UTS UNIVERSITY OF TECHNOLOGY SYDNEY

Understanding How People Integrate Conflicting Health Information: An Epistemic Cognition Approach

by Kristine M. J. Deroover

Thesis submitted in fulfilment of the requirements for the degree of

Doctor of Philosophy

under the supervision of Associate Professor Simon Knight, Professor Paul F. Burke, and Associate Professor Tamara Bucher.

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Certificate of Original Authorship

I, Kristine Deroover, declare that this thesis is submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the Transdisciplinary School at the University of Technology Sydney. This thesis is wholly my own work unless otherwise referenced or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

This document has not been submitted for qualifications at any other academic institution.

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Note on Thesis Format and Style

This is a *thesis by compilation* as described in the University of Technology Sydney's Graduate Research Candidature Management Thesis Preparation and Submission Procedures 2023, comprising a combination of chapters and published/publishable works, and including:

- An introduction to the research study and a justification of how it adds to knowledge in the field: Chapter 1 and the introductions in Chapter 2,3 and 4;
- A chapter reviewing literature or literature review paper: Chapter 2 presents a literature review, in addition Chapter 3 and 4 include literature studies;
- A chapter or paper(s) that describe and justify the research approach and methods: Chapters 2,3 and 4 describe and justify the respective study methods, in addition Chapter 1 describes and justifies the overall research approach;
- Chapters and/or papers that present results: Chapters 2,3 and 4;
- A discussion and conclusion: Chapter 5 in addition to the discussions in Chapters 2,3 and 4.

The thesis is 1.5 spaced and Australian English spelling is used throughout.

Ethical Approval

This project received ethical approval from the University of Technology Sydney Human Research Ethics Committee for the expert interviews in study 2 [ETH19-3782] and for study 3 [ETH20-5078].

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Invited talk and peer-reviewed conference presentations

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Deroover K, Bucher T, Burke P, Knight S, 'Expert interviews about scientific disagreement', *The 43rd Annual Scientific Meeting of the Nutrition Society of Australia*, Newcastle (Dec 2-5, 2019), Proceedings 2020, 43, 2; doi:10.3390/proceedings2020043002(p51)

Deroover K, Bucher T & Knight S 2019, 'A taxonomy of disagreements related to health and nutrition information', *2019 Annual Meeting of the International Society of Behavioral Nutrition and Physical Activity,* Prague (June 4-9, 2019). ISBN: 978-1-7324011-1-2 (p822), *SO05.2 (17458)*

Author Attribution Statement

I am the lead author for the published and prepared papers included in this thesis:

Paper	Status	Contribution	Ch #	Signatures
Deroover K, Knight S, Burke P.F., Bucher T . Conflicting health information: An integrated approach to people's processing of conflicting information.	Drafted for submission	I led the design of this review, identified and developed the methodological approach, completed the database searches, determined inclusion status of studies, extracted data, analysed the data, and wrote the manuscript with feedback from co-authors within their supervisory roles.	2	Production Note: Signature removed prior to publication.SK 2023-10-20 Production Note: Signature removed prior to publication. PB 2023-10-30 Production Note: Signature removed prior to publication. TB 2023-12-15
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Deroover K, Knight S, Burke P.F., Bucher T. Epistemic beliefs and processing conflicting health information: An experiment.	Drafted for submission	I led the design, obtained ethics approval, created the online data collection environment, led the recruitment of study participants, collected the data, developed the coding approach, conducted the content analysis of the qualitative data, conducted the statistical analysis, and wrote the manuscript with feedback from co-authors within their supervisory roles.	4	Production Note: Signature removed prior to publication.SK 2023-10-20 Production Note: Signature removed prior to publication. PB 2023-10-30 Production Note: Signature removed prior to publication. TB 2023-12-15

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Two appendices in relation to study 2 (presented in Chapter 3) detailing the literature search (A) and the development of the taxonomy of disagreements (B) can be found via https://doi.org/10.1177/09636625221110029.

Glossary

Descriptions and explanations of, and reflections on, terms frequently used throughout this thesis:

Conflict and ***Disagreement***: These terms are used as synonyms in this work and in this thesis, they refer to (the perception of) information sources not being in accordance with one another. Please also see Figure 8 on p. 61 for details on the different types of perceived conflict. Reflections on the definition of conflicting health information can be found on p. 60.

Epistemic cognition: Throughout this thesis the terms "epistemic cognition" and "epistemic beliefs", in addition to other related terms, are frequently used. The three-level model of cognitive processing to account for complex monitoring when individuals are faced with ill-structured problems by Kitchner (1983) may help with describing these terms: The model describes cognition as a first level of processing in which one computes, memorizes, reads, perceives, solves problems, etc (Kitchner, 1983). Then at the second level, metacognition refers to how individuals monitor their own progress when they are engaged in these first-order tasks (Kitchner, 1983). The third level of processing refers to epistemic cognition and means that individuals reflect on the limits of knowing, the certainty of knowing, and criteria of knowing (Kitchner, 1983). Epistemic assumptions or beliefs influence how individuals understand the nature of problems and decide what kinds of strategies are appropriate for solving them (Kitchner, 1983). The first two processes develop through childhood, the third process, epistemic cognition, may develop in late adolescence and through adult life (Kitchner, 1983).

Please also see Table 3. Epistemic beliefs and related concepts on p 42 and 4.1 Introduction to chapter 3 on p 104 for further detail on the use of the different terms throughout this thesis and their conceptual meanings.

Expert: Expertise is what distinguishes the amateur from the master. Expertise can be defined as exceptional, elite, or peak performance on specific tasks in specific domains (Bourne Jr et al., 2014). Some have proposed that the devotion of at least 10.000 hours to the study and practice of a subject is the key to becoming an expert (Ericsson et al., 1993; Gladwell, 2008). However, the ten-thousand-hour rule is only a rough indicator based on an average, and several other factors, such as deliberate practice, perseverance, cognitive skills, personality traits (e.g., grit), self-control and physical characteristics are to be considered (Tedesqui and Young, 2017; Duckworth et al., 2011; Ericsson and Pool, 2016; Macnamara et al., 2014). Therefore, while keeping in mind the fluidity of the concepts of "expert" and "expertise" both in terms of their defined and perceived meaning, when in this thesis the term "expert" is used, it refers to "a person who is (perceived as) very knowledgeable about or skilful in a particular area".

Laypeople: In accordance with the above definition for expert, when in this thesis the term "layperson" (or "laypeople") is used, it refers to "someone who is not an expert in a particular area".

Based on these definitions, one *may* be an expert in a particular area, however, is likely to be considered a layperson in all other areas.

Taxonomy: When using the term taxonomy in this thesis, it refers to "a scheme of classification". Chapter 3 (p. 81) presents the development of a taxonomy based on the methodology by Nickerson et al. (2013) . Please also consult p. 162 in the discussion for further reflections on the use of this term.

Transdisciplinary: There are several terms that refer to an integrated approach that moves beyond disciplinary, for example, in research. Work by Stock and Burton (2011) may help with the distinction between multi-, inter-, and transdisciplinary research: "What divides multidisciplinarity from interdisciplinarity and transdisciplinarity is the lack of iterative research, a failure to cross disciplinary boundaries, the lack of integration in the research process, and a failure to engage non-academic stakeholders as participants in the research." (Stock and Burton, 2011 p. 1102) and "Interdisciplinarity is similar to transdisciplinarity. In fact, the only key differences between the two are that transdisciplinary work aims to synthesize new disciplines and theory (whereas this is not an objective for interdisciplinarity) and transdisciplinarity emphasizes holism in its approach (this leads to increased participation from stakeholders and the more likely adoption of pluralist methodologies). The boundaries between interdisciplinary and transdisciplinary projects are thus diffuse and dependent more on a subjective judgment on the level of holism applied than on the presence of clear boundary markers." (Stock and Burton, 2011 p. 1102). Please also see section 1.2.4 Research Approach and Compilation in the introduction and section 5.4.1 on p. 169 in the discussion for reflections on the present work as a transdisciplinary inquiry.

Abbreviations that are frequently used throughout this thesis:

ABS	absolutism	(see p. 42 and p. 104)
CAEB	connotative aspects of epistemic beliefs (Stahl & Bromme, 2007)	(see p. 118)
CIS	critical interpretive synthesis (Dixon-Woods et al., 2006)	(see p. 23)
EBs	epistemic beliefs or epistemological beliefs	(see p. 42 and p. 104)
e.g.	exempli gratia = for example	
ETA	epistemic thinking assessment (Barzilai & Weinstock, 2015)	(see p. 118)
etc.	et cetera = and other similar things	
EVA	evaluativism	(see p. 42 and p. 104)
FU	the follow-up measurement	(see p. 117)
i.e.	id est = that is	
MDP	multiple document processing	(see p. 120)
MULTI	multiplicism	(see p. 42 and p. 104)
Pre	the measurement time before the intervention	(see p. 117)

Post	the measurement time after the intervention	(see p. 117)
SDR	science dispute reasons (Dieckmann & Johnson, 2019)	(see p. 120)
TD	transdisciplinary	

References in glossary:

Barzilai S and Weinstock M (2015) Measuring epistemic thinking within and across topics: A scenario-based approach. *Contemporary Educational Psychology* 42: 141-158.

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Duckworth, A. L., Kirby, T. A., Tsukayama, E., Berstein, H., & Ericsson, K. A. (2011). Deliberate practice spells success: Why grittier competitors triumph at the National Spelling Bee. *Social psychological and personality science*, *2*(2), 174-181.

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Stock, P., & Burton, R. J. (2011). Defining terms for integrated (multi-inter-trans-disciplinary) sustainability research. *Sustainability*, *3*(8), 1090-1113.

Tedesqui, R. A., & Young, B. W. (2017). Associations between self-control, practice, and skill level in sport expertise development. *Research quarterly for exercise and sport*, *88*(1), 108-113.

Abstract

In an era marked by the proliferation of health-related information, individuals are frequently confronted with conflicting advice and divergent perspectives when making crucial health decisions. This thesis, "Understanding how people integrate conflicting health information: an epistemic cognition approach," comprises three interrelated studies aimed at unravelling the complexities of how people process and respond to conflicting health information.

The first study conducts a comprehensive critical interpretive synthesis of existing literature on the processing of conflicting health information. It establishes an integrated model that transcends prior frameworks by amalgamating theoretical constructs from diverse disciplines. This study synthesises stages, pathways, and strategies, and models the determinants that influence the processing of conflicting health information. Key among these determinants are the individual's beliefs about knowledge, the construction of knowledge, and the reasons behind expert disagreements. This study underscores that awareness of the origins of disagreements promotes a balanced mental model of conflicting information, potentially enhancing decision-making.

The second study addresses the underexplored realm of expert perspectives on disagreements in health information. By triangulating findings from a literature review, case studies and expert interviews, it presents a taxonomy of disagreements encompassing ten distinct types, categorised under three dimensions: informant-related, information-related, and uncertainty-related causes for disagreement. This taxonomy provides a valuable tool for understanding and addressing the diverse reasons behind expert disagreements, aiding in more effective communication and education in health and science.

The third study employs a mixed methods approach, combining validated scales and content analysis, to investigate the intricate relationship between individuals' epistemic beliefs, explanations for expert disagreements, and their capacity to navigate conflicting health information through a Multiple Document Processing (MDP) task. The findings reveal that more adaptive epistemic beliefs correlate with better MDP task performance. Furthermore, an innovative intervention method is introduced, showing a promising trend in participants' perspectives showing more adaptive epistemic beliefs.

Collectively, this thesis provides a holistic understanding of the challenges posed by conflicting health information. It underscores the importance of considering individuals' epistemic beliefs and their perspectives on how knowledge is constructed, as well as how experts may disagree when addressing this issue. Ultimately, this research informs strategies for enhancing health communication and promoting information literacy in the context of conflicting health information, contributing to more informed and effective health decision-making.

1. Introduction

1.1. Positioning of this work

Rising Interest in the Infodemic

> In 2006, *Time*'s person of the year was "You." and on the magazine's cover it stated "Yes, you. You control the Information Age. Welcome to your world." under an image of a desktop with reflective material on the monitor so the reader could see themselves (Stengel, 2023). A bold and controversial choice that portrays the huge potential of user-generated content, i.e., instead of "having few creating for the many, having many create for one another", and nicely illustrates the somewhat naïve enthusiasm for this new information age that was present at the time (*Facebook* had just launched). Naïve in the sense that the challenges that were to come with this information age were not fully anticipated, both in terms of what kind of content is created, but also, and perhaps even more so, in terms of how people deal with this multitude (both in quantity and quality) of information.

Whether it is about handling a pandemic, the causes and prevention of bushfires, how to live a healthy lifestyle or what food products to consume or not, developments in technology have led to changes in the information that people are exposed to ; the rise of the internet has made an enormous amount of information available and accessible at any time for people (Bawden and Robinson, 2020; Roetzel, 2019). The increased access to information can allow individuals to self-educate and consequently support them in their decision-making (Jacobs et al., 2017; Rice and Sara, 2019). However, often sources have differing or even conflicting views (Carpenter et al., 2016). Consequently, everyday life decision-making increasingly requires knowledge acquisition through the construction of a meaning based on the comparison and integration of multiple, potentially conflicting sources. Thus, being able to evaluate conflicting information is an essential pre-requisite for people's participation in society (Bromme and Goldman, 2014; Goldman and Brand-Gruwel, 2018; Goldman and Scardamalia, 2013).

Despite their importance, these skills required for dealing with the abundance, complexity and uncertainty of information do not come intuitively (Ferguson, 2015). In addition, formal education may not sufficiently prepare people to develop these skills. The information sources that students typically encounter at school are, to a large extent, single texts in explanatory and descriptive textbook chapters and written by authoritative experts (Nolen, 1995; Paxton, 1997). These information sources, and the way they – and the information they contain – are presented, provide accounts of a concept or issue as definite, unambiguous and consensual. When comparing this type of information source with the variety of information types people are likely to encounter in daily life, for example, on the internet, the differences are multiple and large (Barzilai and Ka'adan, 2017; Knight, 2014). Rather

than one consensus, multiple divergent accounts are to be dealt with. The accounts are also often complex, and hold many uncertainties, including about their relevance and the source's trustworthiness based on aspects such as expertise and interests.

