group (World Health Organization, 2017). It is likely that those who outright refuse vaccinations are more likely to have a vaccine-centred worldview. Therefore, future research may wish to replicate our findings within a population whose vaccine beliefs are strongly linked to their ideology. Nevertheless, the intervention did not backfire and decrease vaccine intentions amongst participants with high vaccine concerns, as found by other studies (Nyhan & Reifler, 2015; Skurnik et al., 2007). Thus, within the context of the pandemic, public health campaigners can feel confident about using debunking without adverse outcomes occurring.

One potential explanation for the differences between the Influenza Experiment results and the COVID-19 Experiment results is the relevance of the disease to the participants. The influenza experiments contained participants who were and were not eligible for the influenza vaccination (those eligible for the influenza vaccination have to be at risk of severe complications from influenza e.g., pregnant people and those with chronic illnesses). In the COVID-19 Experiment, however, all the participants were eligible for the vaccine. Nevertheless, prior studies, such as Pluviano et al. (2019) have failed to find an effect of debunking on vaccine intentions when using an eligible population.

Another potential explanation is the ease at which the behaviour (i.e., accepting the influenza and COVID-19 vaccinations) is accessed. The UK COVID-19 vaccination programme was a highly organised and strategic exercise. The vaccines were available at GP Practices, Community Pharmacies and our two Mass Vaccination Centres on a pre-bookable and walk-in basis. Influenza vaccination does not work in the same way. Thus, the increase in behaviour intentions observed in the COVID-19 Experiment may have been because the COVID-19 behaviour was more easily accessible to participants.

8.4.1. Strengths

A strength of these studies is that they measured behaviour intentions at two timepoints separated by a delay of approximately seven days. Future research may wish to consider using a longer time delay as, especially in the case of COVID-19 where participants would have been exposed to information during the delay, seven days may not be enough of a delay for the participants to forget the correction and/or for the misinformation to be recalled as true.

Both the Influenza and COVID-19 studies used real-world myths about the diseases they addressed. It is unclear which aspect of the debunking messages used led to increased vaccine intentions. Future research should examine how behaviour intentions are linked to knowledge about vaccinations. Specifically, what information or what aspect of a debunking message increases vaccine intentions? Additionally, what information within debunking messages translates intentions into behaviour (i.e., vaccine acceptance).

8.4.2. Future directions

Future research should address other vaccines and/or vaccines more generally. More research is needed, for example, surrounding the MMR vaccinations. In March 2022, Helen Bedford, a professor of children’s health and Helen Donovan, a professional lead for public health nursing, wrote an opinion piece for the BMJ which urgently called for an increase in MMR vaccine uptake (Bedford & Donovan, 2022). Therefore, understanding the gap between knowledge/attitudes and vaccine behaviour is vital to stop almost extinct childhood diseases from re-emerging within the population.

Chapter 9. Individual differences: Vaccine concern and age

In Chapter 7, three myth correction formats (myth-fact, fact-only and question answer) were compared to test for the most effective way to lower beliefs in COVID-19 misinformation. I found myth agreement ratings were significantly lower than baseline for all correction formats. Yet, where baseline myth agreement was high, the question-answer format (in which the reader is invited to consider whether a myth is true) had a more lasting effect than a traditional fact-myth format.

This chapter aims to identify whether individual differences are related to variations in myth agreement (i.e., how much participants agree with COVID-19 statements) and vaccine acceptance (i.e., How likely participants are to accept a COVID-19 vaccine). Firstly, I will test whether vaccine concern is correlated with myth agreement. In Chapter 8 I found that debunking did not have a significant effect on vaccine intentions amongst participants with high vaccine concern. Therefore, this analysis is not repeated here. Finally, I will explore the relationship between age and myth agreement/vaccine intentions.

9.1. Introduction

Throughout the COVID-19 pandemic, age has been a factor that has affected both a) an individual’s experience with COVID-19 and b) their likelihood of engaging in precautionary measures. For example, older members of the population are more at risk of COVID-19 and were found to be more likely to accept a COVID-19 vaccine (Lindholt et al., 2021). Another factor that has affected the pandemic is vaccine concern and, relatedly, the anti-vaccination movement. Individuals who are against vaccines have proactively voiced and spread their anti-scientific beliefs during the pandemic. For example, many anti-vaccination protests took place throughout the UK. Both large- and small-scale rejection of the COVID-19 vaccination is problematic for Public Health. Large-scale rejection can leave large numbers of the population vulnerable to a disease. However, small-scale rejection can lead to pockets of unprotected individuals as vaccine hesitant individuals tend to cluster geographically. This geographical clustering of vaccine refusers can undermine herd immunity in both the geographical area of the vaccine refusers and adjacent regions (Faasse et al., 2016; Loomba et al., 2021; Tomeny et al., 2017).

In August 2021, news stories about patients dying who had refused the COVID-19 vaccine began to increase in both the UK and US press (BBC News, 2021; Brazell, 2021; Walker & Way, 2021). In the UK, the COVID-19 vaccine acceptance rate fluctuated between 64.0% and 83.0% from April to October 2021 (Sallam et al., 2021). Vaccine hesitant individuals within the UK were more likely to be women, aged 16-24 years old, have lower education levels, and belong to Black or Pakistani/Bangladeshi ethnic groups (Robertson et al., 2021). This chapter examines two types of individual differences: vaccine concern and age. I aim to explore the relationship between these individual differences and myth agreement.

9.1.1. Vaccine concern

Vaccine hesitancy refers to a continuum of vaccine beliefs that range from total acceptance of all vaccines to complete refusal. People who refuse all vaccines on principle are often called vaccine-refusers, or antivaxxers, and are said to be part of the anti-vaccination movement. Vaccines were identified as an important strategy to manage COVID-19 from the start of the pandemic. At the beginning of February 2020, the UK Government announced that it had allocated £20 million to fund vaccines for the coronavirus and other infection diseases. Matt Hancock, the Health Secretary at the time said

> Vaccines are our best defence against a host of deadly diseases, including coronavirus. The UK is a hub of world-leading and pioneering research, and it is vital that we lead the way in developing new vaccines to target global threats with scientists from across the world (GOV.UK, 2020a, para. 5).

The COVID-19 vaccination programme began at the beginning of December 2020, and in its first week over 130,000 people received a vaccine (Triggle, 2020). Concerns, however, about the anti-vaccine movement's ability to thwart efforts to end coronavirus pandemic have been discussed since mid-2020 (Ball, 2020). The concerns were raised after false claims such as "Dr Elisa Granato, one of the first participants in a UK Covid-19 vaccine trial, has died." were circulated online (Full Fact, 2020c, para. 1). A now-deleted YouTube video, Plandemic, claiming that the COVID-19 vaccine would kill millions was also published (Ball, 2020, p. 251).

Vaccinations are invasive medical procedures that carry a degree of risk to the individual who accepts the vaccine. The strongest predictors of vaccine acceptance are trust in health authorities and trust in scientists (Lindholt et al., 2021). Similarly, those who trust that the COVID-19 vaccine is safe have been found to be most likely to accept their COVID-19 vaccination (Karlsson et al., 2021).

Transparent communication of COVID-19 vaccine risks (and benefits) has been encouraged to increase vaccine acceptance (Nature, 2020). Kerr, Freeman, Marteau and van der Linden (2021) found that communicating the risk surrounding vaccines neither increases nor decreases individuals' vaccine intentions. They concluded that scientists and public health communicators should not be discouraged from communicating risks surrounding COVID-19 vaccines to the public.

Once trust in a vaccine is lost, it is difficult to gain it back, for example, the controversy surrounding the MMR vaccination. Like trust, once misinformation about a vaccine has been introduced, it is difficult to overcome. For example, using UK and US nationally representative samples for age, gender and sub-national region, Loomba et al. (2021) demonstrated that exposure to COVID-19 misinformation lowered intentions to vaccinate. Participants reported lower intentions to vaccinate to protect both themselves and others. The authors noted that misinformation that sounded scientific was the most damaging. For example, "scientists have expressed doubts […] over the coronavirus vaccine […] after all of the monkeys used in initial testing contracted coronavirus" was associated with a stronger decrease in vaccination intent (Loomba et al., 2021, p. 342).

The vaccine concern analysis in this chapter was motivated by Nyhan and Reifler (2015). They conducted an online survey about the influenza vaccination which, like COVID-19, is often believed to cause the disease that it's designed to prevent. Nyhan & Reifler found that providing corrective information to participants that told them that the influenza cannot give them the flu significantly reduced their beliefs in that false claim. This was found in the full sample as well as participants who had low and high side effects concern (Nyhan & Reifler, 2015, p. 461). However, following correction, participants with a high level of concern about vaccine side effects decreased their intentions to get vaccinated. In other words, they found that participants with high vaccine concerns showed lower intentions to obtain the influenza vaccine following debunking (i.e., a backfire effect where corrections inadvertently strengthen the myth, see Chapter 4 for an in depth review; Cook & Lewandowsky, 2011; Lewandowsky et al., 2012).

9.1.2. Age

The way in which older and younger people make truth judgements, and update misinformation has been proposed to differ. Some have argued that “older adults are at increased risk for falling prey to quackery” (Ansburg & Heiss, 2012, p. 32). One reason to explain this is that older adults have a more heightened awareness of mortality and are more familiar with problems associated with physical decline and illness than young people (Ansburg & Heiss, 2012). Ansburg & Heiss argued that this familiarity with physical illness and mortality makes older patients more vulnerable to false or ineffective cures or treatments such as dietary supplements. For example, older participants were previously found to express more confidence in false memories (Jacoby & Rhodes, 2006), and share more fake news or links to political misinformation (Grinberg et al., 2019; A. Guess et al., 2019). It is possible this reflects a divergence between health myths and other kinds of misinformation, if older participants have accumulated more health or science knowledge to rely upon.

Others have maintained that older adults are more knowledgeable than younger people and have better developed knowledge networks that help them to apply their relevant knowledge (Newman & Zhang, 2021). In a recent study Vijaykumar et al. (2021) investigated the relationship between age, misinformation and corrective information. They found that younger participants (aged 18-54 years) had higher belief in the COVID-19 misinformation (that garlic can cure COVID-19) than older adults (those aged over 55 years). This appears to reverse the previous narrative that older participants are more vulnerable to misinformation (Wylie et al., 2014). Vijaykumar et al. (2021) also found a difference between the two age groups following exposure to corrective information. They reported a backfire effect for COVID-19 myth-busting in older adults, at least in the UK, where misinformation belief increased after viewing corrective materials (Vijaykumar et al., 2021). Likewise, one of the earliest papers on the familiarity backfire effect (Skurnik et al., 2005) found that one week after reading material correcting influenza myth correction, older participants had greater belief in the myths than prior to intervention but younger participants did not, although Swire et al., (2017), failed to find backfire effects in older participants.