These issues have seen increasing popular attention, including, through the emergence of concepts or language including:

> In 2015, the International *Fact-Checking* Network (IFCN) at Poynter was launched to bring together the growing community of fact-checkers around the world and advocates of factual information in the global fight against misinformation (The Poynter Institute).
>
> In late 2016, Oxford Dictionaries selected "*Post-truth*" as the word of the year, defining it as "relating to or denoting circumstances in which objective facts are less influential in shaping public opinion than appeals to emotion and personal belief" (OxfordLanguages, 2016).
>
> In April 2017, the first "*March for Science*" took place, a demonstration aimed to react to the increasing and wide-spread criticism of scientific research. The march's goals were to emphasize the roll science plays in everyday lives and to call for evidence-based policy in the public's best interest (Reardon et al., 2017).
>
> In 2018, the European commission introduced an EU code of practice on *disinformation*.
>
> In 2019, a new definition for "*Information overload*" was proposed by Roetzel (2019): "Information overload is a state in which a decision maker faces a set of information (i.e., an information load with informational characteristics such as an amount, a complexity, and a level of redundancy, contradiction and inconsistency) comprising the accumulation of individual informational cues of differing size and complexity that inhibit the decision maker's ability to optimally determine the best possible decision. The probability of achieving the best possible decision is defined as decision-making performance. The suboptimal use of information is caused by the limitation of scarce individual resources. A scarce resource can be limited individual characteristics (such as serial processing ability, limited short-term memory) or limited task-related equipment (e.g., time to decide, budget)".
>
> In 2020, the term and concept "*Infodemic*" was popularised through the communication of concerns about such information epidemic by the United Nations and the World Health Organisation regarding the Covid-19 pandemic. An infodemic is a rapid and far-reaching spread of both accurate and inaccurate information about certain issues (World Health Organisation, 2020).
>
> In 2021, a paper about what it means to be a science-literate citizen in a digital world by Howell and Brossard (2021) proposes that if *science literacy* is to enable people to become and stay informed, and avoid being misinformed, on complex issues, it requires skills that

span *the lifecycle of science information*. That would mean information on how the scientific community produces science information, how media repackage and share the information, and how individuals encounter and form opinions on this information. The paper resulted from the Colloquium "Advancing the science and practice of science communication: Misinformation about science in the public sphere" of the National Academy of Sciences in 2019.

In 2022, Russia's invasion in Ukraine and the accompanying *information war* was another example of a situation where *fake news* muddies the waters and shapes emerging narratives (Baumann, 2020; Chen and Ferrara, 2023; Stanescu, 2022).

In January 2023, the Minister for Communications announced that the Australian Government would introduce new laws to provide the independent regulator, the Australian Communications and Media Authority (ACMA), with new powers to combat online *misinformation and disinformation*. On the website of the Department of Infrastructure, Transport, Regional Development, communications and the Arts, the Australian Government states "The new powers will enable the ACMA to monitor efforts and require digital platforms to do more, placing Australia at the forefront in tackling harmful online misinformation and disinformation, while balancing freedom of speech. [..] The ACMA powers will strengthen and support the existing voluntary framework established by the Australian Code of Practice on Disinformation and Misinformation (the voluntary code, which commenced on 22 February 2021), and will extend to non-signatories of the voluntary code." In June 2023, the Australian Government released the draft Communications Legislation Amendment (Combatting Misinformation and Disinformation) Bill 2023 for public consultation.

These examples illustrate the timeliness of this issue. While it is worth noting that these concepts are not entirely new – 'infodemic' was coined during the SARS outbreak in 2003 (Rothkopf, 2003), following 'infodemiology' by Eysenbach in 2002 (Eysenbach, 2002) - and may even be inherent to human nature, as Yuval N. Harari suggests: "Humans have always lived in the age of post-truth. Homo sapiens is a post-truth species, whose power depends on creating and believing fictions." (Harari, 2019), the overwhelming volume, complexity, and uncertainty of information is a serious and timely issue that poses a significant challenge for people making daily decisions. In today's society, a prevalence of extensively specialised knowledge is observable, which is widely distributed and instantly accessible through, for example, online search engines (Brossard and Scheufele, 2013). In such knowledge-driven society, the process of constructing meaning frequently involves analysing diverse sources, including expert sources, that may present people with conflicting or contradictory information (Sinatra and Lombardi, 2020). Consequently, efforts towards a better understanding of the mechanisms underlying this complex phenomenon and towards better strategies to deal with it are

needed (Carpenter et al., 2016; Maier and Richter, 2013; Stadtler and Bromme, 2014; Sandoval et al., 2016; Lang, 2019).

Conflicting Experts, not Misinformation, as Underpinning the Infodemic

Fake news and misinformation and disinformation are popular terms in the media and the topic of interest for much research (Nguyen and Catalan, 2020; Vosoughi et al., 2018; Swire-Thompson and Lazer, 2020; Howell and Brossard, 2021; Sharon and Baram-Tsabari, 2020) and conversations (e.g., on the 10th of Oct '18, our research team attended the "Fighting Truth Decay: How to navigate health in a post-truth world" event at the University of Sydney, which talked about the role of corporate interests in influencing public perception of science, particularly health research). And rightfully so. Both efforts to reduce the existence of, and people's exposure to, false and misleading narratives, as well as efforts to increase people's capabilities to verify sources, in addition to perceiving this as the responsibility of people, are timely and essential for all.

However, when prompted to do so, people can be quite capable of distinguishing experts from non-experts (Flanagin et al., 2020). The credibility-related aspects of information literacy may not be the main problem they are dealing with, or it may not be the source of the issue. It may be that people do not feel the need to seek high-quality expert information. Expert-expert and scientific disagreements occur frequently, are a normal aspect of the scientific progress and community, are to be expected and even encouraged (Kuhn, 1962a; Shanteau, 2000; Shapin, 1992; Mumpower and Stewart, 1996). However, this concept may not be well understood by the public (Dieckmann et al., 2017b; Thomm et al., 2015). Furthermore, for a moment, let's go back to the march for science; some of the signs held by demonstrators read "there is no alternative to scientific facts", "real facts matter", "scientists speaking truth to power" and "the good thing about science is that it is true whether or not you believe in it". These signs were most likely very well-intended, and such signs may have needed to be short and eye-catching. However, narratives such as these may not convey an appropriate picture of the nature of science and have received various kinds of criticism, for example: that such actions are (perceived) as too political in nature and should not be done by scientists as they may have a polarising effect on the public's opinion about them (Motta, 2018); that such a politically charged event might send a message to the public that scientists are driven by ideology more than by evidence (Flam, 2017; Young, 2017); that confidence in science is in fact strong and marching for science only jeopardises the perceived credibility (Nisbet, 2017; Rosenbaum, 2017); and, that the march seemed to try to portray a mythical image of science, "a celebration of exceptionalism, elitism and, intentional or not, an attempt to propagate the myth of science as the supplier of truths free of bias" (Lang (2019) and Penders (2017) p.1488). Indeed, such messages give the impression that science is certain, unambiguous and unchanging (Lang, 2019). When people perceive scientific knowledge as certain, they tend to embrace positions that align with their existing beliefs while disregarding the need to carefully compare different sources, which may result in a partial or biased understanding of the issue

(Maier and Richter, 2013; Sinatra et al., 2014). In other words, when people believe that science is a collection of absolute facts, it is hard for them to appreciate any uncertainty, disagreement or tentativeness (Kuhn and Park, 2005). However, such appreciation is a pre-requisite for effective handling of information, i.e., engagement in critical evaluation of (often competing) claims for sustainable decision-making (Bromme and Goldman, 2014; Ferguson, 2015; Barzilai et al., 2020). Furthermore, such understanding and appreciation will not only allow for better handling of scientific conflicts, but also encourage evaluation of the credibility of an information source as opposed to the idea that "if even experts disagree that must mean that there is no need to make sure one uses an expert source of information".

Consequently, this thesis, as an overarching goal, aims to contribute to a better awareness of the concept that any efforts to promote the importance of science and scientific information in people's decision making must convey the message that, science is less about the pursuit of particular truths, but instead about the process of pursuing truth, with knowledge being grounded in that pursuit. Perhaps, people's abilities to see the difference between "science is truth" and "science is a pursuit of knowledge" largely explains their abilities to handle the multitude and complexity of ambiguous, uncertain, and tentative information that often leads to the perception of competing and conflicting claims.

The handling of conflicting information sources becomes particularly intriguing in the health context due to its direct impact on people's well-being (Nagler, 2014). In matters concerning health, individuals need reliable and accurate information to make informed choices about their medical conditions, treatments, and lifestyle choices, for example, regarding what food to consume (Frawley et al., 2014; Wilson et al., 2009; Leikas et al., 2007; Frewer et al., 2016; Visschers et al., 2013; Moynihan et al., 2019). However, the abundance of health-related information available from various sources, such as medical experts, research studies, media reports, and anecdotal experiences, often leads to contradictory viewpoints (Carpenter et al., 2016). This poses a challenge for individuals as they try to discern which information to trust and follow. The consequences of making uninformed or misguided health decisions can be significant, making it vital to navigate through the conflicting sources with critical thinking and evidence-based assessments (Carpenter and Han, 2020; Nagler et al., 2022). The ability to evaluate and interpret scientific contradictions in the health domain is crucial for promoting well-informed choices and fostering a more informed and healthier society (Sørensen et al., 2012).

1.2. How the present work adds to the knowledge in the field

1.2.1. Conflicting health information

Conflicting health information is frequently encountered in naturalistic contexts. For example, it has been reported that 18-50% of patients have been found to receive conflicting medication information

(Carpenter et al., 2010) increasing to more than 80% of patients in a study on rheumatoid arthritis medication (Carpenter et al., 2014), with 50-75% of patients and providers perceive conflicting information about cancer-screening guidelines (Han et al., 2011). Regarding health and nutrition, 72% of US adults reported medium to high exposure to conflicting nutrition information about alcohol, fish, coffee, and vitamin supplements (Nagler, 2014). Furthermore, studies have found that such conflicting health information can cause confusion (Nagler, 2014; Ngo et al., 2023). This confusion, in turn, may result in several adverse outcomes such as; media scepticism and loss of confidence in scientific research's credibility (Vardeman and Aldoory, 2008; Wu and Ahn, 2010), decision-paralysis (Carpenter et al., 2016; Samuelson and Zeckhauser, 1988); and people being less likely to engage in health behaviours (Naylor et al., 2009; Ahn and Kahlor, 2022), including those that are independent of the target-conflicting information (Lee et al., 2018; Nagler, 2014). This backlash, or negative beliefs about health recommendations and research, and the resulting lower intentions to engage in lifestyle behaviours promoted by health educators, was also described in quantitative studies, which found an association between exposure to conflicting information and a lower likelihood to adhere to fruit and vegetable consumption and physical activity recommendations, mediated through confusion and backlash (Nagler, 2014; Vijaykumar et al., 2021b). There is a burgeoning amount of evidence on the presence of conflicting health information and its adverse effects, which may go beyond the current issue and carry over to other topics, perceptions, beliefs and behaviours. Consequently, exposure to conflicting health information has the potential to compromise the effects of health education and promotion interventions. However, despite the awareness of the increased presence of conflicting health information and its adverse side effects, very little theoretical knowledge exists on the underlying causes and effects, and the factors that determine the process of seeking, evaluating, integrating and applying conflicting health information.

1.2.2. Processing conflicting information

In a health context, conflicting information has been discussed both from a health perspective (e.g., Nagler, 2014) and within the field of education (Kienhues et al., 2011), however, few studies have aimed to conceptualise the process (Carpenter et al., 2016; Yoon et al., 2017). Carpenter and Han (2020) proposed a conceptual definition of the phenomenon *conflicting health information* and identified and re-emphasized their earlier proposal that critical research is required for a theoretical model that outlines the antecedents, processing and effects of conflicting health information (Carpenter et al., 2016).

The processing of potentially conflicting information has been investigated in fields other than health. Regarding the theoretical modelling of the processing of conflicting information, key models describe the ways that sources-tasks and people interact, and the processes that people undertake to integrate multiple sources. These models (described in detail in "How people engage with information from multiple sources", p 38) inform the present work, in particular, the literature around epistemic

cognition and multiple-text comprehension, probing how peoples' beliefs regarding the source and nature of knowledge (i.e., their *epistemic beliefs*, see **Table 3.** Epistemic beliefs and related concepts (p 18) for further explanations) influence their understanding of multiple sources (a process discussed in detail on p 41) (Anmarkrud et al., 2014; Bråten et al., 2011; Ferguson, 2015; List and Alexander, 2017; Stadtler and Bromme, 2014).

1.2.3. Overarching aim: Towards a better understanding of conflicting health information

While existing theories and findings from multiple fields of inquiry provide useful lenses for the understanding of the processing of conflicting information, the synthesis, integration and application of those insights into the phenomenon of conflicting health information has been lacking (Carpenter and Han, 2020). This thesis takes a first step in the development of such a conceptual understanding of the processing of conflicting health information. The development of this understanding requires an integration and interpretation of information from different disciplines, fields and topics, and a research approach that allows, supports, accommodates and facilitates this need.

1.2.4. Research Approach and Compilation

The nature of this project

We are surrounded by wicked problems and complex messy societal challenges (Lönngren and Van Poeck, 2021). These problems typically have fuzzy boundaries, are hard to define, and are often are entangled in competing social interests and values and subject to changing circumstances as well as requirements (Lönngren and Van Poeck, 2021; Petrie and Peters, 2020; Plamondon and Pemberton, 2019). They are particularly difficult (or impossible) to solve because, due to their social complexity, there is no determinable stopping point (Lönngren and Van Poeck, 2021). Therefore, rather than applying rational linear thinking trying to *solve* the complexity, it may be of interest to work *with* the complexity, applying more open and adaptive thinking (Petrie and Peters, 2020). To better understand these challenges and develop workable solutions, diverse forms of disciplinary and experiential knowledge are required (Pohl et al., 2017). Public health in the 21st century, as well, requires actors from different backgrounds to co-produce knowledge and policy to solve the complex global challenges that affect health (Pineo et al., 2021; De Leeuw, 2017; de Leeuw, 2022). Thus, these problems, which cross boundaries and overarch disciplinary knowledge types, such as the public's handling of conflicting health information, can benefit from a transdisciplinary research approach (Pineo et al., 2021; Abrams, 2006). Transdisciplinary research is characterised by integrating diverse knowledge and transcending disciplinary approaches and is increasingly seen as essential for understanding and finding solutions for complex global challenges (Pohl et al., 2017; Nicolescu, 2002; Rosenfield, 1992). Such process of moving beyond the boundaries of one discipline provides an exciting opportunity to investigate the issue "conflicting health information" through a novel approach that enables a holistic view and offers hope for impactful solutions.

This process of moving beyond the confines of one discipline includes moving beyond one paradigm and requires the development of an awareness of one's epistemology (Mitchell et al., 2015; Willetts and Mitchell, 2009). Articulation of one's position and its relativity to other positions may allow for a more efficient and respectful engagement with diverging views. Consequently, a transdisciplinary research approach implies transparency and explicitness of the research context and perceives articulation of worldviews and other formative influences as good practice (Mitchell et al., 2015).

Furthermore, in the unfolding of this thesis in the following chapters, we will emphasise the importance of transparent science communication as well as the importance of awareness and understanding of one's epistemic beliefs, and the way they affect people's information processing and subsequent decision-making. Thus, more reflective, reflexive and explicit attention to ontological and epistemological perspectives both within the information creator and within the information receiver is desirable.

Therefore, it seems appropriate or even imperative that a part of the introduction of this thesis is devoted to the positioning of this work within a research team, working within a certain research context and influenced by the team members' background, their values as a person in society, and their epistemological and ontological preferences in research. These worldviews and other formative influences form the lenses through which they interact with the world, the way they define a problem, the (research) questions they ask, the methodologies they use, and the way they interpret any findings and formulate conclusions from those.

In the following, seven aspects of the nature of this research project – as outlined by Mitchell et al. (2015) – are described as a means to allow evaluation of its context: Intent; Worldview; Experience and qualifications; Past engagement with the situation; Funding arrangements; Degree of engagement across disciplines; and Degree of engagement with the situation.