Regarding the sharing of online misinformation, where COVID-19 misinformation was most rife, most research has been conducted within the US. Guess et al. (2020) found that during the 2016 US presidential campaign, although the sharing of articles from fake news domains was rare, older people were more likely to share fake news. Specifically, after controlling for ideology and demographic variables, those over the age of 65 years were almost seven times more likely to share fake news articles on Facebook than those aged between 30 and 44 years (Guess et al., 2020). The authors suggested two possible explanations for the increased sharing of fake news amongst older adults: 1) older people, generally, do not have the same level of skills (i.e., digital literacy) with modern technology due to its recent availability. 2) Older people are less resistant to phenomena such as the illusory truth effect as a result of general aging effects on memory (Guess et al., 2020). Alternatively, older people could share fake news for a novel reason. For example, they could share fake news to "amuse or provoke friends and family" (Lewandowsky et al., 2020, p. 70).

9.1.3. The present study

In sum, research by Nyhan and Reifler (2015) found that debunking materials aimed at correcting misinformation about the influenza vaccination backfired. In chapter 8, I found that debunking did not have a significant effect on vaccine intentions amongst participants with high vaccine concern. Thus, the present study aims to examine whether debunking is effective at correcting myth agreement amongst participants who are concerned about vaccinations. The first research question is:

1. Does debunking effectively lower myth agreement amongst participants with high vaccine concern?

Furthermore, Vijaykumar et al. (2021) found a significant relationship between both age and myth belief, and age and the effectiveness of debunking. They found a) that younger participants believed COVID-19 misinformation significantly more than older participants, and b) that debunking backfired and myth belief increased following correction amongst older participants. Therefore, the second and third research questions are:

2. Does debunking effectively lower myth agreement amongst a) younger and b) older participants?
3. Does debunking increase vaccine intentions of a) younger and b) older participants?

9.2. Methods

9.2.1. Ethics information and pre-registration

The project was approved by Cardiff University School of Psychology's Ethics Committee (EC.19.07.16.5653GR2A4). Participants consented at the beginning of the study and received payment and debrief after participation.

9.2.2. Design and procedure

Participants were recruited via Qualtrics. The data for this chapter was completed at the same the data in Chapter 7 and therefore used the same study design. The study was a mixed-methods design with three between-subjects correction formats (fact-myth, fact-only and question-answer) and three within-subjects timepoints (baseline, timepoint 1 and timepoint 2).

Table 9.1.

COVID-19 myths

	Myth
1	Seasonal colds and flu are wrongly being counted as COVID-19 cases
2	If your symptoms are mild, you can self-isolate and don't have to take a test
3	Lockdowns don't work
4	Thermal scanners can detect people who have COVID-19 but aren't showing symptoms
5	The flu is more deadly than COVID-19
6	The COVID-19 vaccination is mandatory
7	Lockdowns are due to healthy people getting tested
8	Ultra-violet lamps should be used to disinfect hands
9	Face masks do not reduce the transmission of infection
10	Wearing a face mask can lead to increased levels of carbon dioxide in the blood
11	As soon as you have had the vaccine, you can go back to your normal life

Baseline and timepoint 1 occurred during Wave 1 whereby the intervention (i.e., debunking via correction graphics in one of the three correction formats) was presented immediately after the baseline measures were collected, and timepoint 1 immediately followed the intervention. Participants completed timepoint 2 6-20 days later (M = 8.9 days), in which they again rated agreement in a new random order. Eleven myths were corrected during the study (see Table 9.1).

Correction graphics were designed to conform to current myth-busting advice (Lewandowsky et al., 2020). Each graphic therefore contained source information, including an NHS and COVID-19 logo, and a supporting explanation statement that gave an alternative to the myth (For an example of the graphics see Chapter 7: Figure. 7.1, and for examples of how each of the myths were debunked see Chapter 7: Table 7.2).

9.2.3. Measures

9.2.3.1. Myth agreement

Participants rated their agreement with myths in response to questions that differed in style to the correction graphics to avoid pattern matching between the two. Agreement ratings were made on a six-point Likert scale ranging from "Strongly agree" to "Strongly disagree". I also included four fact statements, to encourage participants to use the full scale.

9.2.3.2. Vaccine concern

Just as in Nyhan and Reifler (2015), participants were asked on a five-point scale "In general, how concerned are you about serious side effects from vaccines?" To assess vaccine acceptance, in Nyhan and Reifler (2015)'s influenza vaccine question "How likely is it that you will get a flu vaccine for the seasonal flu during the upcoming flu season (fall 2012–spring 2013)?" (p. 463) was adapted so that it was relevant to COVID-19. Participants were asked "How likely is it that you will get a COVID-19 vaccine?" and responded on a six-point scale from "Very unlikely" to "Very likely".

9.2.3.3. Age

To investigate the relationship between age and myth agreement or vaccine acceptance, I followed the methods used by Vijaykumar et al (2021) and divided participants into younger (18-54 years of age) or older (55+ years of age). The aim of this analysis was to identify whether age was associated with differences in myth agreement and vaccine acceptance.

9.2.4. Participants

I recruited participants representative for age and gender across the UK, via Qualtrics, an online participant platform. To achieve a representative sample, I applied age and gender quotas. Age 18-24: 12%, 25-34: 19%, 35-44: 18%, 45-54: 20%, 55-64: 17%, 65+: 14%. Gender male: 49%, female: 51%. Power calculations are described in the pre-registration. The main dataset consisted of 2215 participants who completed baseline and timepoint 1, of whom 1329 completed timepoint 2 (an attrition rate of 36%). Of these 38 were excluded for not meeting the minimum age requirement (18 years, n = 2) or for failing the catch trials (n = 36). One participant did not provide age information. Therefore, the n for main analysis was 1290.

Participants were allocated to the "younger" and "older" groups using the same methodology as (Vijaykumar et al., 2021). Those aged 18-54 years were allocated to the younger group (n = 810), and those aged 55+ years were allocated to the older group (n = 480). In the younger group, 260 participants viewed the fact-myth format, 260 the fact-only format, and 290 the question-answer format. Of the older participants, 155 viewed the fact-myth format, 175 the fact-only format and 150 the question-answer format.

9.2.5. Vaccine concern analysis overview

9.2.5.1. Myth agreement

Participants who completed both timepoints and answered either "very concerned" or "extremely concerned" were included in the analysis (n = 99). I restricted the analysis to the two items that asked explicitly about vaccines, "It is mandatory for me to have my COVID-19 vaccination," and "I can return to normal life immediately if I have had my COVID-19 vaccine."

To answer the question "does debunking effectively lower myth agreement amongst participants with high vaccine concern?" Model 1 was applied to each correction format and to each timepoint:

```
Model 1: Myth_agreement ~ timepoint + (1+timepoint|participant) +
(1+timepoint|myth)
```

Where `Myth_agreement` is the outcome variable, and `timepoint` is a fixed factor (baseline, timepoint 1, timepoint 2). Random effects (identified to the right of the pipe symbol, |) include intercepts (identified by 1 left of |) and slopes (identified by named factors after 1+), and correlations between the two. Model 1 was applied to each correction format separately (one model to question-answer, one to fact-only etc.)

9.2.6. Age analysis overview

9.2.6.1. Myth agreement

To examine older and younger participants, I created a new factor, age_group, which divided participants into younger (<55 years old, n = 813) or older (>54, n = 481) participants.

To answer, "does debunking effectively lower myth agreement amongst a) younger and b) older participants?" the age group factor was combined with Model 1 to create Model 2:

```
Model 2: Myth_agreement ~ correction*baseline*timepoint*age_group +
(1+timepoint|participant) +
(1+correction*baseline*timepoint*age_group||myth)
```

where `age_group` is a fixed effect with appropriate random effects. Correlations were suppressed for myth random effects. Analysis was on the main set only, not the replication set.

9.2.6.2. Vaccine acceptance

To answer the question "does debunking increase vaccine intentions of a) younger and b) older participants?" I split the participants into older and younger groups. I then conducted a 3 (correction format) by 3 (timepoint) repeated measures ANOVA with baseline myth agreement entered as a covariate.

9.3. Results

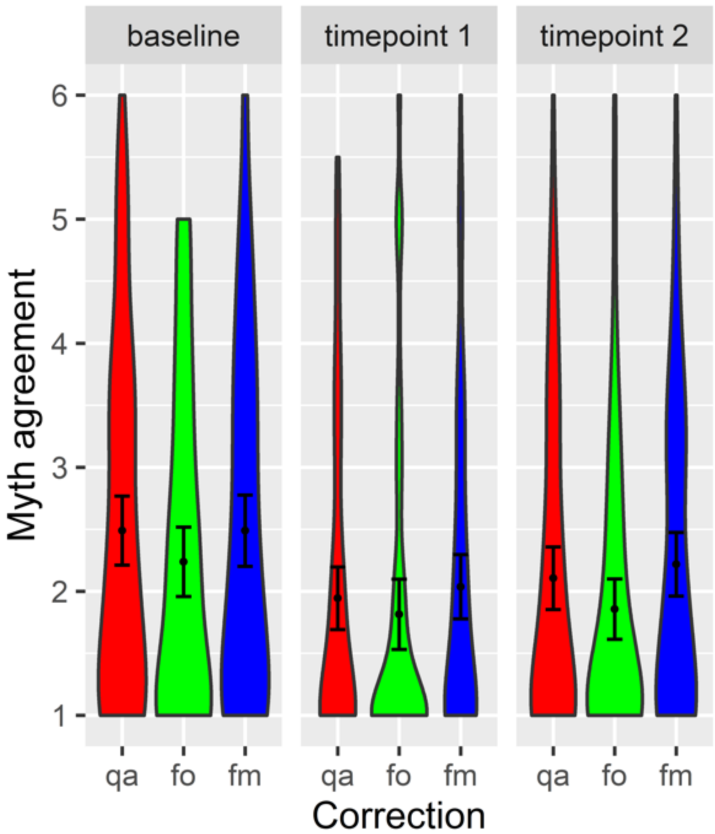
9.3.1. Does debunking effectively lower myth agreement amongst participants with high vaccine concern?

9.3.1.1. Myth agreement

Model 1 was applied to each correction format and to each timepoint. I found no evidence of backfire effects (Figure 9.1). Indeed, each correction condition was significantly or marginally lower at timepoint 1 and 2 than at baseline, all β's <-0.27, *SE*'s < 0.17, *df*'s > 1.76, *t*'s > 2.54, *p*'s < .094.