Seven aspects of the nature of this research project

A first aspect to address is the question "*What is the intent of the research project? (i.e., purposive, normative, descriptive?) e.g., the research might be outcomes-focused with a (moral) commitment to improving the situation, or the intention may be to better understand the situation*" (Mitchell et al., 2015). While creating actual change (i.e., helping people with the handling of health information) is the eventual (and thus purposive) intent of this inquiry, a descriptive intent, leading to a better understanding, is a pre-requisite and first step towards change, and a more realistic aim within a PhD research program.

Second, *the worldview or orientation of the research team can influence the theoretical lens, in addition to where boundaries are drawn around the project and the problem situation, and, which stakeholders participate and who are excluded* (Mitchell et al., 2015). My worldview is anchored in compassion and sustainability in our interactions with others, the planet and the world. The Earth is a

precious resource that sustains us, and it is our responsibility to ensure its health and vitality for future generations. This includes a responsibility for optimised health and well-being for all (Corral-Verdugo et al., 2021; Assmuth et al., 2020; Degeling et al., 2016). I aim to promote a world where resources and knowledge empower everyone to lead healthy lives, transcending barriers that perpetuate health disparities. Open-mindedness and critical thinking are integral to this vision, fostering an environment where diverse viewpoints strengthen our collective problem-solving. I view lifelong learning as a vital life tool, and actively seek out new knowledge and remain open to evolving my perspectives based on new insights. Highly valuing the interconnected world, I believe in the power of collaboration and the strength that comes from diverse voices and perspectives, embracing inclusivity, and balancing progress and tradition.

The idea that people have a responsibility to take care of their health, and by extension of the planet, in addition to the idea that this implies people have a responsibility in terms of educating and informing themselves, has had an important influence on this work; the way the world and the phenomenon *conflicting health information* are seen, and how the research problem is defined. In addition, the view on the need for, and benefits of, the inclusion of diverse perspectives to achieve a better understanding and problem-solving has influenced the design of the studies included in this project and the approaches they take. The following section (Researcher profile and epistemological perspective) of this introduction further elaborates on the philosophical perspectives in the research context and in the discussion (section 5.3.1) discusses how the included studies' research questions and designs reflect these perspectives.

A third aspect of a research project's context is based on the questions "*What are the existing qualifications, formal training, skills? Life experiences? Sense of role and responsibility in the project?"* (Mitchell et al., 2015). I embarked on this PhD journey with a MA in Rehabilitation Sciences and a MSc in Health Education and Promotion. Through both educational and professional endeavours, I have worked on several research projects spanning across health promotion, nutrition education, food and beverages consumer behaviour and the public's understanding of science, providing me with the knowledge, skills and perspectives I have today. I led the project from its conceptualisation (i.e., writing the research proposal) over the many iterations of the methodological design, to conducting the studies and reporting and disseminating the findings. On this journey, I was mentored by highly experienced supervisors who are world experts in their fields. Associate Professor Simon Knight (SK) is Director of the University of Technology Sydney Centre for Research on Education in a Digital Society (UTS: CREDS), and theme lead of the Transformative Learning research theme in the Transdisciplinary School. Dr Paul Burke (PB) is Professor in Marketing and Deputy Director of the University of Technology Sydney Centre for Business Intelligence and Data Analytics (BIDA) at UTS: Business. Dr Tamara Bucher (TB) is Associate Professor Food and Consumer Behaviour and Head of discipline Food Science and Human Nutrition at The University of

Newcastle. This international and multidisciplinary team formed a strong foundation for this research project, in addition to access to two Australian universities that provide a highly supportive, collaborative, successful, competitive, in addition to, dynamic and well-connected (nationally and internationally) research environment.

A fourth aspect is related to "*What past experience, engagement or relationships in the situation under investigation does the research team have?"* (Mitchell et al., 2015). Health literacy, the role of knowledge, and the way people perceive, process and apply information has been a research interest in earlier projects. For example, my master's research thesis investigated different types of nutrition knowledge (e.g., informational and procedural) and their role in diet quality. SK studies how people learn to navigate uncertainty, disagreement, and evidence, and the mediating role of technology in that process. His work has explored the use of data as a form of evidence, and design for learning towards epistemic and ethical reasoning. He has extensive expertise in research on the role of epistemic beliefs in different educational contexts and learning situations. PB studies applied and theoretical aspects of choice modelling, experimental design and consumer behaviour. TB studies nutrition education and environmental influences on food choice.

Funding arrangements are described in this fifth aspect; "*Who is funding the research? This has implications both in terms of the outcomes of the research (e.g., whether it is likely to be implemented by the funding body – e.g., a government department or water utility); and, in terms of trust (e.g., if funded by a particular industry/governmental group the research may be perceived by others as biased if care is not taken to ensure independence)"* (Mitchell et al., 2015). This research has been funded through an Australian Government Research Training Program Scholarship. This research, and the included studies, were conducted by a team with a very high level of independence and none of the research team members declares a conflict of interest.

A sixth aspect considers *"What is the degree of engagement across theoretical and epistemological perspectives?"* (Mitchell et al., 2015). The team's relevant expertise was based in disciplines varying from the learning sciences and psychology, over marketing and consumer and behavioural sciences to health and nutrition sciences. The multitude of disciplines provided important opportunities for engagement across disparate philosophical perspectives, allowing for emergence of novel insights. The following section "Researcher profile and epistemological perspective'' elaborates further on the epistemological perspectives.

A last aspect of this project's research context describes *"What is the degree of engagement across sectors and stakeholder groups?"* (Mitchell et al., 2015). A range of stakeholder groups (and their work) were consulted, analysed and interpreted in this research, ranging from published academic work and media publications over interviews with experts from differing fields to a sample of laypeople consisting of undergraduate students. Such variety within and across the stakeholder groups

provides an increased breadth of perspectives and is expected to positively influence the saliency, credibility and legitimacy of the research (Mitchell et al., 2015).

Researcher profile and epistemological perspective

The PhD trajectory offers the opportunity to practise and further develop one's critical thinking and reflective and reflexive reasoning skills. Throughout this trajectory, the research team, environment, and the project itself encouraged reflection, i.e., an iterative approach was used which meant that the research project and the including activities evolved over time and were adapted based on emerging insights and the evolving context. In addition, reflexivity, and the need for reflexivity, i.e., a continuing awareness and questioning of one's own views, values, beliefs and ways of thinking, and how they affect the research e.g., the problem definition, the methodology and the interpretation, were encouraged by all parties involved and in an ecological way due to the nature of the project and the message it aims to convey.

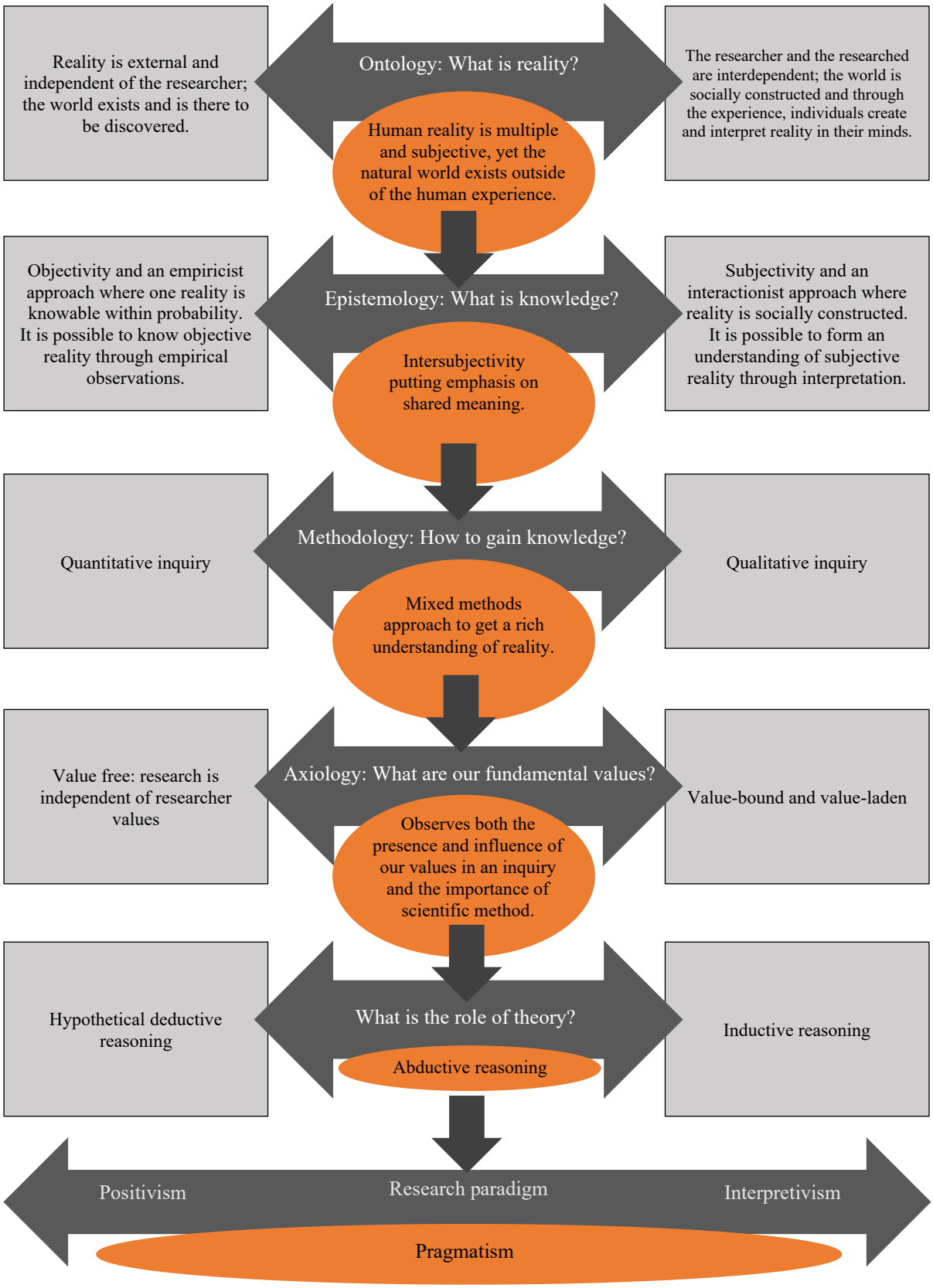
Consequently, I first wish to note that my awareness of my and others' perspectives and their consequences, and my ability to articulate these (while still bound by limitations) have evolved through this project and are expected to continue to evolve beyond. As, I believe, is the case for many researchers with a background in the natural sciences (in its widest definition), a positivist research paradigm was evident and implied, without much, or any, explicit articulation of that orientation nor much reflexivity regarding the consequences (Moon and Blackman, 2014). While, for example, in the health sciences some have started to gain interest in, and adopted, a more pragmatic approach, much of the research in this field is still mainly focused on positivist thinking (Park et al., 2020; Tombs and Pugsley, 2020). Therefore, elaboration on this aspect may not only assist with the interpretation of this project but may also add to the conversation between researchers starting or shifting to the social sciences and/or transdisciplinary enquiries where work is conceived from differing knowledge, belief and paradigm types, a conversational need as recently suggested by Fuyane (2021). Second, it may be useful to note and be mindful of the dynamic and evolving terminology used in this space to describe these philosophical perspectives.

To study and tackle real world phenomena, I believe an epistemologically plural position is most appropriate. Epistemological pluralism acknowledges that in any given research context, there may be several valuable ways of knowing, and that accommodating this plurality can lead to more successful integrated study (Fuyane, 2021; Miller et al., 2008). Consequently, I identify with a pragmatic approach which values positivism-oriented research (valid knowledge is generated from objective empirical observation experienced through the senses and carried out according to the scientific method (Crotty, 1998; Park et al., 2020) in certain situations and contexts and which values research based on interpretivism-oriented research, including constructivism (reality is socially constructed and meaning-making of reality is constructed by the individual (Crotty, 1998) in other situations and

contexts, or both in a synchronous manner (Fuyane, 2021). Such pragmatic belief that all necessary approaches should be applied in order to understand and address the issue at hand aligns with the idea of integrating all necessary disciplines and knowledge types in order to understand and address a problem which transdisciplinary research offers (Mitchell et al., 2015). **Figure 1** presents a visual overview of the pragmatic research paradigm and the corresponding perspectives on ontology, epistemology, methodology, axiology and the role of theory on the respective continua.

Thus, I believe in adopting a reflective and transdisciplinary framework for inquiry, recognizing that all relevant approaches should be utilized to comprehend and tackle the problem at hand. The pragmatic outlook is clearly reflected in the way this project is approached, adopting quantitative, qualitative and mixed methods approaches as constructive tools that enable us to better navigate the intricacies of real-world challenges shaped by both biophysical realities and human interactions. While much of this work focuses on conceptual work with the aim of gaining a better understanding of the phenomenon "conflicting health information", it also values the translation to practice and aims to provide these insights and practical implications. Consequently, in this thesis, and within the included studies, the aim is to strike a balanced approach between delving deep into conceptual reflections and arriving at actionable conclusions.

Figure 1. A pragmatic research paradigm



Note: The information in the figure is derived and adapted from: Fuyane (2021). Research methodology choice dilemma: A conceptual note to emerging researchers. *International Journal of Business & Management Studies*, *2*(02), 29-43.; Moon & Blackman (2017). A guide to ontology, epistemology, and philosophical perspectives for interdisciplinary researchers.; Moon and Blackman (2014). A guide to understanding social science research for natural scientists. Conservation biology, 28(5), 1167-1177.; Morgan (2007). Paradigms lost and pragmatism regained: Methodological implications of combining qualitative and quantitative methods. Journal of Mixed Methods Research, 1(1), 48-76.

Compilation of the three studies included in this thesis

This thesis aims to contribute to the development of an improved understanding of the handling of conflicting health information. The development of such understanding requires an integration and interpretation of information from different disciplines, fields and topics. In doing so, it is found that people react in different ways; while some ignore or quickly choose one side, for others the perception of conflict triggers careful investigation and elaboration. Consequently, a first study aims to describe the processing of conflicting health information and develops a framework for the characteristics related to the individual and the information sources that influence the process.

STUDY 1: CONFLICTING HEALTH INFORMATION: AN INTEGRATED APPROACH TO PEOPLE'S PROCESSING OF CONFLICTING INFORMATION

Since empirical evidence shows that people react in different ways (Nagler, 2014; Stadtler and Bromme, 2014), a need exists for an overview of the different determinants that influence how one handles conflicting health information or the perception thereof. In other words, there is a need for a theoretical understanding of the mechanisms that underlie the processing of conflicting health information.

To address this need, literature from differing fields, including the learning sciences, epistemic cognition, multiple document processing and the public understanding of science is integrated in the health communication literature. This study presents a critical interpretive synthesis using the literature on conflicting health information processing as an object of inquiry. An integrated model is described that adds to the literature and extends previous frameworks by bringing together theoretical conceptions about processing stages, pathways and strategies from various disciplines, in addition to seeking to identify and categorise the determinants that influence the processing of conflicting health information.

The first objective regarding the understanding of the process aims to provide a comprehensive overview of the determinants involved. There is a need for a useable model that provides a structure that can be used by a wide range of researchers and practitioners. Study 1 aims to provide a structured way to classify these determinants based on their role in the communication; "Who communicates what in what form and in what context to whom, who is in what situation, using what strategies and to what effect".

Then, in a second objective, this first study looks at the process through the lens of potential intervention. Consequently, it identifies those determinants within the individual that are modifiable and may be improved through intervention. As such, we propose the importance of people's beliefs about knowledge, how knowledge is constructed, and why and how experts may disagree with each other, and conflicting information may arise. This idea leads to Study 2 which aims to develop a taxonomy of disagreements or an overview of possible causes for expert disagreement.

Lastly, this first study looks at the implications of the framework and how it may inform further research and practice. These findings feed into Study 3 which describes an experimental study that investigates an educational activity using the taxonomy developed in Study 2 and its' effect on participants' epistemic beliefs and performance on a multiple source integration task.

STUDY 2: WHY DO EXPERTS DISAGREE? THE DEVELOPMENT OF A TAXONOMY

Although conflicting expert opinions about complex issues such as health and nutrition are in fact natural and expected, laypeople tend to use a narrower set of explanations. A number of studies have collected empirical data on laypeople's views on and explanations for scientific disagreement and have shown that they typically attribute disputes to expert incompetence and intentional bias (Dieckmann et al., 2017b; Thomm et al., 2015). The findings suggest that laypeople (defined as "a person/people who is/are not expert in a particular area", see also Glossary on p 15) often see consensus as a necessary requirement for expertise and consequently propose that when experts disagree this is caused by incompetence or due to differing motivations based on personal interests. Experts (defined as "a person/people who is/are (perceived as) very knowledgeable about or skilful in a particular area", see also Glossary on p 15), however, often expect to disagree and see this as a normal aspect of the scientific process (Kuhn, 1962a). They recognize that next to expert-related causes a range of causes can be identified that are based on the content of the information. Disagreement may arise from differences in the strength of scientific evidence, the way the problem is seen, defined and structured, and ambiguity about the relevance of the input and output variables. Experts are often uncertain about their own estimates and recognize an important degree of uncertainty inherent to the topic or issue at hand (Mumpower and Stewart, 1996). They also recognize that the constant renewal and self-correctiveness of science mean that the "facts" of today may, in the very near future, be regarded as the flaws of yesterday (Shanteau, 2000; Shapin, 1992).

Handling a scientific conflict and differentiating between more and less valid scientific claims in order to make well-informed decisions, requires an understanding of the underlying cause for the conflict (Barzilai and Ka'adan, 2017; Barzilai et al., 2020; Thomm et al., 2017). Therefore, knowing why and how experts may disagree is a pre-requisite for effective handling of information. Previous research has suggested that next to informing the public about what scientists know, it is equally as important to educate lay people about what scientists do and what their role is in knowledge construction (Shapin, 1992; Thomm et al., 2017). However, there is a gap in existing frameworks to understand the range of reasons for these contradictions. Creating such a framework or taxonomy would assist in supporting people in navigating these conflicts. A more accurate understanding of the role science and scientists play in the construction of knowledge will allow people to appreciate why experts may disagree about some topics and express certainty and unanimity over others. Therefore, this second study aims to develop an overview of causes for expert disagreement in a health context

and aims to explore expert's perspectives on the use of a taxonomy of disagreement in supporting people with handling conflicting information.

To address these aims, a taxonomy of disagreements was developed. The initial conceptualization was grounded in the literature; this includes (a) literature that directly or indirectly conceptualized scientific disagreements, (b) a set of studies presenting conflicting information to consumers, investigating their perception and explanations for the nature of those conflicts, and (c) a conceptual analysis of disagreements in a set of nutrition topics. Furthermore, to support the taxonomy building and evaluation process, semi-structured interviews with experts were conducted to collect their views on the concept of expert disagreement (Nickerson et al., 2013).

The taxonomy presented in this second study aims to list and classify possible causes for disagreement and suggests a terminology to use in the communication about disagreement. As such, it provides researchers with a framework and terminology to use in future research. In addition, we propose the taxonomy may be used to inform practice. For communicators (those on the providing end of a message), it can help them framing their message so that it assists people in the evaluation of the source and the information itself and promote more effective science communication efforts (Simis et al., 2016). For those on the receiving end of a message, it may support the handling of conflicting information. The characteristics in this taxonomy may help by raising awareness about what scientists do, how that informs knowledge and the normalcy of expert disagreement. Such awareness may result in more advanced epistemic beliefs, i.e., the belief that knowledge is uncertain and dynamic, and that knowing requires justification, e.g., cross-corroboration between multiple sources. Epistemic beliefs are thought to play an important role in the way people process information and handle conflict (Ferguson, 2015; Knight et al., 2017; Ferguson et al., 2013; Kienhues et al., 2016). Those with more adaptive beliefs are expected to be less likely to discredit health advice or science in general and being less likely to ignore the information but instead actively engage with the information on both sides of the disagreement to come to well-informed decision-making (Ferguson, 2015; Stadtler and Bromme, 2007; Rogers and Gould, 2015). Next to a) raising awareness of the normalcy of expert disagreement, it may help people with b) explaining disagreement, and c) conflict resolution.

In conclusion, we propose that when evaluating multiple sources, beliefs regarding the epistemic and social practices of science play a crucial role. This taxonomy aims to help increase the understanding of these practices and sheds light on the role experts play in knowledge construction. By increasing people's awareness and understanding of why and how experts may disagree, or may be perceived as disagreeing, they are expected to adopt better coping strategies to deal with conflicting information (Williams et al., 2023). Therefore, the third study in this thesis presents an experimental study where we test the effect of an intervention, which included the developed taxonomy of disagreements, on people's epistemic beliefs and performance on a multiple source integration task.

STUDY 3: EPISTEMIC BELIEFS AND PROCESSING CONFLICTING HEALTH AND NUTRITION INFORMATION: AN EXPERIMENT.

As mentioned, research in educational psychology has proposed that having more or less adaptive epistemic beliefs could explain one's ability to integrate and comprehend conflicting information (Anmarkrud et al., 2014; Barzilai and Ka'adan, 2017; Bråten et al., 2011; Ferguson, 2015; Kienhues et al., 2016). In addition, it has been suggested that epistemic beliefs can change over time and may be changed through reflection about the epistemic implications of multiple conflicting information sources (Ferguson, 2015). However, few studies have investigated the impact of short-term text-based interventions to raise meta-cognitive awareness of these beliefs in people (Barzilai et al., 2020; Rogers and Gould, 2015).

This study aims to explore a) the potential associations between people's beliefs about knowledge and reasons for scientific disagreements as measured through psychometrically validated scales and their performance on a multiple source integration task, and b) the effect of an educational intervention on participants' beliefs and their capacity to deal with conflicting health information. In the intervention, participants were provided with information about the causes for expert disagreement, through the taxonomy developed in Study 2, and are guided through a multiple document processing task that encourages reflection on the epistemic implications of thought-provoking and conflicting written information.

An experiment is conducted in the form of an online study with pre, post and follow-up measurements. Participants are randomly assigned to one of three groups; guided, exposed or control. The participants are provided with a set of documents with different viewpoints on a nutrition topic. They are asked to read the information and write a health behaviour recommendation, including a justification for that recommendation. The content in these answers is analysed and scored for several qualitative measures assessing the multiple document processing performance. A questionnaire collects socio-demographic information and assesses co-variables such as topic familiarity and involvement. A questionnaire also measures epistemic beliefs and beliefs about scientific disputes through validated scales and measures self-efficacy to deal with multiple information sources, and intention to engage in health behaviours. Within and between group differences are investigated and the implications for the potential role of such a novel intervention method to improve one's ability to handle conflicting health information are discussed.

Table 1 presents an overview of the three studies that were conducted in the context of the present thesis, and shortly describes the studies' aim, research questions and design.

Table 1. The three studies conducted in the context of the present thesis

Study	Aim	Research questions	Design
Study 1	To improve the understanding of the phenomenon "conflicting health information", the study aims to develop a conceptual framework for the processing of conflicting health information.	1) How can we conceptualise conflicting health information?" 1a) What factors influence the process? And how can we classify them? 1b) Which factors can be modified to support the handling of conflicting health information?	Viewing the literature as the object of inquiry, a Critical Interpretative synthesis is conducted: • Synthesising quantitative and qualitative empirical evidence and theoretical work • Integrating concepts from multiple disciplines • Using both induction and interpretation to develop a synthesising argument
Study 2	To improve the understanding of expert disagreement, the study aims to develop a taxonomy of disagreements as conceptualised through experts, presenting an overview of the range of possible causes for expert disagreements.	1) What are the causes for expert disagreement? 2) What are experts' perspectives on the use of a taxonomy of disagreement in supporting people with handling conflicting information?	A rigorous method for systematically developing taxonomies was used (Nickerson et al., 2013) • an iterative approach integrating conceptual and empirical evidence • Including a conceptual and an empirical part: 1. Initial conceptualisation grounded in literature 2. Semi-structured interviews with experts were conducted to examine and evaluate the conceptual model
Study 3	Through the collection of empirical data, part 1 aims to shed light on people's epistemic and reasons for disagreement (conflict explanations) beliefs and how they associate with their performance on a multiple document processing (MDP) task. Through the conduct of an experiment, part 2 aims to provide information about the role of a multiple source processing task based on a taxonomy of disagreements as a novel intervention method.	Part 1: Associations with MDP task performance *1)* Do participants with more adequate epistemic beliefs perform better on a MDP task? *2)* Are there significant associations between participants' task performance and a) their prior beliefs and involvement with the topic and b) the time they spend on the task? 3) Are there significant associations between conflict explanations and epistemic beliefs? 4) Are there significant associations between participants' epistemic beliefs, task performance and information literacy self-efficacy? Part 2: Exploring the effect of an educational intervention 1) Are participants' epistemic beliefs different after the intervention as compared to before? And are there differences between the experimental conditions? 2) Are there differences between the experimental conditions in terms of performance on the MDP task? 3) Are there differences between the experimental conditions in terms of the reasons for disagreement people indicate? 4) Are there differences between the experimental conditions in terms of self-reported information literacy self-efficacy? 5) Are participants' intentions to engage in healthy lifestyle behaviours different after the intervention as compared to before? And are there differences between the experimental conditions?	• A mixed methods approach, including quantitative (i.e., psychometrically validated scales) and qualitative (i.e., MDP task performance measures based on content analysis) data • A 3 x 3 design was used with experimental condition (guided, exposed and control) as between-subjects factor and time (pre, post, and follow-up) as within-subjects factor • Study sample: n=150

2. An integrative literature review: A theoretical understanding of the processing of conflicting health information

2.1. Introductory paragraph to chapter 2

In this chapter a framework for the processing of conflicting health information is developed and a review of the literature on the phenomenon 'conflicting health information', its conceptualisation and the modelling of its processing is described. To synthesise the relevant knowledge, a Critical Interpretive Synthesis was conducted that aims to integrate the knowledge from differing fields of research, i.e., health communication, health literacy and health education and promotion on the one side, and the learning sciences and educational psychology on the other side. In addition, relevant insights from philosophy of science, the public understanding of science, and marketing and consumer behaviour are considered and integrated. The resulting framework aims to provide a structured, useful and practical classification of the factors that influence the perception, processing and consequences of conflicting health information.

A shortened and adapted version of this study has been prepared as a paper for publication in a scientific journal.

2.2. Study 1: Conflicting health information: An integrated approach to people's processing of conflicting information

Abstract

Increasingly, people need to navigate conflicting information to make decisions about their health. There is, however, a lack of theoretical understanding of the mechanisms that underlie the processing of conflicting health information. In the present study, a critical interpretive synthesis of the literature on the processing of conflicting health information is presented. An integrated model is described that adds to the literature and extends previous frameworks by bringing together theoretical conceptions about processing pathways and strategies from various disciplines, in addition to seeking to identify and categorise the determinants that influence the processing of conflicting health information, i.e., what pathway is taken and what strategies are used. To do so, literature from fields, other than the health sciences, including the learning sciences on epistemic cognition and diverging information is integrated in the literature on conflicting health information. An integrated framework is proposed that identifies stages, paths, strategies and determinants related to the processing of conflicting information and aims to improve its conceptual understanding. A useable structured presentation of the determinants is proposed. We identify modifiable characteristics of the source and individual and propose the importance of people's beliefs about knowledge, how knowledge is constructed, and why and how experts may disagree with one another, and why conflicting information may arise. Lastly, we describe the implications of our framework and how this may inform further research and practice. We suggest that when people are aware why conflicting information may exist, understand how experts may disagree, and understand that this is a normal aspect of science, they are more likely to accept the conflict and engage in elaborative processing of the information to come to decision making based on a balanced mental model of the controversy.

2.2.1. Introduction

Developments in technology have led to changes in exposure to information; the rise of the internet has made an enormous amount of information available and accessible at any time for many of us. The increased access to scientific information can allow individuals to self-educate and consequently support them in their decision-making, for example, regarding health and nutrition issues. However, often, sources have differing, or even conflicting views. Therefore, careful consideration and evaluation of the information are essential (Andreassen et al., 2007; Bromme et al., 2015; Scharrer et al., 2019). The skill needed for dealing with complex information does not come intuitively (Ferguson, 2015). Therefore, educational intervention may be necessary to develop pre-requisite beliefs and skills for critical evaluation and integration of multiple perspectives and consequent effective and efficient processing of conflicting information (Greene and Seung, 2014). To develop

potential interventions to improve lay people's capacity to handle conflicting information, there is a need to understand the underlying mechanisms that play a role in the processing of conflicting information. In the present paper, we draw on research from various disciplines to propose a theoretical model of the processing of conflicting information in the health context.

Health information

The shift towards preventive health care and health promotion based on a better awareness of the link between lifestyle, health behaviours and health outcomes, the shift in the medical world towards more shared decision making, together with the increased availability and accessibility of health information, result in overall increased exposure and handling of health information by lay people.

Although moderated by other factors, information we encounter affects us; for example, higher potential exposure to news articles with an anti-sun protection or ambiguous message can be associated with increased pro-tan attitudes and lower perceived susceptibility to skin cancer (Dixon et al., 2014), exposure to anti-vaccination conspiracy theories may reduce the likelihood of intent to vaccinate (Jolley and Douglas, 2014), and 'responsible drinking' campaigns may confuse the public that there is a cachet to be gained from drinking, and even from drinking a lot, if it's done 'properly' (Jones et al., 2017). These examples also show that information can come in different shapes and forms, examples include misinformation (unintentional false information), disinformation (intentional false information), uncertain, ambiguous, and conflicting information.

Misinformation in health contexts has been defined as acceptance of false or (scientifically) inaccurate data as useful (a) despite exposure to (scientifically) accurate data, (b) in the absence of accurate data or messages to the contrary, or/and (c) within historical or contextual legacies (Krishna and Thompson, 2021). While health misinformation is very prevalent and thus a relevant concept for investigation (for a recent review on misinformation about health see (Krishna and Thompson, 2021), in the present paper, the focus is on conflicting information. This means that rather than examining the causes and effects of incorrect information, we wish to investigate the scenario where one is exposed to multiple information sources that provide, or are perceived as, conflicting information. Whether the conflict is caused by either one or more of the sources containing inaccurate information is thus a possibility but not a requirement. Similarly, ambiguous and uncertain information could be possible causes for the perceived conflict.