Figure 9.1.

Means of myth agreement ratings for vaccine concern participants on vaccine related items. All correction formats show lower myth agreement post-intervention, in contrast to the backfire effects observed by Nyhan and Reifler (2015). Key – qa: question-answer, fo: fact-only, fm: fact-myth.



9.3.2. Does debunking effectively lower myth agreement amongst a) younger and b) older participants?

There were differences in agreements ratings across age (Figure 9.2 & Figure 9.3). Younger participants showed higher agreement overall than older participants, β = -0.12, SE = 0.018, *df* = 131, *t* = -6.78, p < .001, and there was an interaction of age by time, β = -0.029, SE= 0.0065, *df* = 12.17, *t* = -4.42, *p* < .001, with the increase from timepoint 1 to timepoint 2 being greater in older participants (Figure 9.2. & Figure 9.3). Because there were significant three and four-way interactions involving age, correction format, baseline and time (age by question-answer vs fact-only by baseline, β = -0.11, SE = 0.028, *df* = 41, *t* = -3.96, *p* < .001; age by question-answer vs fact-myth by baseline β = 0.085, SE = 0.031, *df* = 22, *t* = 2.70, *p* = 0.013; age by fact-only vs fact-myth by baseline by time, β = -0.044, SE = 0.022, *df* = 19490, *t* = -2.01, *p* = 0.045), I considered the effects of correction format on younger and older participants separately (convergence issues prevented me from estimating the simple effects of age from Model 2).

Figure 9.2.

Myth agreement ratings for (A) younger participants and (B) older participants. For both groups, the interventions successfully lowered agreement at both timepoints. Younger participants had more varied and higher average ratings than older participants but a shallower increase from timepoint 1 to timepoint 2. Key – qa: question-answer, fo: fact-only, fm: fact-myth.

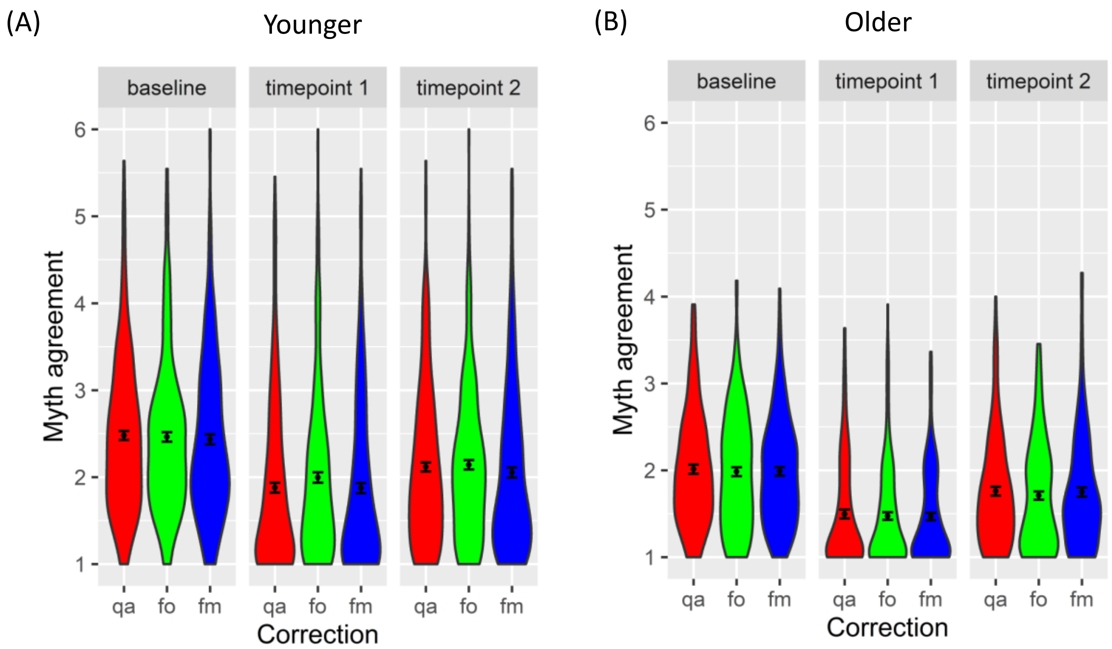


Figure 9.3.

Means of myth agreement by baseline, correction format and time for (A) younger participants (B) older participants. Where baseline myth agreement was high, the question-answer format and fact-myth were most effective at lowering ratings at timepoint 1, while at timepoint 2, question-answer and fact-only were most effective. Key – qa: question-answer, fo: fact-only, fm: fact-myth.

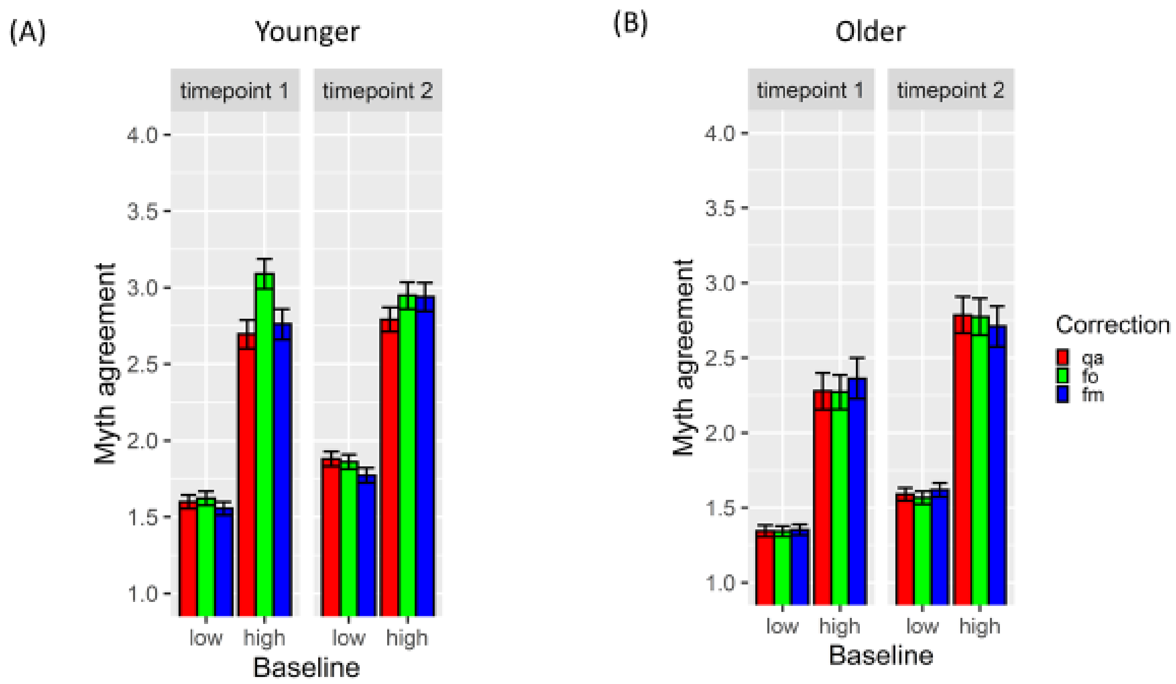
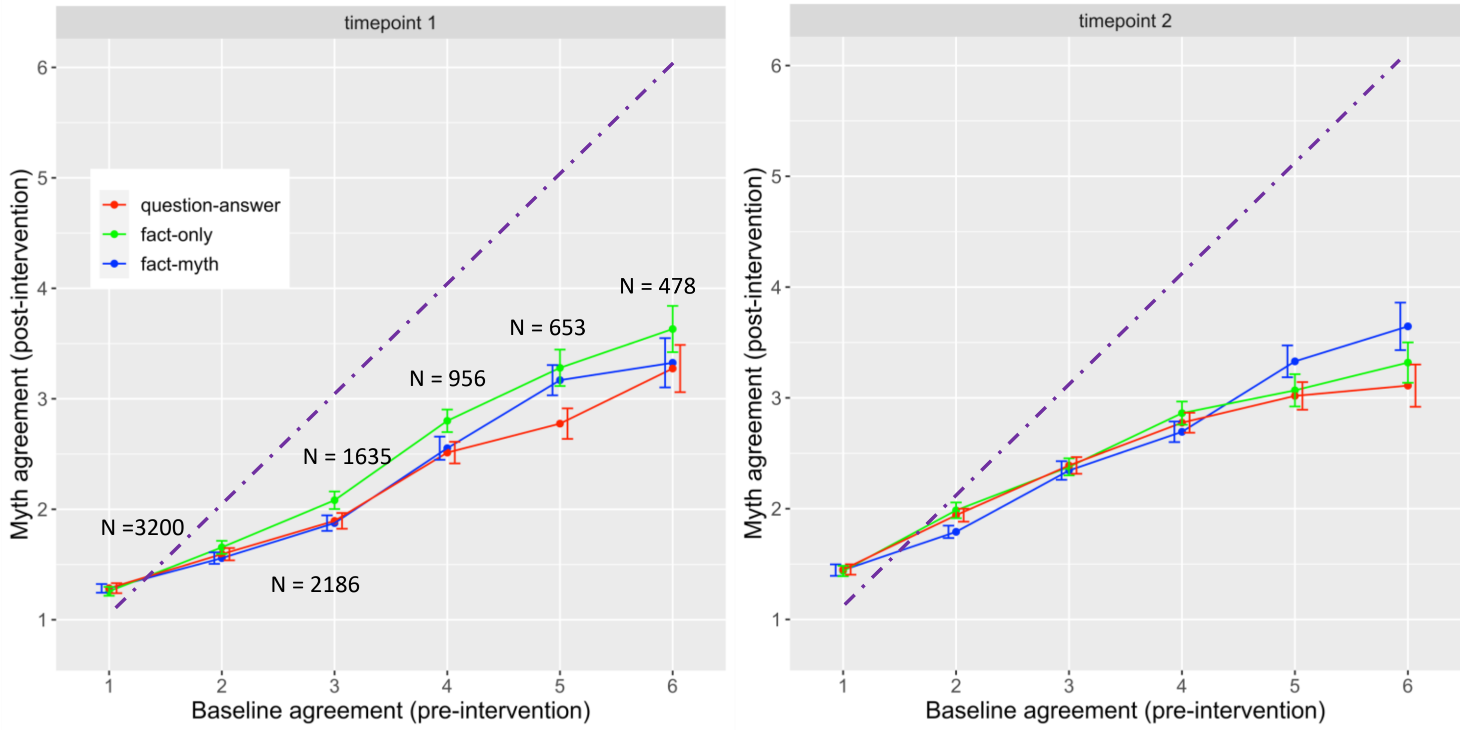


Figure 9.4.