Conflicting health information

An increasing amount of evidence shows the presence of conflicting health information; for example, 51.3% of 228 vasculitis patients reported to receive conflicting medication information (Carpenter et al., 2010) going up to more than 80% of patients in a study on rheumatoid arthritis medication (Carpenter et al., 2014). In a US study by Nagler et al. (2019a) , content analyses suggested that about 55% of content in TV news coverage of mammography screening recommendations described

conflict or controversy surrounding the recommendations; in 45% of the stories, the reporter or anchor mentioned conflict or controversy explicitly, and 36% referenced conflict across professional organisations' recommendations. In addition, 50-75% of patients and providers perceive conflicting information about cancer-screening guidelines (Han et al., 2011). Regarding health and nutrition, 72% of US adults reported medium to high exposure to conflicting nutrition information about alcohol, fish, coffee, and vitamin supplements (Nagler, 2014). In a study in the UK, 42.7% of participants reported a little, 26.5% some and 13.3% a lot of exposure to conflicting nutritional information in the past 12 months (Vijaykumar et al., 2021b). In 2020, nearly 75% of participants in a US study reported having recently heard conflicting information about COVID-19 (Nagler et al., 2020).

Some empirical studies have investigated the effects of such exposure to conflicting health information, and pointed to several adverse outcomes such as confusion (Nagler, 2014), media scepticism and loss of confidence in scientific research's credibility (Vardeman and Aldoory, 2008; Wu and Ahn, 2010; Chang, 2015), decision-paralysis (Carpenter et al., 2016; Samuelson and Zeckhauser, 1988), and people being less likely to engage in health behaviours (Naylor et al., 2009; Chang, 2015), including those that are independent of the target conflicting information (Lee et al., 2018; Nagler, 2014; Nagler et al., 2021). The processing of conflicting health information has been investigated (Nagler, 2014; Nagler et al., 2021), however, few have aimed to conceptualise the process (Carpenter et al., 2016). Recently, Carpenter and Han (2020) proposed a definition of the concept *conflicting health information* and identified and re-emphasized a critical research need for a theoretical model for understanding the antecedents, processing and effects of conflicting health information

In sum, there is a burgeoning amount of evidence on the presence of conflicting health information and a consensus that the perception of conflicting health information can have adverse effects which may go beyond the current issue and carry over to other topics, perceptions, beliefs and behaviours. However, despite this awareness, very little theoretical knowledge exists on the underlying causes and effects, and the factors that determine the process.

Processing multiple conflicting health information sources

We imagine a scenario where one is passively exposed or where one actively searches for documented (rather than e.g., verbal information from family/friend or medical professional) health information (e.g., on the internet) to answer a health information need, such as "Should I consume a Mediterranean diet?", "Should I drink wine?", "Should I get a mammogram?", "Should I take vitamin supplements?". In these exemplar scenarios, one would encounter a variety of conflicting advice and claims, often presented as scientific or expert information.

In the learning sciences and the public understanding of science, it has been suggested that people react to conflicting scientific claims and information in different ways (Ferguson, 2015; Ferguson et

al., 2013; Gottschling et al., 2019; Hendriks et al., 2020). While for some the perception of conflict is associated with adverse outcomes (such as emotional distress and information avoidance), for others it seems to be a positive nudge and a trigger for more goal-directed and effortful engagement with the information (Hendriks et al., 2020; Stadtler and Bromme, 2014).

Relevant viewpoints on this matter come from information processing and multiple document processing within the field of education. When it comes to theoretical modelling of the processing of conflicting information, major contributions come from models such as the Knowledge Revision Components framework (Kendeou and O'Brien, 2014), the Content-source-integration model (Stadtler and Bromme, 2014) and the Two step validation model (Richter and Maier, 2017), together with models from the literature around epistemic cognition and multiple source integration such as the integrated model of epistemic beliefs and multiple-document processing (Anmarkrud et al., 2014; Bråten et al., 2011; Ferguson, 2015; List and Alexander, 2017). However, there is a gap in the literature in terms of the application and integration of these models in the conflicting health information context.

Aim

In sum, existing theories and findings from multiple fields of inquiry provide useful lenses for the understanding of the processing of conflicting information, however synthesis, integration and application of those insights into the phenomenon of conflicting health information is currently lacking (Carpenter and Han, 2020). In the present paper, we attempt to make a first step in the development of such a theoretical understanding of the processing of conflicting health information. Our objective regarding the understanding of the process aims to provide an overview of the constructs involved, i.e., a framework to conceptualise conflicting health information. There is a need for a useable model of the determinants involved in the process that provides a structure which can be used by a wide range of researchers and practitioners. Then, we discuss the process through the lens of potential intervention from both the supply-side (the information provider) and the demand-side (the information receiver). Consequently, we identify those determinants within the individual that are modifiable and may be improved through intervention, and those determinants of the source that could be considered by communicators. Implications for health communication and health education are discussed.

2.2.2. The present study

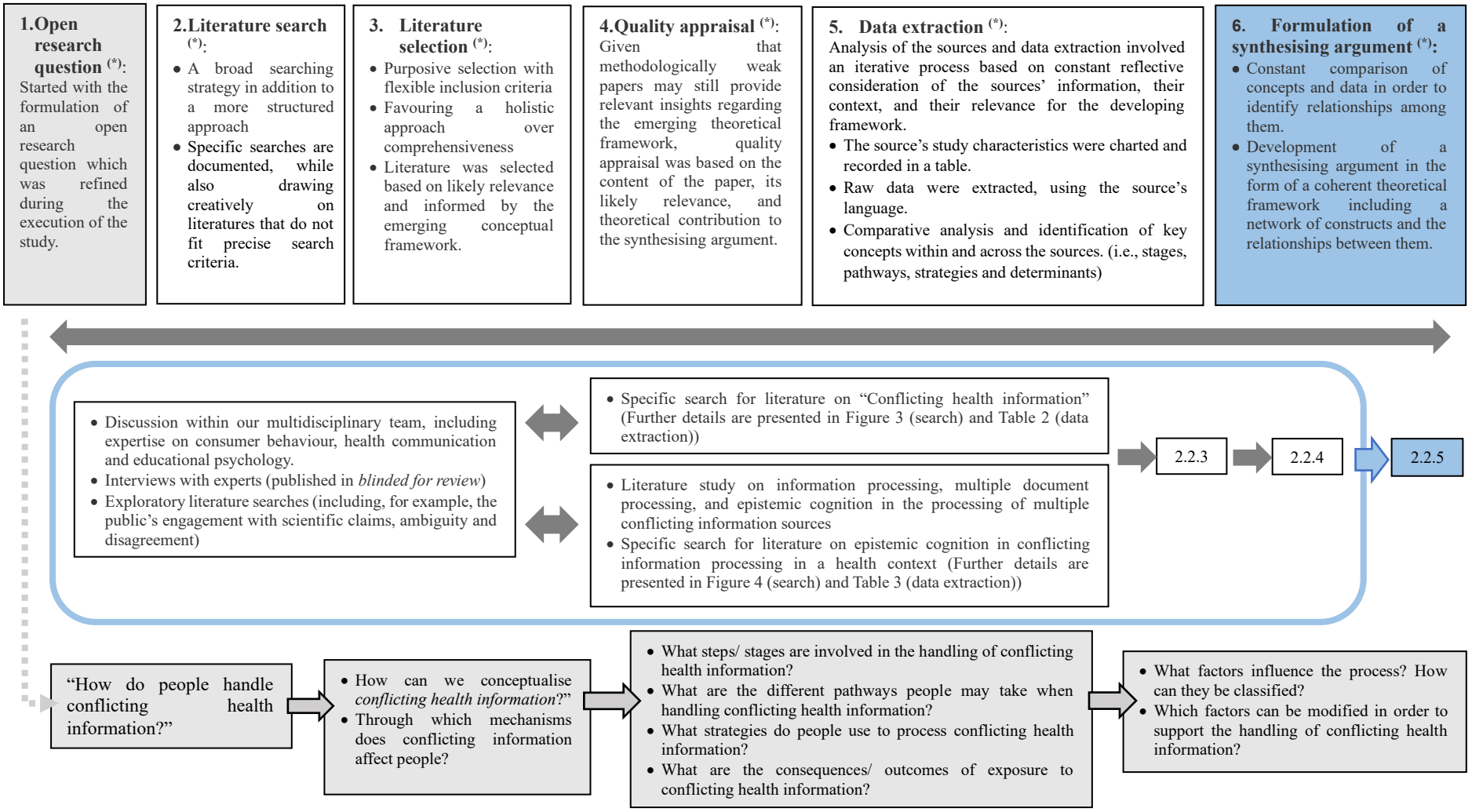
Theory development and literature review: The selection of a vehicle for knowledge synthesis

The model described in this paper addressed the open research question “How do people handle conflicting health information?” through analysis of relevant literature across fields. To help people

process conflicting information when making important health decisions, a range of stakeholders (e.g., researchers, policy makers, industry bodies) would benefit from understanding the mechanisms by which conflicting information affects people and the strategies they typically use to process it. The development of such understanding requires integration and interpretation of information from different disciplines, fields and topics. The specific information from different fields that is relevant to the present study can differ in nature. For example, literature on information processing may describe processing mechanisms that would also be relevant in the scenario of multiple conflicting information sources. In addition, literature on the public understanding of science may identify determinants that influence the way people engage with claims that are relevant to the way they process conflicting health information. However, the parts of information of relevance for the present study have differing characteristics and cannot easily be found by the same set of well-defined and pre-defined inclusion criteria. Furthermore, rather than adjudicating, i.e., producing *settled science* and eliminating error, the aim of the present research is to use a more holistic view in order to gain a better understanding of a phenomenon and promote new insights and the emergence of new kinds of research (Cronin and George, 2023; Turner et al., 2017). Therefore, rather than applying an aggregative, highly systematic review methodology, the present study aims to be a synthesis of empirical (qualitative and quantitative) and theoretical work, as well as to offer an integration of concepts from multiple disciplines.

The critical interpretative synthesis (CIS) specifically acknowledges the relevance of adjacent literatures. Moreover, the CIS also aligns with our present aim to build theory through synthesis that involves both induction and interpretation, viewing the literature as an object of inquiry (Dixon-Woods et al., 2006). The voice of the author, as well as the need for flexibility in CIS, are explicitly acknowledged, fuel the development of the emerging theoretical framework, and guide the search for all types of evidence (Dixon-Woods et al., 2006; Schick-Makaroff et al., 2016). **Figure 2** presents an overview of the methods used in the development of the framework based on the CIS methodology as described by Dixon-Woods et al. (2006) and Depraetere et al. (2020).

Figure 2. Development of the framework using techniques and concepts from the Critical Interpretive Synthesis



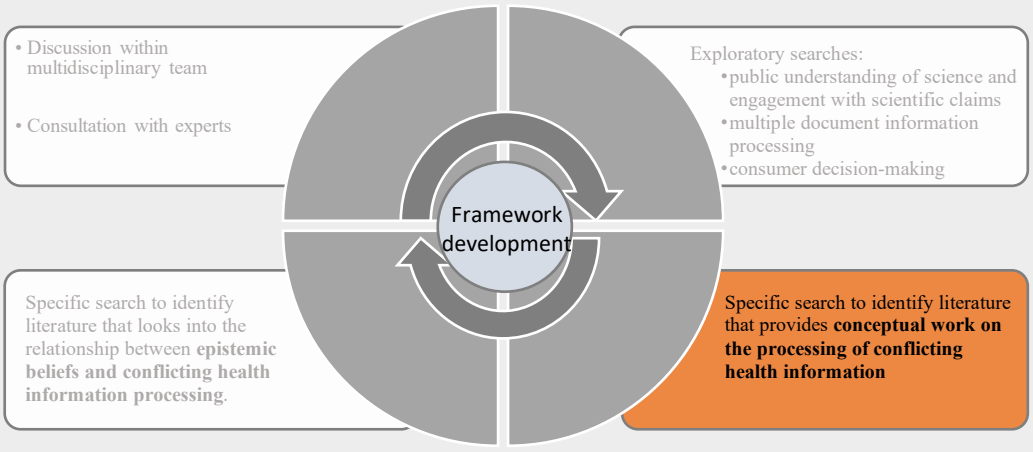
Note:
(*) Based on the six general activities in the dynamic process of the Critical Interpretive Synthesis as described in the methodological work by Dixon-Woods et al., 2005 and the recommendations for reporting practices by Depraetere et al., 2021.

Searching the literature

Exploratory searches were conducted to get an idea of the amount and type of literature existing on this topic. Searches were performed all along the development of the framework, the last searches were conducted in August 2022. We searched different combinations of *(conflicting OR contradicting OR diverging OR two-sided OR inconsistent) AND (health OR medical OR nutrition) AND (information OR advice OR message OR news OR research) (no time limitations)* in three electronic databases; Web of Science (45), PsycInfo (22) and Ovid Medline (223). We also conducted a search in a search engine: Google Scholar (372). To identify a manageable yet comprehensive amount of literature, we performed a specific search *"conflicting health information" (no time limitations),* and to increase sensitivity, the Google Scholar search was conducted in all fields as well. Google Scholar is a multidisciplinary compendium of scientific world knowledge with excellent coverage (Gusenbauer, 2019; Gusenbauer and Haddaway, 2020; Martín-Martín et al., 2021). While Google scholar is not ideal for systematic searching (Martín-Martín et al., 2021), we found that for this literature search, Google Scholar's search result was most comprehensive, and proved useful for our aim to find multidisciplinary literature of all types, e.g., quantitative, qualitative, conceptual, dissertations and theses. Duplicates were removed and sources with a retrievable full text in English which provide information on exposure to, processing of, or what to do about conflicting health information were selected. Further reference chaining was conducted, and a total of 185 sources that provide information on the processing of conflicting health information were identified. The graph in **Figure 3** shows the growing research interest in this topic over time. The sources were further analysed to identify conceptual work on the processing of conflicting health information. In that process, it was noted that almost all empirical studies mentioned a theory, model or framework that they used to design their study. Particularly interesting is that almost all studies used a different model, examples include dual processing models (such as the elaboration likelihood model), the uncertainty management theory, and the health belief model. As such, these conceptual models reflect the assumptions (research questions and hypotheses) of the researchers and have the goal to serve as a structure to build a study that answers a specific research question. None of these models is necessarily more or less "correct", but all are simplified abstractions that serve a specific purpose. This observation suggests a need for a more general framework to conceptualise the phenomenon *conflicting health information*. In a similar fashion, others have identified the need for a conceptualisation of uncertainty in health care and aimed to address that gap through the development of an overarching orienting framework (Han et al., 2019), while recognizing the need for such work on the concept of conflicting health information (Carpenter et al., 2016; Han et al., 2019). Our literature study confirms this gap in the literature and demand for a more holistic view, an integrated framework, that aims to develop a better understanding of the overall concept of "conflicting health information" to assist both research and practice.

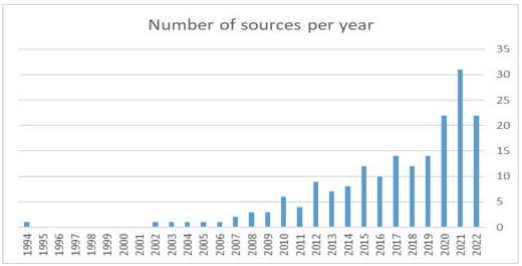
While providing much relevant information, usually on a particular selection of determinants and strategies involved in the handling of conflicting health information, the initial search was considered unsatisfactory in terms of answering the question how conflicting health information is processed, and a need to look at information processing beyond the health context was identified. In the further search for literature, we found that in addition to literature in health communication investigating cognitive and behavioural outcomes related to specific conflicting health information exposure and the effect of differing levels of health literacy (e.g., Chang, 2015; Lee et al., 2018), relevant information may come from: models for information processing from decision making theory and artificial intelligence (e.g., Benferhat et al., 2004); literature in education investigating multiple document processing (e.g., Barzilai et al., 2018); literature in educational psychology investigating the role of metacognition in information processing (e.g., Bråten et al. (2011)) and the specific contribution of perceived conflict in such processing (e.g., Ferguson et al., 2013); and literature on the public understanding of science investigating the public's engagement with scientific claims (e.g., Hendriks et al., 2020), ambiguity (Dieckmann et al., 2017a; Dieckmann et al., 2015) and disagreement (Thomm et al., 2017; Thomm et al., 2015), their level of science literacy and its' association with information- and media literacy in a context of conflict (e.g., Jensen and Hurley, 2012). Furthermore, theoretical models used in marketing and consumer behaviour research to explain consumers' decision making (e.g., Hibbard and Peters, 2003) may provide insights in individual traits, and situational and contextual characteristics that determine the process of handling conflicting information. Given the importance of epistemic cognition in multiple document processing identified in educational psychology, an additional specific search was conducted to see whether this concept of epistemic cognition had also been investigated in the health context and how this was done. In OVID Medline (39), PsycInfo (34) and Web of Science (65), the following search was conducted *(epistem*) AND (information AND (conflict* OR contradict* OR diverg*) AND health) (all fields).* Here, further hand searching and reference chaining proved more useful than a *Google Scholar* search as the topic (health) used in the information processing literature is hard to identify through such search. Purposive and ongoing selection of the literature was informed by the emerging conceptual framework. **Figures 2, 3 and 4** present an overview of the methods used in our search for literature.

Figure 3. Search strategy for literature on the processing of conflicting health information



- Searches were performed all along the development of the framework, the last searches were conducted in August 2022.
- We searched different combinations of *(conflicting OR contradicting OR diverging OR two-sided OR inconsistent) AND (health OR medical OR nutrition) AND (information OR advice OR message OR news OR research)* in three electronic databases; Web of Science (45), PsycInfo (22) and Ovid Medline (223).
- We also conducted a search in a search engine: Google Scholar (372). To identify a manageable yet comprehensive amount of literature, we performed a specific search *"conflicting health information" (no time limitations),* and to increase sensitivity, the Google Scholar search was conducted in all fields as well. Google Scholar is a multidisciplinary compendium of scientific world knowledge with excellent coverage (Gusenbauer, 2019; Gusenbauer and Haddaway, 2020; Martín-Martín et al., 2021). While Google scholar is not ideal for systematic searching (Martín-Martín et al., 2021), we found that for this literature search, Google Scholar's search result was most comprehensive, and proved useful for our aim to find multidisciplinary literature of all types, e.g., quantitative, qualitative, conceptual, dissertations and theses.
- Duplicates were removed and sources with a retrievable full text in English which provide information on exposure to, processing of, or what to do about conflicting health information were selected.
- Further reference chaining and hand searching were conducted.

- A total of N=185 on *conflicting health information* were identified
- Most sources are from Health Communication literature.
- The graph presents the growing research interest in this topic over time.



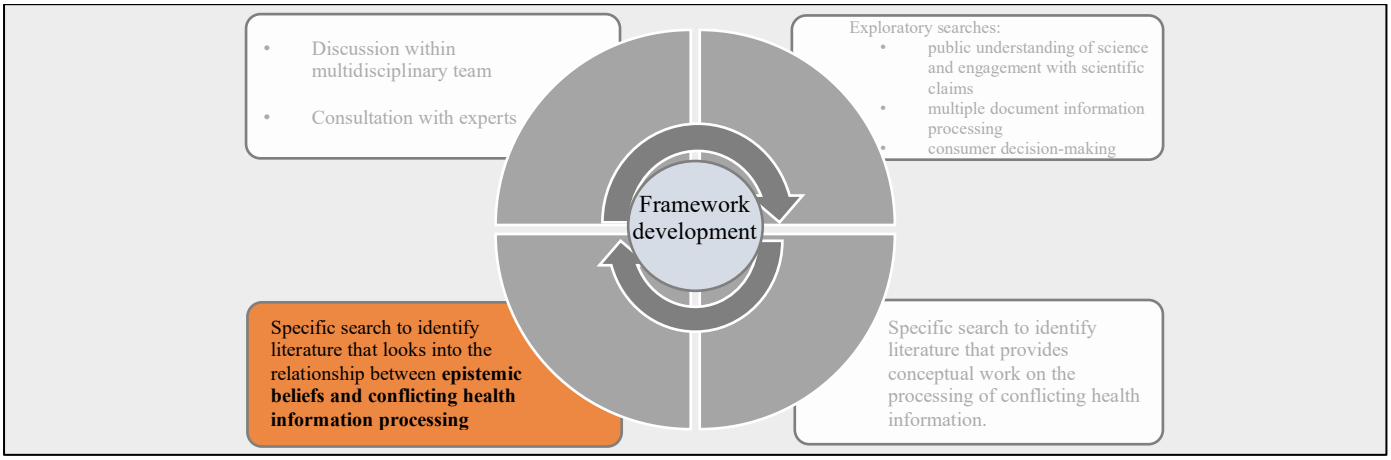
Note: N=185 (last search was performed on 12AUG22)

- Given our interest in *conceptual* contributions that allow us to better understand the processing of conflicting health information, we further screened the sources for such works.
- Further analysis identified n=10 sources with conceptual work on conflicting health information processing. In addition, n=2 sources on uncertain information and n=5 on the processing of health information (without the focus on conflicting information) were selected because they discuss concepts and processes relevant to the processing of conflicting health information.
- Study details and summary findings of the n=17 selected sources are provided in **Table 2.**

References:

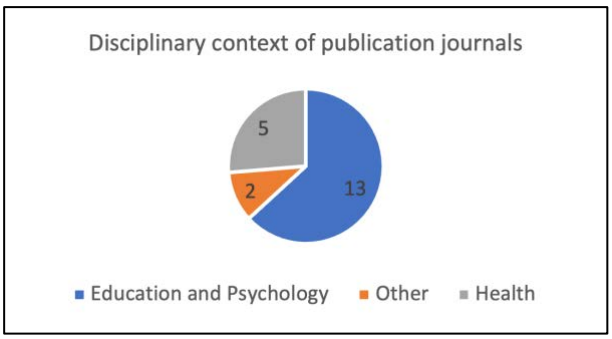
Gusenbauer M (2019) Google Scholar to overshadow them all? Comparing the sizes of 12 academic search engines and bibliographic databases. *Scientometrics* 118(1): 177-214.; Gusenbauer M and Haddaway NR (2020) Which academic search systems are suitable for systematic reviews or meta-analyses? Evaluating retrieval qualities of Google Scholar, PubMed, and 26 other resources. *Research synthesis methods* 11(2): 181-217.; Martín-Martín A, Thelwall M, Orduna-Malea E, et al. (2021) Google Scholar, Microsoft Academic, Scopus, Dimensions, Web of Science, and OpenCitations' COCI: a multidisciplinary comparison of coverage via citations. *Scientometrics* 126(1): 871-906.

Figure 4. Search strategy for literature considering epistemic cognition in the processing of conflicting health information.



- Searches were performed all along the development of the framework, the last searches were conducted in August 2022.
- In OVID Medline (39), PsycInfo (34) and Web of Science (65), the following search was conducted *(epistem*) AND (information AND (conflict* OR contradict* OR diverg*) AND health).*
- Duplicates were removed and sources with a retrievable full text in English which provide information on the role of epistemic beliefs in the handling of conflicting health information were selected.
- Here, further hand searching and reference chaining proved more useful than a Google Scholar search as the topic (health) used in the information processing literature is hard to identify through such search.

- A total of N=20 sources that consider epistemic cognition in conflicting information processing in a health context were identified.
- The graph presents the disciplinary context of the identified sources and shows that most sources are from education and psychology literature.



- We identified n=5 sources that provide information on the influence of conflicting health information on epistemic beliefs
- N=11 sources provide information on the role of epistemic beliefs in the processing of conflicting health information
- N=4 sources present experiments on effect of manipulation of epistemic beliefs on handling of conflicting health information
- Study details and summary findings (n=20) are provided in **Table 3.**

Analysis and reporting of the findings

The development of a conceptual framework starts with analysis of the literature sources and identification of relevant concepts, including the identification of recurring themes. This involves an iterative process where themes and concepts are constantly compared and analysed within their context to identify relationships among them with the aim to develop a synthesis argument (Depraetere et al., 2020; Dixon-Woods et al., 2006). Relevant literature sources were listed in an Excel sheet, data relevant for narrative synthesis of the literature were charted, and systematic data extraction was performed for those sources that provided conceptual work on the processing of conflicting health information (as reported in Table 1) and those that investigated epistemic cognition in the context of conflicting health information (as reported in Table 2). In section 2.2.3, we aim to report on the key themes and concepts identified in the selected literature sources and adopt a critical and reflexive approach to the literature and its relevance to the development of an understanding of how conflicting health information is processed. Then in section 2.2.4, we aim to integrate the evidence from across the reviewed studies into a coherent theoretical framework with a network of constructs and showing the relationships between them (Dixon-Woods et al., 2006). In our analysis, we identified multiple stages in the processing of conflicting information, differing pathways and strategies people may take or use when they handle conflicting information, and a variety of determinants that influence which pathways and strategies apply. Consequently, section 2.2.5 presents a synthesising argument with the function to provide more insightful, formalised, and generalisable ways of understanding the phenomenon (Dixon-Woods et al., 2006), i.e., a framework that describes the stages, pathways, strategies and determinants in a structured way.

In sum, the present study aims to develop a theory beyond merely reviewing the literature given the emphasis and explicit acknowledgement of the authors' interpretation of and inferences made based on what is not explicit in existing research. Using Daan Van Knippenberg's metaphor in Cronin and George (2023), with the description of the framework in the present paper, while grounded in the literature, we aim to provide *a blueprint* (i.e., useable framework) *for houses that could be built* (e.g., further testing and refining of the model and its applicability in research and practice) *rather than just reporting on houses that already exist* (a pure literature review).

2.2.3. Findings of the literature review

Conceptual work on conflicting health information

We identified 10 papers that present conceptual work on the *processing of conflicting health information*. Three reviews discuss the definition of conflicting health information and identify four dimensions in which a conflict may be presented (Carpenter et al., 2016; Carpenter and Han, 2020;

Yoon et al., 2017). In the other papers, quantitative (Chang, 2015; Li et al., 2020; Nagler, 2014; Nagler et al., 2021; Zimbres et al., 2021) and qualitative (Ong, 2018; Wu and Ahn, 2010) empirical work discusses concepts such as motivated processing (Chang, 2015), cognitive dissonance (Ong, 2018), uncertainty discrepancy (Li et al., 2020), nutritional backlash (Nagler, 2014), and carry-over effects (Nagler et al., 2021) relevant in the processing of conflicting health information. The idea that one goes through several stages or phases in the process was suggested by a few (Li et al., 2020; Ong, 2018; Wu and Ahn, 2010; Zimbres et al., 2021), although the particular elaboration of those differed. The influence of some individual and source factors on the process was suggested, in particular, the perceived salience of the information (Carpenter et al., 2016; Li et al., 2020; Yoon et al., 2017) and one's perceived self-efficacy (Li et al., 2020; Zimbres et al., 2021)

In addition, we identified 5 papers that presented conceptual work on the processing of health information in general, and 2 on uncertain health information, which provide elements that are relevant for *conflicting* health information and are considered in the general development of the framework. An overview of the papers, including a summary of their conceptual contribution is provided in **Table 2**.

Table 2. Literature providing conceptual work relevant to the processing of conflicting health information.

Processing conflicting health information (n=10)			
Reference	Study aim	Study type	Conceptual contribution

Carpenter, D. M., Geryk, L. L., Chen, A. T., Nagler, R. H., Dieckmann, N. F., & Han, P. K. (2016). Conflicting health information: a critical research need. *Health Expectations*, *19*(6), 1173-1182.
 	
Carpenter, D. M., & Han, P. K. (2020). Conflicting health information. *The Wiley encyclopedia of health psychology*, 47-53.
	To propose a working definition for conflicting health information and describing a conceptual typology classifying 4 dimensions in which a conflict may be presented.	Viewpoint article	• definition of conflicting health information = two or more health-related propositions that are logically inconsistent with one another
			• Types of perceived conflict:
			  • absence of information
			  • decisional conflict
			  • informational conflict
			• 4 dimensions in which a conflict may be presented:
			  • the substantive issue under conflict
			  • the number of conflicting sources
			  • the degree of evidence heterogeneity
			  • the degree of temporal inconsistency
			• determinants mentioned:
			  • salience
			  • nature of the decision at hand
			  • background of the individual

Chang, C. (2015). Motivated processing: How people perceive news covering novel or contradictory health research findings. *Science Communication*, *37*(5), 602-634.	To examine responses to news stories that cover novel (vs. familiar) or contradictory (vs. one-sided) health research findings	Telephone survey + 2 experiments	• Both novel and contradictory news can generate negative consequences. • motivated processing explicates possible influences of news exposures on perceptions of both the focal issues and health research in general • Determinants: They identify novelty and contradiction as two prototypical biases that exemplify dramatization in health research coverage
Li, J. Y., Wen, J., Kim, J., & McKeever, R. (2020). Applying the Theory of Motivated Information Management to the Context of Conflicting Online Health Information: Implications for Childhood Vaccination Communication with Parents. *International Journal of Strategic Communication*, *14*(5), 330-347.	To apply the Theory of Motivated Information Management in online health communication contexts	Survey	the Theory of Motivated Information Management in online communication contexts (TMIM) predicts a person's uncertainty and information management through a three-phase process that individuals go through when evaluating whether to seek or avoid information about a challenging issue: • Interpretation: involves "uncertainty discrepancy," which refers to a difference between the amount of uncertainty that a person has about a challenging issue and the amount of gains that he/ she intends to realize from the issue (Afifi & Weiner, 2004). • Evaluation: when individuals evaluate the potential outcomes of information seeking (i.e., outcome expectancies) and their perceived self-efficacy to execute such an information search (Afifi & Weiner, 2004). That is, people weigh a decision about whether to seek additional information based on two general considerations: 1) will the search outcome be positive or negative and 2) will the search outcome be too overwhelming to manage. Coping efficacy involves individuals' beliefs about whether they can cope with the information they discovered from seeking.

			• Decision: phase occurs after people pass through the interpretation and evaluation phases when deciding whether to engage in information (i.e., seek or avoid information) (Afifi & Weiner, 2004). TMIM posits that positive perceptions about information search outcomes and efficacy increase the likelihood of information-seeking behavior. Determinants: • perceived uncertainty; emotions (PANAS consists of 10 positive emotions (i.e., interested, alert, attentive, excited, enthusiastic, inspiring, proud, determined, strong, and active) and 10 negative emotions (i.e., distressed, upset, guilty, ashamed, hostile, irritable, nervous, jittery, scared, afraid, worried, and anxious).); outcome expectancies; communication efficacy; coping efficacy; target efficacy; info seeking; personal beliefs; issue salience

Nagler, R. H. (2014). Adverse outcomes associated with media exposure to contradictory nutrition messages. *Journal of health communication*, *19*(1), 24-40.	To investigate the extent to which people notice contradictory nutrition messages in the media.
	