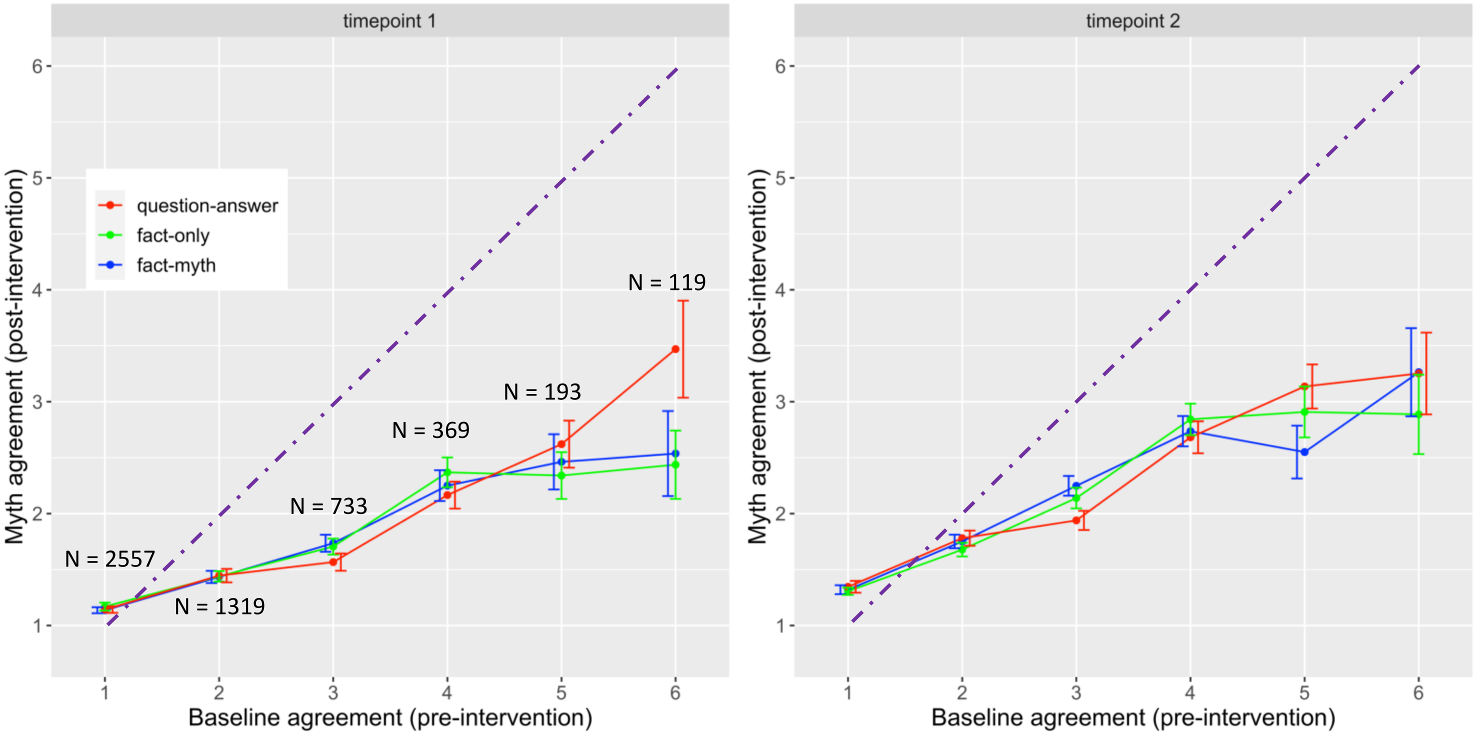
Means of myth agreement (post-intervention) as a function of baseline agreement (pre-intervention), correction format, and time, for younger participants. Error bars are participant standard errors by correction format and baseline. N's indicate the number of responses that constitute each data point. Dashed line shows equivalence between baseline and myth agreement (post-intervention) so that data below the line indicates effective correction. There were interactions of correction format and baseline agreement at both timepoints. At timepoint 1, fact-only was less effective than question-answer and fact-myth at higher baselines. At timepoint 2, fact-myth was less effective than question-answer.



Younger

Figure 9.5.

Means of myth agreement (post-intervention) as a function of baseline agreement (pre-intervention), correction format, and time, for older participants. Error bars are participant standard errors by correction format and baseline. N's indicate the number of responses that constitute each data point. Dashed line shows equivalence between baseline and myth agreement (post-intervention) so that data below the line indicates effective correction. There were interactions of correction format and baseline agreement at both timepoints. At timepoint 1, fact-only was less effective than question-answer and fact-myth at higher baselines. At timepoint 2, fact-myth was less effective than question-answer.



Older

9.3.2.1. Younger participants

There was a significant question-answer vs fact-only by baseline by time interaction, $\beta = -0.063$, $SE = 0.026$, $df = 9128$, $p = 0.014$. Simple effects showed that at timepoint 1, there was a significant question-answer vs fact-only by baseline interaction (Figure 9.4), $\beta = 0.097$, $SE = 0.024$, $df = 29$, $t = 4.01$, $p < .001$, such that question-answer was more effective than fact-only at high baselines, but at timepoint 2 there was not, $\beta = 0.032$, $SE = 0.023$, $df = 25$, $t = 1.39$, $p = 0.18$.

There was a marginal question-answer vs fact-myth by baseline by time interaction, $\beta = 0.044$, $SE = 0.026$, $df = 10010$, $p = 0.09$, with effects larger at timepoint 2. At timepoint 1, there was no significant question-answer vs fact-myth by baseline interaction, $\beta = 0.024$, $SE = 0.022$, $df = 45$, $t = 1.13$, $p = 0.26$, but there was at timepoint 2, $\beta = -0.074$, $SE = 0.021$, $df = 56$, $t = -3.49$, $p < .001$, such that question-answer was more effective at reducing myth agreement than fact-myth at high baselines.

Finally, there was a significant fact-only vs fact-myth by baseline by time interaction, $\beta = 0.11$, $SE = 0.027$, $df = 10320$, $t = 4.01$, $p < .001$. At timepoint 1, there was a fact-only vs fact-myth by baseline interaction $\beta = -.074$, $SE = 0.021$, $df = 56$, $t = -3.49$, $p < .001$, with fact-only less effective than fact-myth at higher baseline, but at timepoint 2, the ordering of fact-only and fact-myth had reversed, so that fact only was now more effective than fact-myth, although not significantly so, $\beta = -0.036$, $SE = 0.023$, $df = 29$, $t = -1.59$, $p = 0.12$.

9.3.2.2. Older participants

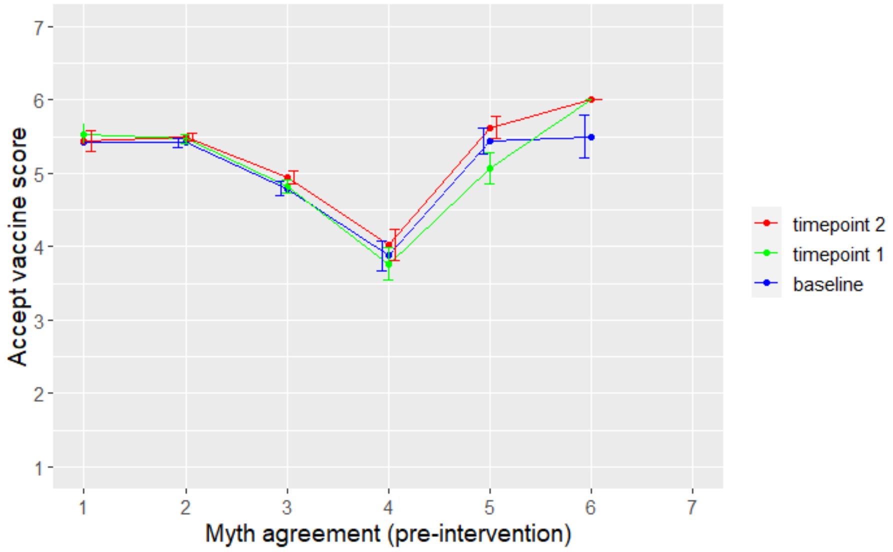
For older participants, importantly, there were no backfire effects (Figure 9.5. There were also no interactions with format. There was a significant main effect of time, $\beta = 0.24$, $SE = 0.042$, $df = 12$, $t = 5.87$, $p < .001$, such that agreement increased from timepoint 1 to timepoint 2.

9.3.3. Does debunking increase vaccine intentions of a) younger and b) older participants?

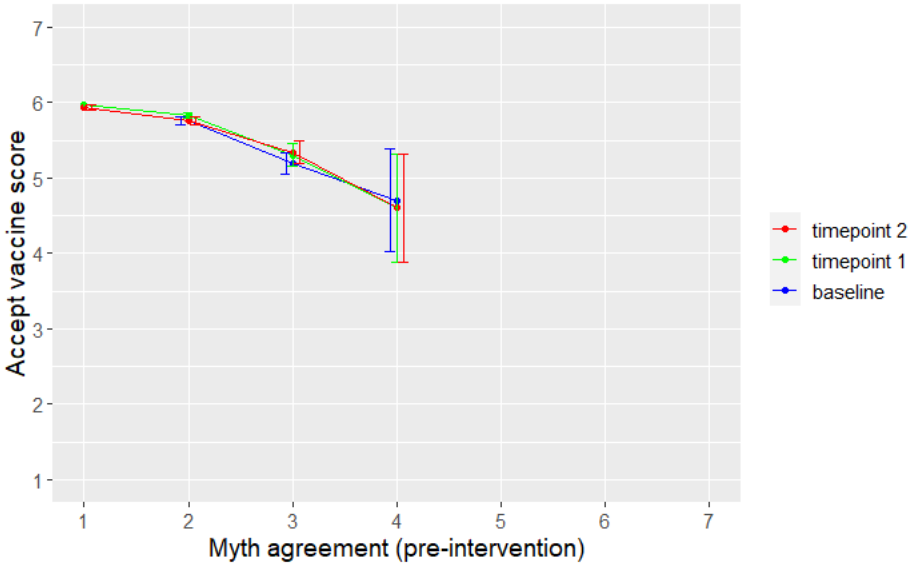
To test for a main effect of age, a repeated measures ANCOVA was conducted with timepoint entered as a repeated measures factor, correction format and age group entered as between subject factors, and baseline vaccine acceptance scores entered as a covariate.

Figure 9.6.