	To evaluate whether such exposure is linked to potentially deleterious outcomes—specifically, nutrition confusion (defined as perceived ambiguity about nutrition recommendations and research), nutrition backlash (defined as negative beliefs about nutrition recommendations and research), and, ultimately, lower intentions to engage in recommended health behaviors (e.g., fruit/vegetable consumption, exercise).
		Survey	• Definition: contradictory health messages = messages that offer information about a single behavior producing two distinct outcomes
			• Outcomes of exposure to conflicting health information:
			  • confusion
			  • backlash
			  • intention to adhere to recommendations
			  • intention to adhere to recommendations about non-conflicting topics
			• Based on the decision theory concept of ambiguity (Ellsberg, 1961), they make a theoretical case for the relationships between the above constructs:
			  • Exposure to contradictory nutrition messages is positively associated with nutrition confusion, or perceived ambiguity about nutrition recommendations and research.
			  • Nutrition confusion is positively associated with nutrition backlash.
			  • There is an indirect path from contradictory message exposure to nutrition backlash through nutrition confusion
			  • Nutrition confusion is negatively associated with intentions to adhere to healthy lifestyle recommendations (e.g., fruit/vegetable consumption, exercise).
			  • Nutrition backlash is negatively associated with intentions to adhere to healthy lifestyle recommendations (e.g., fruit/vegetable consumption, exercise).
			  • There is an indirect path from nutrition confusion to behavioural intention through backlash.
			• Additional determinants (confounders)
			  - SES
			  - Generalised mistrust

Nagler, R. H., Vogel, R. I., Gollust, S. E., Yzer, M. C., & Rothman, A. J. (2022). Effects of prior exposure to	To test whether prior exposure to conflicting health information renders people less receptive to subsequent unrelated health messages about	longitudinal experiment with a three-wave, online,	• Carry-over effects of exposure to conflict on two dimensions of message receptivity: greater resistance to the unrelated ads and lower perceptions of the health behaviours featured in the ads.

conflicting health information on responses to subsequent unrelated health messages: Results from a population-based longitudinal experiment. *Annals of Behavioral Medicine*, *56*(5), 498-511.	behaviors for which the evidence is clear and consistent.	population-based survey	• Modelling indicated that carryover effects were a function of generalized backlash toward health recommendations and research elicited by prior exposure to conflicting information.

Ong, A. S. J. (2018). *Cognitive dissonance in food and nutrition: the development and initial efficacy test of the food cognition dissonance framework* (Doctoral dissertation, Newcastle University).	to address current gaps and critical issues underlying cognitive dissonance research in food and nutrition	focus group discussion
		
		Questionnaire
			• The Food Cognition Dissonance (FCD) conceptual framework: combi of basic cognitive dissonance process:
			  • cognitive dissonance paradigm(s)
			  • cognitive dissonance arousal: Dissonance (= affective motivational state) + cognitive discrepancy (= the cognitive inconsistency it produces)
			  • cognitive dissonance resolution
			  • cognitive discrepancy reduction
			• tri-partite model of attitude: = affect + behaviour + cognition
			• They then distinguish an inter- and intra-attitudinal structure

Wu, L., & Ahn, H. (2010). Making sense of conflicting health information: an exploratory study. *Proceedings of the American Society for Information Science and Technology*, *47*(1), 1-9.	to explore how people perceived the information, and how they resolved the perceived inconsistency in messages or inconsistency between their own belief and delivered information.	in-depth qualitative interviews	Possible pathways identified as responses toward conflicting tanning-related health info: Perception: • Inconsistency perceived: 1. Info in 2messages are contradictory, 2. Info contradicts personal belief • No inconsistency perceived Making sense of conflicting info: • Persisting in a personal belief • Cognitive negotiations to make justifications: 1. Tanning as a fringe benefit of outdoor activities, 2. Skin cancer as a long-term effect, 3. Skin cancer happens to others • Seeking more information • Staying in the middle ground • No influence

Yoon, H., Sohn, M., Choi, M., & Jung, M. (2017). Conflicting online health information and rational decision making: implication for cancer survivors. *The Health Care Manager*, *36*(2), 184-191.	To examine the background knowledge and the current phenomenon of why conflicting health information occurs in real-world conditions.
	To review causes and solutions for cancer survivors who cannot themselves be active in seeking health information.
		Narrative review	• 4 types of inconsistency in health info:
			  • kind of health issue
			  • extent of confusion is proportional to the nr of inconsistencies
			  • the reliability and public confidence of the info source
			  • more confusion is caused by synchronous inconsistency than by asynchronous
			• Two major predictors of information seeking are health-related sociodemographic characteristics (eg, demographics, personal experience, salience, and belief) and carrier factors. the information carrier factor includes various environmental factors from mass media such as the source of the information and the channel.
			• they also mention decisional vs informational conflict

Zimbres, T. M., Bell, R. A., Miller, L. M. S., & Zhang, J. (2021). When media health stories conflict: Test of the contradictory health information processing (CHIP) model. *Journal of Health Communication*, *26*(7), 460-472.	To test a model that explicates how uncertainty arising from contradictory health information is managed through information seeking, guided by Uncertainty Management Theory	online experiment	• Model identifies 5 stages:
			  • message characteristic (message contradiction)
			  • perceptual outcome (perceived contradiction)
			  • state of uncertainty (issue uncertainty will lead to decision uncertainty)
			  • appraisals and emotions (negative appraisals will lead to threat emotions)
			  • uncertainty management (info seeking intention)
			• Determinants:
			  • nutrition overload
			  • need for cognition
			  • intolerance for uncertainty
			  • cognitive outcome expectation
			  • emotional outcome expectation
			  • health self-efficacy

Uncertainty (n=2)			

Gustafson, A., & Rice, R. E. (2019). The effects of uncertainty frames in three science communication topics. *Science Communication*, *41*(6), 679-706.	To test the effects of four distinct uncertainty frame types on three outcomes across three science issues (climate change, GMO food labeling, machinery hazards)	Experiment	• 4 types of uncertainty:
			  Deficient uncertainty
			  technical uncertainty
			  scientific uncertainty
			  consensus uncertainty
			• 3 types of outcome:
			  claim belief
			  source credibility
			  behavioral intention
			• Determinants:
			  • prior issue position (attitude)
			  • deference to science
			  • ideology
			  • worldview
			  • issue contexts

Han, P. K., Babrow, A., Hillen, M. A., Gulbrandsen, P., Smets, E. M., & Ofstad, E. H. (2019). Uncertainty in health care: Towards a more systematic program of research. *Patient education and counseling*, *102*(10), 1756-1766.
 	
Han PK, Klein WM, Arora NK. Varieties of uncertainty
	To promote a more systematic approach to research on uncertainty in health care, and to explore promising starting points and future directions for this research.
	First, what exactly is uncertainty, and how does it originate? Second, how does uncertainty affect patients, clinicians, and other stakeholders? Third, how—and why—should we communicate uncertainty in health care?
		Literature review	• definition of uncertainty = a human epistemic state consisting of the conscious, metacognitive awareness of ignorance (Han et al., 2011)
			• a conceptual taxonomy that classified the varieties of uncertainty in health care according to three fundamental, independent dimensions:
			  • 1) source: 3 primary phenomena that give rise to uncertainty: probability, ambiguity, complexity
			  • 2) issue: the substantive outcomes, situations, or alternatives: scientific, practical, and personal
			  • 3) locus: the particular stakeholder(s) in whose minds uncertainty resides
			• Determinants:
			  • Stimulus characteristics

in health care: a conceptual taxonomy. Med Decis Making. 2011 Nov-Dec;31(6):828-38. doi: 10.1177/0272989x11393976. PMID: 22067431; PMCID: PMC3146626.			• Individual characteristics • Situational characteristics • Cultural factors • Social factors
Health information processing (n=5)			
Ashley, J. M., Hodgson, A., Sharma, S., & Nisker, J. (2015). Pregnant women's navigation of information on everyday household chemicals: phthalates as a case study. *BMC Pregnancy and Childbirth*, *15*(1), 1-11.	To investigate how pregnant women obtain, evaluate, and act on information regarding their pregnancy (particularly regarding phthalates in cosmetics and canned food liners).	semi-structured interviews	Development of a model on how pregnant women navigate information on everyday household chemicals. A model was developed from the relationship between themes that describes how pregnant women navigate the multiple sources of information available to them. It identifies 3 stages: • 1) evaluate strength of information source, • 2) Modification of the strength through 4 techniques which represents the appraising of information and the funneling of only the most significant information to the final stage of the model, • 3) Once a piece of information is deemed significant, they decide whether they actually can avoid an exposure and how they would do so.
Kim, J. N., Oh, Y. W., & Krishna, A. (2018). Justificatory information forefending in digital age: Self-sealing informational conviction of risky health behavior. *Health communication*, *33*(1), 85-93.	• To suggest a potential measure of justificatory information forefending in health controversies, and assess how justificatory information forefending relates to other health-related concepts (as antecedents or consequences). • To provide an extended picture of online health information behavior and guide the development of interventions to increase overall health literacy among the lay population.	Survey	• This study proposes the idea of justificatory information forefending, a cognitive process by which individuals accept information that confirms their pre-existing health beliefs (information approach), and reject information that is dissonant with their attitudes (information avoidance). • They suggest that approach and avoidance vary largely in the same direction (if approach increases, avoidance increases). • Determinants: • justificatory information forefending • internet self-efficacy • exposure to contradictory health info • current health efforts • current risky behaviours
Osimani, B. (2012). Risk information processing and rational ignoring in the health context. *The journal of socio-economics*, *41*(2), 169-179.	To adopt the normative model of the expected value of information in order to provide a framework that can explain health information-seeking behavior while also factoring in the anticipated emotional cost attached to information as an explanatory antecedent for seemingly irrational search behavior.	Theoretical account	An integrated model of health-risk information processing: suggest that information-seeking behavior is predicted by decision sensitivity to incoming information (indecision) *and* the perceived information disutility in emotional terms (anticipated emotional distress), rather than explained by the knowledge gap (epistemic uncertainty) alone. • contrary to the classical equation "information = uncertainty reduction", it seems that information tends to be avoided in certain contexts precisely because it is expected to increase rather than to decrease uncertainty. • Coping strategies: • Information avoidance. • Situation reappraisal.

			• Search for counterbalancing, reassuring information.
			• Determinants:
			  • Epistemic uncertainty
			  • Emotional uncertainty
			  • Decision-sensitivity
			  • self-efficacy
			  • choice delegation

Ramondt, S., & Ramírez, A. S. (2017). Fatalism and exposure to health information from the media: examining the evidence for causal influence. *Annals of the International Communication Association*, *41*(3-4), 298-320.	To review and synthesize the current state of the literature on the association between media exposure and fatalism, and the causal direction between them.	Literature review	• fatalism= predestination, pessimism, and attribution of one's health to luck. These three domains are all cognitive in nature. Fatalism is therefore seen as a set of beliefs, in which an individual has a situation-specific attitude towards a specific outcome. • 2 possible causal pathways: 1) fatalism may be a stable trait or set of beliefs that individuals are predisposed to and which produces selective exposure to health information. In the present study, we found minimal evidence for this pathway: only three studies examined this relationship from a perspective in which media exposure was the outcome, and of these, only one had significant effects. • 2) a set of malleable health beliefs, which can change based on external influences such as media exposure. Six of seven studies investigating the association between media exposure and fatalism using cross-sectional survey designs found a significant positive association, and this was true for a broad spectrum of mass media. None of the studies used a conflated measure of fatalism outside of information overload.

Wedderhoff, O. (2021). The daily dose of health information: A psychological view on the health information seeking process.	• to develop and evaluate a model of intention-building for a comprehensive or thorough search for health information, which includes relevant personality factors in the form of motivational dispositions and relevant skills in the form of emotion regulation competencies.
	• To investigate the impact of health (information) literacy on the preference of sources in the health information seeking process
	• To assess the phenomenon of selective exposure as a common bias in the step of evaluation and selection of relevant information
		Experiment	• The development of a model of info seeking that identifies 5 stages, influenced by both skills and personality traits:
			  • 1) health threat
			  • 2) intention building
			  Emotion regulation skills + Motivational disposition as personality trait
			  • 3) Choice of source(s)
			  Health literacy skills + intelligence as personality trait
			  • 4) Evaluation & selection of info
			  Health literacy skills + Motives and goals (to confirm the own subjective perception and to protect relevant parts of the self-image) as personality trait
			  • 5) Transfer into behaviour
			• Determinants:
			  • personality traits; intelligence; Motivational dispositions (approach and avoidance motivation); Goals; emotion regulation competencies; information skills; health information literacy; self-efficacy; characteristics of health information sources (i.e., expertise, personal interaction, and accessibility); selective exposure; risk perception

How people engage with information from multiple sources

Integration of information from different sources is informed by educational research on Multiple Text comprehension. A model that has enjoyed popularity in educational psychology to describe multiple-text comprehension, is the documents model by Britt and colleagues (Britt et al., 1999; Perfetti et al., 1999), which is based on the Construction-Integration model that was developed by Kintsch (Kintsch, 1988; Kintsch and Walter Kintsch, 1998) and was further extended by Rouet (2006) and Bråten et al. (2011). A visual presentation can be found in **Figure 5**. Stadtler and Bromme (2014) extended the model even further and applied it to the context of conflicting information. The model shows that the text base of each source is evaluated against one's prior knowledge to form a situational model of each source, i.e., an interpretation of what is described in the source. At the same time, the source information (e.g., author, journal, date, etc.) for each text is linked to the text content, so that the reader "knows" which source was putting what information forward. This connection between source and information for each of the texts is called the inter-text model. This inter-text model, together with the situational models of all texts involved, then constructs the mental model, i.e., an integrated mental representation of the situations described across the different texts (Bråten et al., 2011). A visual presentation can be found in **Figure 6**.

Several individual and situational determinants may influence these processes. An overview of individual characteristics relevant in multiple document literacy can be found in Anmarkrud et al. (2021). In particular, the beliefs the individual holds about knowledge and what it is to know may determine how one gains an integrated understanding of a complex issue that is represented in multiple sources. This resulted in efforts from several researchers to extend the models of text comprehension to include the individual's *epistemic beliefs* (Afflerbach et al., 2013; Alexander et al., 2012; Bråten et al., 2011; List and Alexander, 2019). **Table 3** presents background information on the definition, conceptualisation and labelling of epistemic beliefs.

Consequently, such models show that recognition and acknowledgement of conflicting information may cause epistemic doubt. Furthermore, depending on the individual's motivations, resolution strategies, and situational interest, the challenge of the exposure to conflicting information in multiple texts may encourage the individual to adapt and advance his or her beliefs (Bendixen and Rule, 2004; Bråten et al., 2014b; Ferguson and Bråten, 2013). This may then, in turn, lead to improved meta-cognition and more careful consideration of information, i.e., the construction of the situation model, the inter-text base, and the final mental model.