Means of accept vaccine score (post-intervention) as a function of baseline myth agreement (pre-intervention), and timepoint, for A) younger and B) older participants. Error bars are participant standard errors by correction format and baseline. There was a significant time by baseline myth agreement interaction for younger participants. The younger participants who agreed with the myths the most at baseline demonstrated the biggest changes in their vaccine intention scores at timepoints 1 and 2. However, there was no significant interaction for older participants.



A)



B)

Note. Myth agreement scores were rounded for the figure. N's at each myth agreement were the same at each timepoint (Younger: 1 = 90, 2 = 374, 3 = 243, 4 = 80, 5 = 16, 6 = 4; Older 1 = 127, 2 = 254, 3 = 89, 4 = 10).

Table 9.2.

Accept vaccine score: Means and Standard Deviations

	Mean	Std. Dev
Younger		
Baseline	5.07	.048
Timepoint 1	5.10	.048
Timepoint 2	5.18	.047
Older		
Baseline	5.68	.043
Timepoint 1	5.74	.039
Timepoint 2	5.70	.044

In Chapter 8, there was a significant within-subjects effect of time on vaccine intentions. Using pairwise comparisons, I found that vaccine intentions were higher at timepoints one (M = 4.02) and two (M = 4.24) compared to baseline (M = 3.76; *p's* < .001). When the data was split by age, however, this effect was no longer significant (Younger participants: F (806) = 2.59, p = .075, η_p^2 = .003; Older participants: F *(476)* = .448, p = .639, η_p^2 = .001).

For the Younger participants, there was a significant time by baseline myth agreement interaction (Figure 9.6; F (806) = 5.23, p = .005, η_p^2 = .006). The younger participants who agreed with the myths the most at baseline demonstrated the biggest changes in their vaccine intention scores at timepoints 1 and 2 (Figure 8.1). Furthermore, the participants who agreed with the myths a medium amount at baseline (i.e., a score of 3 or 4) had lower vaccine intentions at all timepoints. However, this interaction was not significant for the older participants (F (476) = .307, p = .736, η_p^2 = .001).

None of the older participants agreed with the myths at baseline (none of the older participants gave their agreement rating a score above 4 out of 6). There was no significant time by correction format for either the younger or older participants. Furthermore, there was no significant between-subjects difference between the correction formats for either group of participants.

9.4. Discussion

This chapter sought to investigate the relationship between individual differences, myth agreement and vaccine intentions. The individual differences of interest were vaccine concern and age.

9.4.1. Vaccine concern

For the participants with high vaccine concern, I found that each correction condition produced myth agreement scores that were significantly or marginally lower at timepoint 1 and 2 than at baseline. Thus, debunking effectively lowered myth agreement amongst participants with high vaccine concern.

The vaccine concern participants behaved similarly to the sample as a whole (see Chapter 7) i.e., there was no backfire, in contrast to Nyhan and Reifler (2015). There were several important differences between the study which could explain the difference. First, the vaccine myths I used were not contentious or political. For example, I did not try to address concerns about the harm that a COVID-19 vaccine might do, nor try to persuade participants of the benefits of the vaccine. Second, the location of the studies was different. Nyhan & Riefler conducted their study in the USA, where vaccinations may be more contentious than in the UK.

The disassociation between the presence of the backfire effect and the factors distinguishing the two studies suggest that the effect observed by Nyhan & Reifler (2015) was a world-view backfire effect, in which participants strengthened their beliefs while seeking to defend them (world view; Nyhan & Reifler, 2010), rather than a familiarity backfire effect, in which memory processes increase the familiarity of myths (Lewandowsky et al., 2012; Swire et al., 2017). Our materials should have caused a familiarity backfire effect, if such effects were common, but they may not have been sufficiently contentious to cause world-view backfire.

9.4.2. Age

9.4.2.1. Myth agreement

There were stark differences in myth agreement between age groups. Older people had substantially lower agreement with myths than younger people, consistent with Vijaykumar et al. (2021) both at baseline and after correction. The convergence across studies suggests that these findings are not due to idiosyncratic choices of myths but represents a general pattern in the belief of misinformation. One explanation is that older people are able to engage their more extensive general knowledge to discount new information (Umanath & Marsh, 2014), as argued by Vijaykumar et al. (2021), but it is also possible that they are exposed to a smaller range of myths, with less frequent repetition, than younger people, due to lower engagement with social media.

Although I replicated the age differences in myth belief observed by Vijaykumar et al. (2021), I observed clear positive correction effects in older people (Figure 9.3) rather than backfire effects. Differences could have arisen because of the materials used. Vijaykumar et al. used only one myth (the curative properties of garlic), whereas I used eleven (of which none concerned garlic), and it is possible that only certain myths yield backfire effects. Vijaykumar et al. also reinforced the myth prior to correction, which I did not. There may therefore be an interaction between age, reinforcement and correction that was present in Vijaykumar but not in our study.

Myth agreement in older participants was corrected at similar proportions to younger participants immediately post-intervention. However, beliefs returned towards baseline at a faster rate than for younger participants, perhaps because correcting beliefs requires strategic memory processes, and these are less efficient in older people (Prull et al., 2006; Swire et al., 2017).

For myth agreement, correction format effects were present in younger participants - more clearly than in the main analysis - but not in older participants. Furthermore, there were interactions with age that indicate that this was not only due to lower baseline beliefs in the older group but to the participants themselves. One explanation is that there were floor effects in the older group but not the younger group: older participants were at minimum agreement levels at timepoint 1, whereas younger participants were not. However, it is clear that by timepoint 2, older participants were not at floor level, and at timepoint 2 no effects of correction format were visible in older participants, but they were in younger participants. It is therefore possible that the differing cognitive abilities of older participants are responsible for the insensitivity to correction format.

9.4.2.2. Vaccine acceptance

When examining age, I found older people had significantly higher vaccine acceptance scores than younger people. This is not an unexpected result the risk of severe illness, hospitalisation and death from COVID-19 increases with age, with older unvaccinated patients most at risk (Centers for Disease Control and Prevention, 2021). The risk has been reported to increase from age 50, and men are more at risk than women (Mallapaty, 2020). Early in 2021, in the United Kingdom, the Government named vaccines as "a foundation of our way out of this pandemic and the best way to protect people from COVID-19" (GOV.UK, 2021). The Government then named four vaccination priority groups that were mainly prioritised because of their older age. Thus, much of the communication surrounding COVID-19 and protection from the disease has focused on older age as a risk or priority group.

For the younger participants, there was a significant interaction between baseline myth agreement and timepoint. The younger participants who agreed with the myths the most at baseline demonstrated the biggest changes in their vaccine intention scores at timepoints 1 and 2. However, this result should be interpreted with caution due to the low number of participants who agreed with the myths at baseline (n = 18). Furthermore, the participants who agreed with the myths a medium amount at baseline (i.e., a score of 3 or 4) had lower vaccine intentions at all timepoints. The participants who believed the myths a medium amount at baseline (i.e., a score of 3 or 4) had lower vaccine intentions at all timepoints.

Further research with more agreeable myths would help to clarify the interaction between baseline myth agreement and timepoint. Future research should also consider explaining why participants who were more ambivalent about the myths at baseline demonstrated lower vaccine intentions than those who weakly or strongly believed the myths.

The vaccine acceptance scores for both groups were high at every timepoint (no scores dropped below 5 out of 6 which indicated that participants were likely to get vaccinated. The study was also conducted in February 2021, during which time the UK COVID-19 vaccination programme was described as a front runner globally (Baraniuk, 2021) as they had administered more first doses of the vaccine per 100 people than any other countries of similar population size (Baraniuk, 2021).

9.4.3. Conclusion

In contrast in Nyhan & Reifler (2015), I found that participants with high vaccine concern had significantly lower myth agreement in timepoints 1 and 2 than in baseline. Furthermore, younger people report higher myth agreement and lower vaccine acceptance scores than older participants. I demonstrated that the beliefs in COVID-19 myths can be effectively reduced using materials and formats typical of health campaigns for those with high vaccine concerns and across age groups.

SECTION 4: GENERAL DISCUSSION

Chapter 10. General Discussion

10.1. Overview

Reasons for vaccine non-acceptance for infectious diseases, such as COVID-19, often include erroneous beliefs based on misinformation. When the COVID-19 pandemic and infodemic arrived, social and political phenomenon such as populism and science denialism provided a fertile environment for misinformation about the disease to grow and spread. Populist governments, such as the Conservative government in the UK, were criticized for their slow response to the pandemic. For example, following their enquiry, the House of Commons reported that the poor decisions on lockdowns and social distancing during the early part of the pandemic led to excess deaths (Health and Social Care, and Science and Technology Committee, 2021). In fact, the report estimated that if the national lockdown had been enforced a week earlier, the number of deaths would have reduced by at least half (Health and Social Care, and Science and Technology Committee, 2021). This weak performance was not just observed within the UK. Populist governments performed poorly throughout the world and were associated with lower physical distancing and increased infection rates (Gollwitzer et al., 2020). One strand of science denialism, the anti-vaccination movement, provided a challenge for public health. The anti-vaccination movement threatened to thwart the success of COVID-19's vaccination programmes (Ball, 2020) as misinformation about the vaccine lowered people's intentions to get vaccinated (Loomba et al., 2021).

Understanding how misinformation is believed, and later corrected is complex. When making truth judgements, we can engage in either an intuitive or analytical process. The analytical process is effortful and can require additional resources and time as we may need to seek extra information. The intuitive process, on the other hand, provides us with quick and easy heuristics (or rules of thumb) to reach a decision. For example, the more information is repeated, the more familiar it becomes, and the more likely we are to believe it (i.e., the illusory truth effect, (Brashier & Marsh, 2020; Cook & Lewandowsky, 2011). Heuristics are usually unproblematic in our precedented day-to-day lives as most information we receive is boring, inconsequential and true. When presented with misinformation, however, these heuristics can lead our judgements astray.

Misinformation is difficult to correct as, following its correction, it can continue to influence our beliefs and behaviour (i.e., the continued influence effect; Lewandowsky et al., 2012). This led to a debate in the literature about a) whether misinformation should be included during correction (Lewandowsky et al., 2020; Lewandowsky et al., 2012), and b) if misinformation is included, which is the best correction format (Lewandowsky et al., 2020)?

Swire-Thompson et al. (2021) noted that the recommendations for correction format had not been experimentally tested. Therefore, they identified three correction formats (myth-first, fact-first and fact-only) and tested for the most effective correction method. The three formats were chosen as researchers had argued for each of the three format's superiority over the others:

1. **Myth-first format**

   In the myth-first format, the misinformation is presented first and followed by the fact. It is believed that this approach allows for the activation of both the misinformation and the new corrective information during correction. The activation of both the misinformation and the corrective information allows both pieces of information to be combined and stored within memory (Kendeou et al., 2014, 2019).
2. **Fact-first format**

   The fact-first format presents the corrective information first and the misinformation second. It's believed that this method not only emphasises the correct information by presenting it first, but cognitively prepares readers for the upcoming misinformation (Swire-Thompson et al., 2021).
3. **Fact-only format**

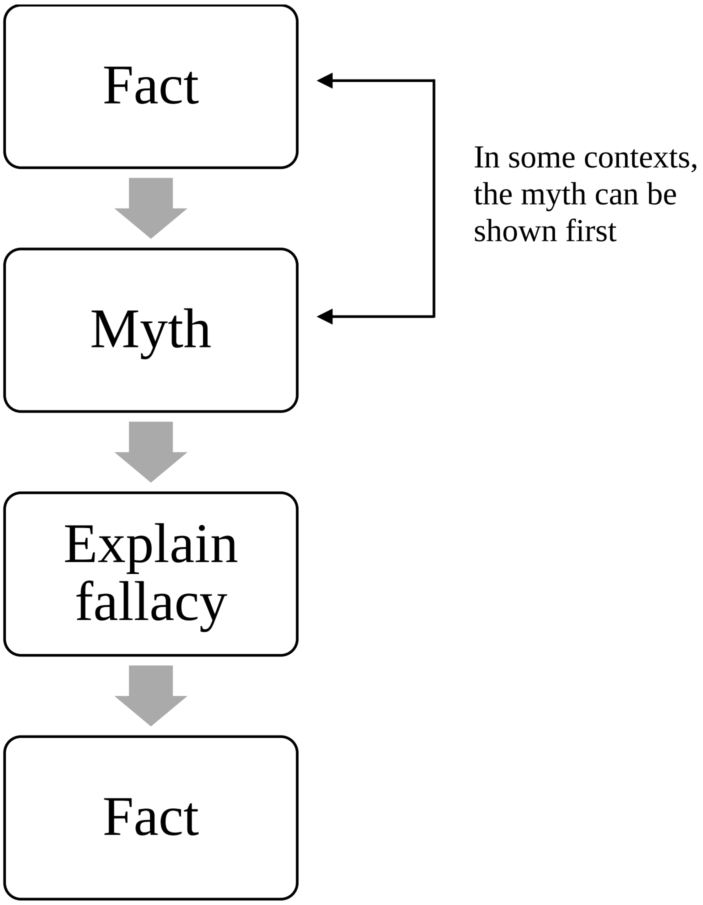
   Some believe that the fact-only format should remove the risk of a familiarity backfire effect by omitting the misinformation all together. However, emerging research has failed to find backfire effects even when the conditions are biased in favour of them (Swire-Thompson, DeGutis, et al., 2020; Wood & Porter, 2019).

Swire-Thompson et al. found that all three correction formats successfully reduced belief in misinformation compared to a control. The only significant difference was between myth-first and fact-first after a delay where myth-first was more effective. The authors concluded that simply providing a correction is more important than how the correction is presented.

Ecker et al. (2022) acknowledge Swire-Thompson et al. (2021)'s findings in the most recent debunking guidelines. They state that an effective correction should prioritise the presentation of truthful information and present the fact first. However, they added that the myth can be shown first (and even be more effective than presenting the fact-first) in some contexts (see Figure 10.1).

Figure 10.1.

Recommendations from Ecker et al. (2022)



10.2. The gap in the literature

Ecker et al. (2022), however, do not provide further guidance or elaborate upon which contexts allow the myth to be shown first. It appears this recommendation is based upon speculation. Similarly, the current guidance is not based upon research focused on public health campaigns. This is problematic for several reasons. First, corrections created using the recommended formats are long (Cook & Lewandowsky, 2011). Although detail is beneficial for providing alternative explanations, Public Health campaigns often use posters which require fewer words.

Second, the use of a myth-busting format is widespread within public health campaigns. A potential problem with presenting misinformation during its correction is that the fact is often a negatively worded version of myth. For example, to counter the myth "flu vaccines cause the flu", the truth would state "flu vaccines *do not* cause the flu". Statements containing negations (i.e., *not*) are often more difficult to process than affirmative statements (Clark & Chase, 1972). In health research, negations have been shown to backfire with participants remembering the information without the negation tag (Wilson & Park, 2008). A possible explanation for this is that the tag (e.g., not or myth) fades in memory faster than the original misinformation (Mayo et al., 2004). Public health myth busting posters often refute misinformation using a negation tag due to their brevity. It is not clear from Ecker et al.'s (2022) advice whether public health campaigns can continue to use this short format negation and whether they are a context in which the myth can be presented first.

Thirdly, research is needed in the context of public health as within public health, the effect of accuracy labels on beliefs may be more complex or nuanced. For example, public health campaigns about influenza or COVID-19 vaccines are not neutral. Both vaccines have not escaped the antivaccination movement and its associated misinformation. The best evidence we have comparing correction formats comes from Swire-Thompson et al. (2021). They used five topics. However, most topics were neutral and would not challenge an individual's worldview. This is potentially problematic as beliefs in some topics are correlated with an individual's worldview (Lewandowsky, 2021b). Therefore, it is unclear whether correction formats perform differently when challenging an individual's ideology during a public health campaign.

10.3. Thesis summary

Misinformation is problematic for public health for both its influence on behaviour, and its difficulty to correct. Over the course of the COVID-19 pandemic, independent fact-checking organisations such as Full Fact (Full Fact, n.d.) have been invaluable. They have not only helped to quash misinformation that may have a detrimental effect on human health, but they have also held politicians to account and become "an integral part of democratic discourse in many countries" (Lewandowsky et al., 2020, p. 70).

Over the course of the pandemic, public health and scientific measures became political and/or emotive issues. For example, preventative behaviours for COVID-19 (i.e., social distancing and mask wearing) were less likely to be undertaken by people with certain political ideologies (Gollwitzer et al., 2020). Furthermore, in the face of a majority scientific consensus saying that vaccines are safe and needed, a minority have formed a worldview based upon the opposite ideology. During the COVID-19 pandemic the antivaccination movement spread beyond being anti-vaccinations to science denialism more generally. For example, during the pandemic, anti-vaxxers held anti-mask and "freedom" protests in the UK (Pyman, 2021) and beyond (Ondrak & Wildon, 2021).

To modify the gap in the literature about debunking within a public health context. My thesis examined misinformation correction using two infectious respiratory diseases: influenza and COVID-19. Summaries of my research questions and results can be seen in Tables 10.1 and 10.2.

Table 10.1.

Summary of Results from Section 2

<table>
<tr><th colspan="2">SECTION 2: INFLUENZA MISINFORMATION AND HEALTHCARE WORKERS</th></tr>
<tr><td colspan="2">Chapter 5
Reasons for influenza vaccination non-acceptance amongst healthcare workers</td></tr>
<tr><td>Research Question(s)</td><td>Results Summary</td></tr>
<tr><td>1. What were the most reported reasons for non-acceptance given by healthcare workers pre-arrival of COVID-19?
2. Is there a difference between the reasons for non-acceptance given during each influenza season?
3. What were the most reported reasons for non-acceptance post-arrival of COVID-19?
4. Did reasons for non-acceptance change following the arrival of the COVID-19 pandemic?</td><td>1. Fear of adverse reactions, lack of perception of own risk, self-perceived contra-indications, dislike of injections & avoidance of medications.
2. No.
3. Fear of adverse reactions, lack of perception of own risk, self-perceived contra-indications, dislike of injections & avoidance of medications.
4. No.</td></tr>
<tr><td colspan="2">Chapter 6
Does correction format influence influenza myth agreement and vaccine intentions?</td></tr>
<tr><td>1. Is the myth-fact format effective at reducing beliefs in misinformation?
2. Is misinformation required for effective correction to take place?</td><td>1. Yes, both immediately and after a delay of seven days.
2. Some evidence that myth-fact is better than fact-only for people with high baseline vaccine concerns</td></tr>
</table>

Table 10.2.

Summary of Results from Section 3

SECTION 3: DEBUNKING COVID-19 MISINFORMATION	
Chapter 7 COVID-19 myth busting: An experimental study	
Research Question(s)	**Results Summary**
1. Which formats are effective immediately and after a delay? That is, does each format lower agreement with myths (effective correction), increase agreement (a backfire effect), or neither? 2. What is the most effective myth correction format?	1. All correction formats (question-answer, fact-only and fact-myth) were effective at lowering myth agreement both immediately and after a delay. 2. There was no overall difference. However, when myths were strongly believed at baseline, question-answer was more effective than fact only at timepoint 1. Question-answer was also more effective than fact-myth at timepoint two for participants who believed the myths more strongly at baseline. Fact-myth was also more effective than fact-only at timepoint 1 when baseline myth agreement was high.
Chapter 8 Does debunking increase behaviour intentions?	
1. Does debunking increase vaccine intentions immediately? 2. Does debunking increase vaccine intentions after a delay? 3. If a null effect is observed, is it due to lack of power? 4. Is myth agreement associated with vaccine intentions? 5. Does debunking cause backfire effects?	1. Yes, vaccine intentions were higher at timepoint 1 than baseline for all datasets. 2. It did not for the influenza datasets, but it did for the COVID-19 Wave 1 & 2 dataset. 3. No, there was sufficient power. 4. In the Wave 2 dataset, there was a significant negative correlation between baseline myth agreement and vaccine intentions at timepoints 1 and 2. 5. No evidence of a worldview backfire effect. However, the participants who scored the maximum vaccine intention scores at baseline had lower intention scores at timepoints 1 and 2.

<table>
<tr><th colspan="2">SECTION 3: DEBUNKING COVID-19 MISINFORMATION</th></tr>
<tr><td colspan="2">Chapter 9
Individual differences: Vaccine concern and age</td></tr>
<tr><td>Research Question(s)</td><td>Results Summary</td></tr>
<tr><td>1. Does debunking effectively lower myth agreement amongst participants with high vaccine concern?
2. Does debunking effectively lower myth agreement amongst a) younger and b) older participants?
3. Does debunking increase vaccine intentions of a) younger and b) older participants?</td><td>1. Yes, each debunking condition produced significantly or marginally lower myth agreement scores at timepoints 1 and 2 than at baseline.
2. Younger participants had higher myth agreement than older participants. Debunking effectively lowered myth agreement both immediately and after a delay for younger and older participants. However, beliefs returned towards baseline at a faster rate in older participants.
3. I did not find clear evidence to support the use of debunking to increase vaccine intentions amongst younger or older adults.</td></tr>
</table>

10.3.1. Misinformation and public health

The influenza vaccination is recommended annually for frontline healthcare workers (Lorenc et al., 2017). Its uptake, however, is suboptimal. In Chapter 5, I examined the reasons for influenza vaccination non-acceptance amongst healthcare workers from the Aneurin Bevan University Health Board (ABUHB). I failed to find significant differences in reasons for influenza vaccination non-acceptance between the three influenza seasons (2017/2018, 2018/2019, 201/2020) before the arrival of the COVID-19 pandemic. Furthermore, when these three influenza seasons were grouped into a pre-pandemic variable and compared to reasons for influenza vaccination non-acceptance post-arrival of the COVID-19 pandemic, I also failed to find significant differences. Thus, the reasons for influenza vaccination non-acceptance were consistent over time.

The primary reason for non-acceptance amongst healthcare workers was “fear of adverse reactions”. This is consistent with the extant literature as it was also the primary reason for non-acceptance identified by Hollmeyer et al. (2009) in their review of 15 studies. I found "fear of adverse reactions" was followed by "lack of perception of own risk", "self-perceived contra-indications", "dislike of injections", "doubts about vaccine efficacy" and "avoidance of medications". The findings from my PhD and the wider literature, therefore, emphasise the importance of both educational and debunking campaigns. These campaigns are needed to deliver correct information to patients and correct existing (and persistent) misinformation about the diseases and their associated vaccinations.

One thing that strikes me is that the reasons reported in the literature for influenza vaccine non-acceptance are similar to the reasons for COVID-19 vaccine non-acceptance. For example, Troiano and Nardi (2021) reviewed 15 studies and found that the most common reasons for COVID-19 vaccine refusal were "concerns about safety and efficacy", "considering the vaccine useless because they failed to understand the risk of COVID-19", and "a general lack of trust and antivaccine attitudes". It is possible that this reflects a general vaccine hesitancy and/or similar misconceptions about vaccines. Public health campaigns should capitalise on the similarities between infectious diseases. For example, a strong influenza vaccination campaign detailing the safety of vaccines and how rigorously they are tested before they are allowed to be given to patients, could have spill over effects to another vaccine campaign. It is not only vaccinations that share similarities. Behavioural measures such as frequent hand washing, social distancing and mask wearing are recommended preventative measures for influenza and COVID-19 (Aguilar-Díaz et al., 2011). Thus, an education in one disease should, in theory, benefit the other.

10.3.2. Correction format and myth agreement

In this thesis I tested four types of correction format: myth-fact, fact-only, fact-myth, and question answer. Previous research by Swire-Thompson (2021) has experimentally tested three of these correction formats (myth-fact, fact-myth and fact-only). The question-answer format has not, to my knowledge been experimentally compared to other formats. I found that each of the four correction formats were successful at reducing vaccination myth agreement. The myth-first correction format was effective at lowering influenza myth agreement immediately after correction and after a delay (Chapter 6). As was the fact-myth (or fact-first) format (Chapter 7). The fact-only format was also successful at reducing myth agreement (Chapter 6 & 7). However, it did not always perform as well as other debunking formats. I found a significant interaction between fact-only and baseline vaccine concern whereby the fact-only correction format was not as effective at lowering the influenza myth agreement scores of participants with high baseline vaccine concerns than those with low baseline vaccine concern scores (Chapter 6). Similarly, the fact-only format underperformed when debunking COVID-19 misinformation where baseline (pre-intervention) myth agreement was high. Immediately post-intervention, question-answer and fact-myth were more effective correction formats than fact-only, and after a delay, question-answer was more effective than fact-myth (Chapter 7).

Amongst participants with high vaccine concern, each correction condition was significantly or marginally lower at timepoint 1 and 2 than at baseline (Chapter 9). Thus, debunking was effective, and I didn't observe the backfire effects reported previously in the literature (Nyhan & Reifler, 2015). Younger participants had higher myth agreement than older participants. Debunking effectively lowered myth agreement both immediately and after a delay for younger and older participants. However, beliefs returned towards baseline at a faster rate in older participants. A possible explanation is that correcting beliefs requires strategic memory processes, and these are less efficient in older people (Prull et al., 2006; Swire et al., 2017).

8.4.2.1. Underlying cognitive mechanisms

In their paper, Swire-Thompson et al. (2021) compared three correction formats to test for the most effective at debunking misinformation. In experiment 4 they found that the myth-first format was more effective than a fact-first format after a time delay. This aligns with co-activation theory (Kendeou et al., 2019) as co-activation and conflict detection are conducive to knowledge revision. It also supports the recency effect (Baddeley & Hitch, 1993) whereby the last item of information is encoded more clearly and better remembered/retrieved than the information that came before it. However, in Experiment 1 they found that fact-first was more effective than myth-first at communicating that 97% of climate scientists agree humans are causing global warming. Swire-Thompson et al., concluded that as this wasn't observed in the other measures, it provided weak evidence for the primacy effect. The primacy effect, in contrast to the recency effect, proposes that the most strongly encoded information is the item that is presented first, and each subsequent item is encoded with decreasing strength (Farrell & Lewandowsky, 2002).

I initially referred to the fact-only condition of the COVID-19 study as a fact-fact condition as two facts were presented to participants in the correction graphics. The fact-only format, therefore, acts as a sort of middleman between the myth-first and fact-first formats as its success could be explained by either primacy or recency. The first piece of information is a fact (primacy), and the last piece of information encoded is a fact (recency). Thus, the underlying mechanism could be explained by primacy or recency. If primacy explained the underlying mechanism for knowledge revision, the fact-only and fact-myth would have outperformed all other formats. Similarly, if recency explained the mechanism, in theory, fact-only, myth-fact, and question-answer should have outperformed fact-myth.

I found that fact-only did not perform as well as myth-fact for influenza misinformation or fact-myth and question-answer for COVID-19 misinformation. This indicates that neither the primacy nor recency explanations capture the cognitive mechanism underlying knowledge revision. Therefore, I propose that the efficacy of the myth-fact and fact-myth formats is due to the inclusion of misinformation.

I propose that the coactivation theory provides the best explanation of the cognitive mechanism underlying knowledge revision when misinformation is included. There are two reasons for this: Firstly, when the correction format included misinformation, it was more successful than the fact-only format. In other words, it did not matter where the myth or fact positioned (i.e., myth-fact, or fact-myth), as long as they were both present, they were better than a fact-only format. Secondly, I believe co-activation also explains why the question-answer format was more successful than fact-myth after a delay. In the question-answer format, it was not clear whether the information being presented was true as its veracity was questioned. The participants had to read on to obtain an answer (unlike the myth-first and fact-first conditions where the information was labelled as “myth” or “fact”.

Kendeou et al. (2014, 2019) suggest that within the Knowledge Revision Components Framework, all information (whether true of false) encoded in memory cannot be erased and can therefore potentially be reactivated. The process whereby encoded information is activated is passive and therefore any stored information can become part of the conscious experience. Combine this with what we know about how humans make truth ratings (see Chapter 3). We know that people use heuristics to make intuitive (as opposed to analytic) truth judgements (Schwarz & Jalbert, 2021). It has been proposed that we automatically use our intuitive process to make truth judgements but switch to an analytical method if information is flagged for further inspection (Song & Schwarz, 2008). I argue that the question-answer format flags the information for further inspection and therefore deeper processing via analytic reasoning. This prompts people (and those with higher vaccine concerns) to engage more deeply with the material. The new corrective information is subsequently coactivated alongside old incorrect information, processed analytically, and the two pieces of information are more strongly integrated.

Future research should replicate Swire-Thompson et al. (2021)'s finding that myth-first is better than fact-first. It should then test whether question-answer is better than the myth-first format (this is the missing comparison in my thesis). This should further help to confirm whether: co-activation is the mechanism that underlies knowledge revision.

10.3.3. The effect of debunking on vaccine intentions

For each of the datasets analysed in Chapter 8, debunking increased vaccine intentions at timepoint 1. That is, debunking made the participants more likely to report that they would accept a vaccination immediately following debunking. At timepoint 2, however, the results were mixed. Within the influenza datasets, debunking only increased vaccine intentions at timepoint 1. For the COVID-19 dataset that included timepoint 2, however, debunking resulted in increased vaccine intentions. Therefore, debunking increased vaccine intentions both immediately and in the longer term.

When individual differences were considered, the debunking intervention had no significant effect on vaccine intentions amongst participants with high vaccine concern (Chapter 8). When examining age, I found older people had significantly higher vaccine acceptance scores than younger people (Chapter 9). This is not an unexpected result as the risk of severe illness, hospitalisation and death from COVID-19 increases with age, with older unvaccinated patients most at risk (Centers for Disease Control and Prevention, 2021). The risk has been reported to increase from age 50, and men are more at risk than women (Mallapaty, 2020). Furthermore, most of the communication surrounding COVID-19 and protection from the disease has focused on older age as a risk or priority group.

Older people had substantially lower agreement with myths than younger people, consistent with Vijaykumar et al. (2021) both at baseline and after correction. The convergence across studies suggests that these findings are not due to myth characteristics but represents a general pattern in the belief of misinformation. Amongst the younger participants there was a significant interaction between baseline myth agreement and timepoint. That is, the younger participants who agreed with the myths the most at baseline demonstrated the biggest changes in their vaccine intention scores following correction. However, this result should be interpreted with caution due to the low number of participants who agreed with the myths at baseline.

10.4. Research implications and recommendations

My PhD thesis has important implications for public health campaigns aiming to correct misinformation about influenza and COVID-19. Overall, my results indicate that the question-answer format outperformed fact-myth in the long term for participants who believed the myths the most at baseline. The question-answer, fact-myth and myth-fact correction formats also performed better than the fact-only format. Therefore, question-answer is the preferred format for myth-busting influenza and COVID-19 misinformation. However, I note that 1) I have not experimentally compared question-answer, fact-myth and myth-fact to each other, and 2) the question-answer, fact-myth and myth-fact formats do not have negative effects on either myth agreement or vaccine intentions. Therefore, I recommend that public health teams can choose between question-answer and a correction format that contains misinformation.

The main ways my recommendations differ from the most recent debunking recommendations by Ecker et al. (2022) are:

1. **The addition of a question-answer format.** This correction format was novel and had not, to my knowledge, been previously compared to other common correction formats.
2. **The omission of a fact-only approach to debunking.** This format was consistently out-performed, at least to some level, by the correction formats that contained misinformation and the question-answer format. Thus, when correcting misinformation about COVID-19 and influenza, I support the move away from approaches that omit or ignore misinformation completely.

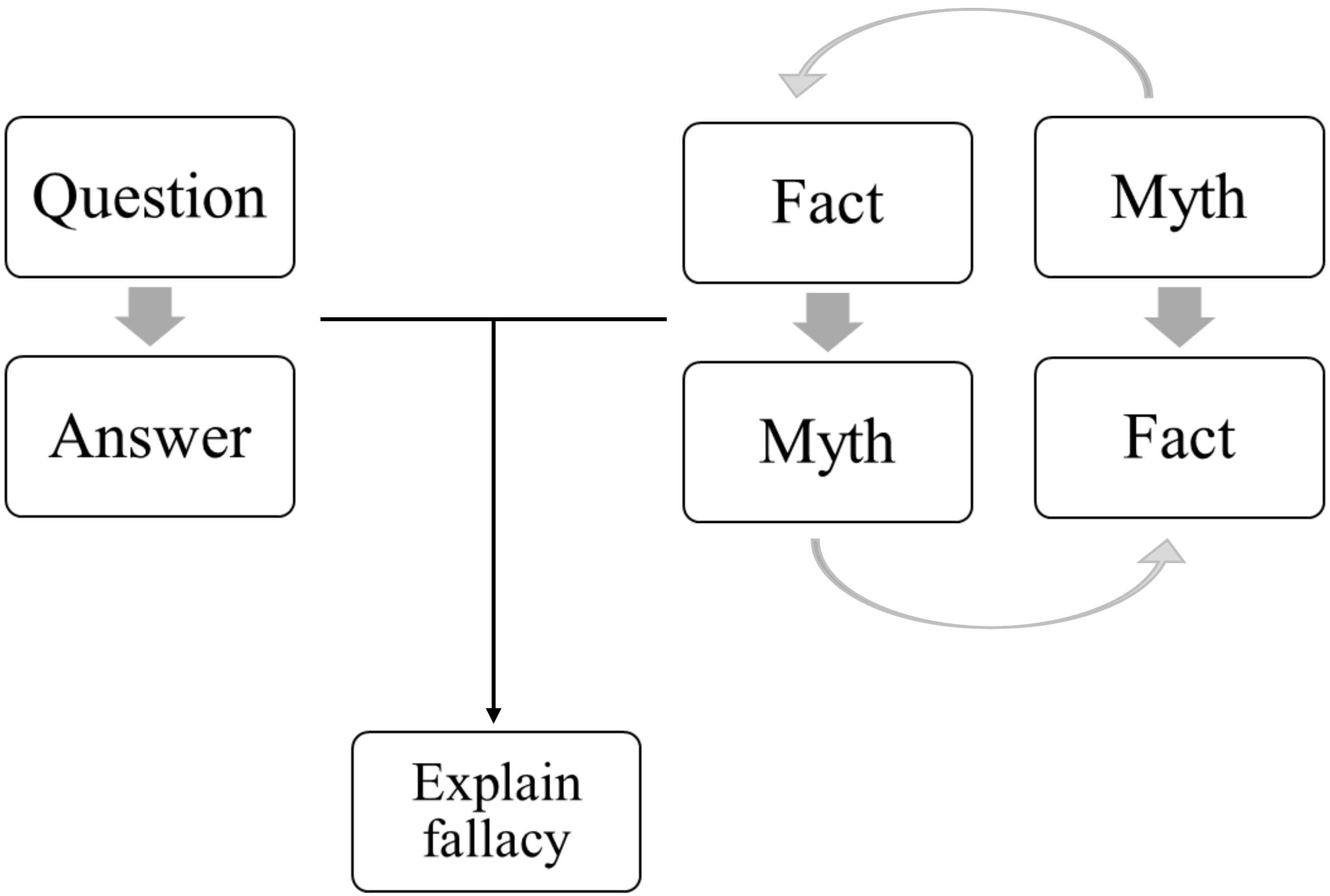
3. **Fewer components.** Ecker et al. (2022) recommended that debunking should have four components:
    - Fact
    - Myth
    - Explain Fallacy
    - Fact

   My recommendations, however, contain three components:
    - Question *or* Fact *or* Myth
    - Answer *or* Myth *or* Fact
    - Explain fallacy

Furthermore, Ecker et al. (2022), like previous other recommendations, suggest that informative graphics can help knowledge revision. In my experiments, I used non-probative images. That is, the images did not add any additional information about the truth status of the misinformation. Whilst I do not disagree that informative graphics are useful, research has indicated that the use of any image can increase belief in information (Fenn et al., 2013, 2019; Newman et al., 2012).

Like Ecker et al. (2022), I added additional information to my corrective materials that explained why the misinformation was wrong. For example, when correcting the myth that "the COVID-19 vaccine is mandatory", I included the following explanation "There are no mandatory vaccines in the UK. You can choose whether to have them. Nevertheless, vaccines are an important way to keep ourselves, friends and family safe". Therefore, my recommendations include the use of an "explain fallacy" component.

Figure. 10.2.
My debunking recommendations



10.5. Future directions

10.5.1. Shallow processing

Future research should consider the effects of partial engagement. Many readers outside of an experiment will only shallowly process posters or social media content, perhaps just reading the title (Gabielkov et al., 2016) or initial sentences. Alternatively, their attention might be divided between reading the correction and other tasks, impairing memory (Craik et al., 1996) and even the processing of corrections specifically (Ecker et al., 2010).

Correction under these conditions may be weaker than effects reported here and may differ according to correction format. For example, were people to read the question of a question-answer format poster without reading the answer (i.e., “Does the COVID-19 vaccine change your DNA?”), the myth may become more familiar than if the question had not been read at all. This scenario may be more likely when the answer was separated from the question by large chunks of intervening material.

I did not use attention checks to detect inattentiveness during the influenza studies and the rate of inattentiveness (i.e., failure of the checks) was very low for the COVID-19 experiment. Attention checks, had more participants failed them, could have been a potential proxy measure for an analysis of inattentiveness in the current dataset. Another potential proxy measure for attentiveness for future analysis using the current datasets could be the time taken to complete the study. Short completion times could be used as a proxy for inattentiveness.

10.5.2. Prolonged debates

In “the real world”, misinformation is not typically a static, or one-off occurrence. For example, misinformation on social media can be further affirmed or debated in the comments section. Mourali and Drake (2022) found that the positive effects of debunking on masking attitudes and intentions were dissipated by further arguments against and in favour of masking. They found debate decreased participants’ perceived objectivity of truth (i.e., that there is a clear correct answer). Further research should consider the efficacy of correction formats in dynamic environments such as social media.

10.5.3. Historically excluded and marginalised communities

Not all members of the population have equal access to information and healthcare. Some communities such as people with disabilities, those who have low-income or experience poverty, LGBTQ people, and those from Black and Minority Ethnic communities often face unique obstacles, inequalities, and challenges (Lewandowsky et al., 2021). For example, there have been devastating disparities in the risk and impact and outcomes of Black and minority ethnic people (Health and Social Care, and Science and Technology Committee, 2021). Not only were Black and minority ethnic people more likely to experience serious illness and death from COVID-19, they also faced greater difficulty protecting, or shielding themselves from COVID-19 (Haque et al., 2020; Robertson et al., 2021). Furthermore, studies have reported that Black people are less likely to accept a COVID-19 vaccine (Johnson et al., 2021, Troiano & Nardi, 2021; Robertson et al., 2021).

Future research should consider at risk populations such as the ones discussed above as public health communications that use one-size-fits-all approach may not be suitable.

10.6. Limitations

One potential limitation of the studies within my thesis, and most studies within the debunking literature, is that the pre-manipulation measures may have made the hypothesis salient to participants. This, in turn, could have resulted in demand characteristics. Demand characteristics occur when participants “guess” the aims of the study and adjust their behaviour accordingly (Orne (1962). In my experiments, participants demonstrating this phenomenon would have guessed that the interventions aimed to lower their agreement with the influenza or COVID-19 myths and lowered their agreement with the myths post manipulation. One way I attempted to prevent this was via the use of distracter questions. For example, in the first influenza experiment I included questions such as “I regularly drink 6-8 glasses of low sugar soft drinks a day” and “I regularly eat at least 5 portions of a variety of fruit and vegetables every day”.

Another limitation of making the concept the salient is that it can result in the illusory truth effect. That is, statements that match previously studied topics, or single words, can yield higher truth ratings (Begg et al., 1985). This effect has been demonstrated even when participants have had their prior knowledge of a topic explicitly tested (Fazio et al., 2020). In the case of my experiments, mentioning the topics influenza or COVID-19 could have resulted in higher myth agreement. This would have made it harder for the interventions to significantly lower myth agreement.

Despite this, there was low overall belief in the COVID-19 myths (around 40%) at baseline. This meant that there was only limited room for correction (although it provided much more room for backfire effects). The consequence was that the power of the study was reduced relative to a study with more strongly believed myths (Swire et al., 2017). Nevertheless, a strength of the myths was that they were genuine real-world myths that had been debunked by fact checker websites.

For the COVID-19 experiment, I limited the materials to myths found in current COVID-19 health information. Therefore, I not only limited the pre-existing myth belief, I also limited the range of myths. The myths we tested could all be considered *rumours* (Islam et al., 2021), in that they were factually verifiable and designed not to inflame political beliefs. The conclusions are thus limited to these forms of misinformation. Other types of misinformation, such as conspiracy theories, tend to be much more difficult to correct (Lewandowsky, 2021b), and may respond differently to the correction formats tested in this thesis.

Debunking has some general limitations as the corrections are unlikely to reach the number of people who have been affected by the misinformation (Roozenbeek & van der Linden, 2022). Therefore, successful public health campaigns should consider the use of both pre-emptive (i.e., prebunking) and reactive (i.e., debunking) communications and campaigns. For example,

10.7. Impact

The materials I developed in Chapter 6 were used in the ABUHB 2019/2020 Staff Flu Vaccination Programme. Approximately 300 posters in Welsh and English were displayed across health board sites. Influenza myth-first messages were posted on the health board's intranet, news and social media platforms (e.g., Facebook, Twitter and Instagram). Flu champions and divisional flu leads also used our resources to display posters in staff areas. The content of the posters was also used within staff communication.

10.8. Conclusions

This thesis examined which correction methods are the most effective at debunking misinformation about two infectious respiratory illnesses: influenza and COVID-19. COVID-19 currently has pandemic status whilst influenza is a seasonal virus that has been the cause of past, and likely future, pandemics. By studying how misinformation emerges, spreads, and persists, we can better prepare for both future health emergencies (such as pandemics) and seasonal public health campaigns.

Overall thesis demonstrates that simple, poster-like correction formats, of the style used in public health campaigns, can reduce myth agreement and increase vaccine intentions. My findings have important implications for public health campaigns countering misinformation about infectious respiratory illnesses.

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