More specifically, some have suggested that certain epistemic beliefs influence the inter-text base, whereas others influence the mental model. Epistemic beliefs are beliefs about knowledge and knowing and are typically presented by four dimensions: certainty, simplicity, justification by authority, personal justification (Hofer and Pintrich, 1997). Bråten et al. (2011) found that the inter-

text base is mostly influenced by certainty and source beliefs, while the construction of the mental model is mostly influenced by simplicity and justification beliefs. The more philosophically inspired model by Greene et al. (2008) focuses on the justification beliefs and Ferguson et al. (2012) adds a third justification dimension; the need for justification through corroboration and integration of information across sources. Bråten et al. (2014a) found that the belief that there is a need for justification by multiple sources has both a direct and indirect effect on multiple-text comprehension. More specifically, this belief has an effect on process variables such as level of *effort*, *strategy use*, and *situational interest (topic involvement and salience of the information)*, which in turn influence multiple text comprehension (Bråten et al., 2014a; Ferguson, 2015).

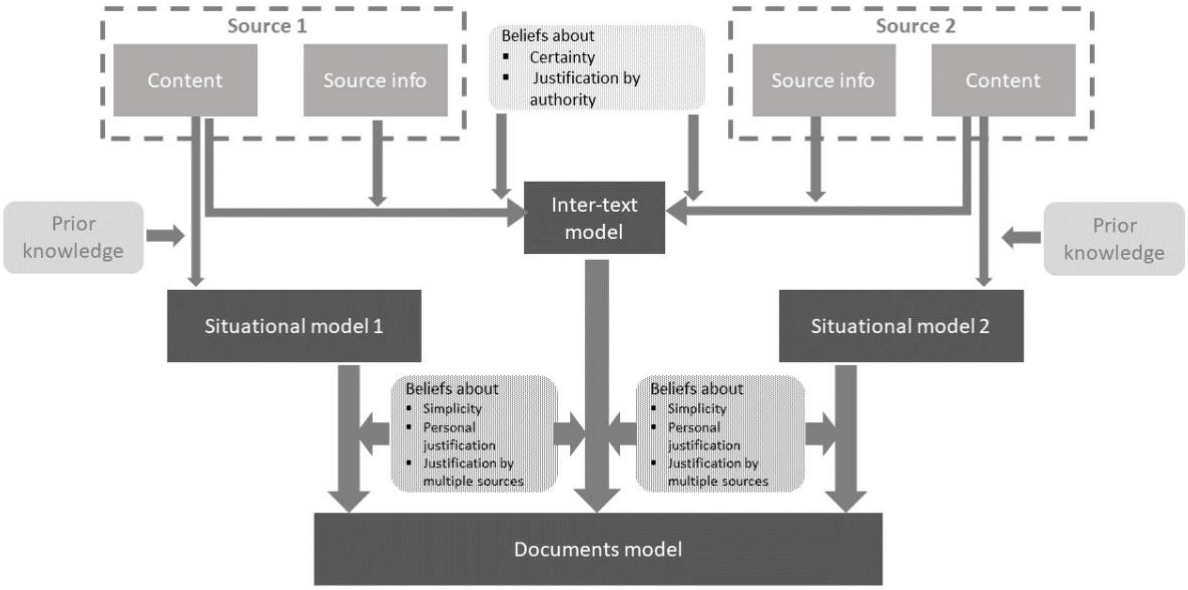
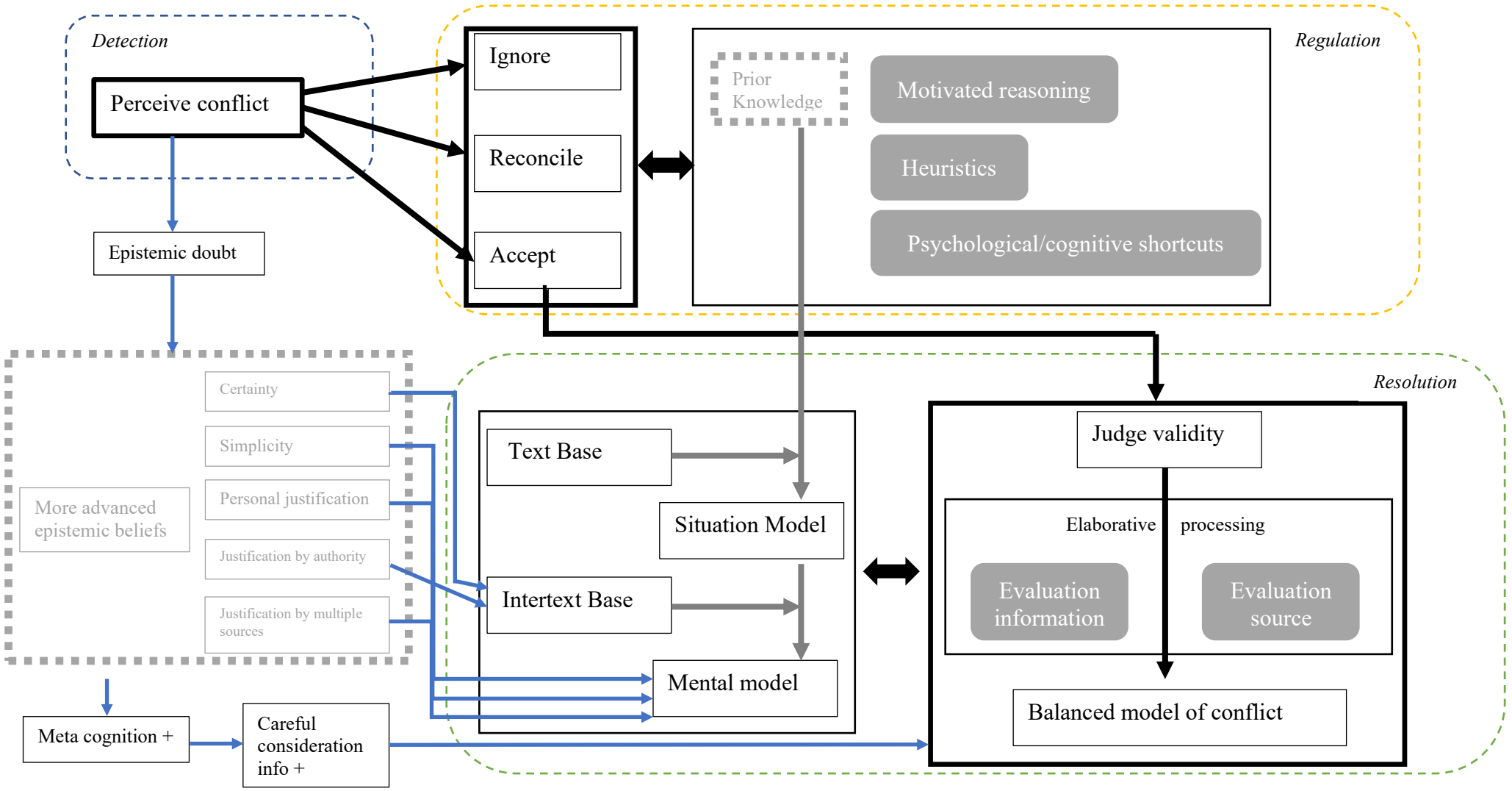


Figure 5. Multiple document processing.

Note:

- This figure visualises the present paper's authors' interpretation of the original and later modifications of the Documents model by Britt and colleagues (Britt et al., 1999; Perfetti et al., 1999) and the integrated model of epistemic beliefs and multiple-document processing (Bråten et al., 2011).
- The model shows that the text base of each source is evaluated against one's prior knowledge to form a situational model of each source, i.e., an interpretation of what is described in the source. At the same time, the source information (e.g., author, journal, date, etc.) for each source is linked to the source content so that the reader "knows" which source was putting what information forward. This connection between source and content for each of the sources is called the inter-text model. This inter-text model, together with the situational models of all sources involved, then constructs the documental model, i.e., an integrated mental representation of the situations described across the different sources (Bråten et al., 2011). The situational and the inter-text model are combined through content-source links or tags, i.e., aspects of the situational model are being tied to their source. Furthermore, Bråten et al. (2011) found that the inter-text base is mostly influenced by certainty and source beliefs, while the construction of the documental model is mostly influenced by simplicity and justification beliefs. Bråten et al. (2014a) found that the belief that there is a need for justification by multiple sources has both a direct and indirect effect on multiple source comprehension.

Figure 6. The Documents model in a context of conflicting information.



Note: The figure represents the authors' interpretation of the Documents model when applied to the context of conflicting information as described by Bråten et al., 2011 and Stadtler and Bromme (2014).

Table 3. Epistemic beliefs and related concepts

Personal epistemology and **epistemic beliefs** describe people's personal views or theories about knowledge and knowing that may influence task definition, meta-cognition and strategy use (Greene et al., 2008) or personal theories about the nature of knowledge (what knowledge is) and the nature of knowing (how one comes to know) (Hofer and Pintrich, 1997; Stahl and Bromme, 2007; Ferguson, 2015). **Epistemic thinking** can be defined as a process involving dispositions, beliefs, and skills regarding how individuals determine what they actually know, versus what they believe, doubt, or distrust (Chinn et al., 2011; Hofer and Bendixen, 2012) and thus a multi-faceted concept (Barzilai and Zohar, 2014; Barzilai and Zohar, 2016), including **epistemic cognition** (= Consideration of the epistemic status and properties of specific information, knowledge claims, and their sources, as well as engagement in strategies and processes for thinking and reasoning about specific information, knowledge claims, and sources) and **epistemic metacognition** (= Knowledge, skills, and experiences related to the nature of knowledge and knowing) (Barzilai and Ka'adan, 2017).

Thus, epistemic beliefs are conceptions about the nature of knowledge and knowing (Hofer & Pintrich, 1997; Lederman, 2007). Models of epistemic beliefs focus on describing individuals' beliefs about the structure, sources, and development of knowledge and knowing. Such beliefs can show stability across contexts, yet can also differ across domains and topics (Merk et al., 2018; Schiefer et al., 2022; Sandoval et al., 2016; Muis et al., 2006)

Two main streams of research on epistemic beliefs have dominated; the developmental view of individuals' epistemic beliefs (Kuhn et al., 2000; Perry Jr, 1968) and the dimensional perspective (Hofer and Pintrich, 1997; Hofer, 2016; Schommer, 1990).

Developmental perspective:

The developmental view differentiates the qualitative stages that individuals commonly go through in the development of their epistemic beliefs.

Realist
- External reality and truth correspond (Kuhn et al., 2000).
- assuming that assertions are copies of an external reality and that knowledge comes from external authorities (Kuhn and Weinstock, 2012)
- accept all information as true knowledge regardless of the source (Burr and Hofer, 2002)

Absolutist
- Assertions are **facts** that are correct or incorrect in their representation of **reality.**
- Believe that knowledge is **certain** and that an **objective truth exists** (Kerwer and Rosman, 2018).
- Knowledge is viewed as certain and unconditional, requiring no **justification** other than on the basis of **authority** and those who make knowledge claims are either correct or incorrect (Ferguson, 2015; Kuhn et al., 2000).

Multiplist
- Assertions are **opinions** freely chosen by and **accountable only to their owners**.
- Believe that knowledge is **inherently subjective (Kerwer and Rosman, 2018)**
- There is an increasing acknowledgement that the nature of knowledge is **uncertain** and increasing doubt that true knowledge exists, leading to the view that **one's own opinion is equally valid as other's** given that knowledge is something that is generated in the mind and thus uncertain and relative (Ferguson, 2015; Kuhn et al., 2000).

Evaluatist
- Assertions are judgments that can be **evaluated and compared** according to criteria of argument and evidence.
- Acknowledge the importance of **weighing** evidence and **integrating** contradictory knowledge claims (Kerwer and Rosman, 2018)
- In addition to acknowledgement of the **uncertainty** and **tentativeness** of knowledge, there is an understanding of the **constructed** nature of knowledge and why and how knowledge claims need to be justified in light of competing theories and supporting evidence (Ferguson, 2015; Kuhn et al., 2000).

Dimensional perspective:

Schommer (1990) proposed that rather than developing in universal stages, beliefs may be more nuanced and may be conceptualized as several distinct dimensions which may develop on a continuum independently in a non-synchronised manner (Schommer, 1990; Ferguson, 2015). Schommer (1990) originally named four dimensions, i.e., structure, stability, source of knowledge, and ability of speed of learning.

Although there is consensus on the existence of multiple more or less independent dimensions of epistemic beliefs (Hofer, 2016), a vivid debate about the specific dimensions of the construct has evolved (Chinn et al., 2011; Hofer, 2016; Schiefer et al., 2022). For example, it has been questioned whether *certainty* and *simplicity of knowledge* are a measure of one's ontological beliefs rather than one's epistemic beliefs (Greene et al., 2008).

Some of the main identified dimensions include;

Certainty: beliefs that true knowledge exists (Hofer and Pintrich, 1997)

Simplicity: Knowledge is a collection of unambiguous facts (Hofer and Pintrich, 1997)

Certainty: "beliefs about the stability of knowledge" in (Conley et al., 2004).

Development: "beliefs that recognize science as an evolving discipline." It ranges from the idea that scientific knowledge does not develop to statements that scientific answers are continuously developing (e.g., based on new evidence) (Conley et al., 2004).

Source: beliefs about the knowledge that resides in external authorities. Stances range from strict beliefs in authorities (e.g., teachers) to an understanding of the importance of critical evaluation, scrutinizing authorities, and the ability to generate knowledge through one's own thinking (Conley et al., 2004)

Justification: beliefs about the role of experiments and to how students evaluate claims. It ranges from denying the need for data and experiments to support arguments to the acceptance that knowledge is justified via a variety of thinking tools, experimentations, and observations (Conley et al., 2004).

Nature of knowledge (simplicity/uncertainty): belief that knowledge is composed of a collection of unchanging facts (Greene et al., 2008)

Personal justification: Knowledge claims are justified or validated by relying on internal sources such as gut-feeling or prior knowledge (Greene et al., 2008)

Justification by authority: Knowledge claims are justified or validated by relying on external sources of knowledge (Greene et al., 2008)

Justification by multiple sources: Knowledge claims are justified or validated by consideration of and corroboration across multiple sources (Ferguson et al., 2012)

The integrative models aim to characterize the different developmental stages for a set of dimensions. (e.g., the epistemic thinking assessment (ETA) by Barzilai and Weinstock (2015) (Schiefer et al., 2022)).

Note:

Barzilai S and Ka'adan I (2017) Learning to integrate divergent information sources: The interplay of epistemic cognition and epistemic metacognition. *Metacognition and Learning* 12(2): 193-232.; Barzilai S and Weinstock M (2015) Measuring epistemic thinking within and across topics: A scenario-based approach. *Contemporary Educational Psychology* 42: 141-158.; Barzilai S and Zohar A (2014) Reconsidering personal epistemology as metacognition: A multifaceted approach to the analysis of epistemic thinking. *Educational psychologist* 49(1): 13-35.; Barzilai S and Zohar A (2016) Epistemic (meta) cognition: Ways of thinking about knowledge and knowing. *Handbook of epistemic cognition*. 409-424.; Bråten I, Anmarkrud Ø, Brandmo C, et al. (2014) Developing and testing a model of direct and indirect relationships between individual differences, processing, and multiple-text comprehension. *Learning and Instruction* 30: 9-24.; Bråten I, Britt MA, Strømsø HI, et al. (2011) The role of epistemic beliefs in the comprehension of multiple expository texts: Toward an integrated model. *Educational psychologist* 46(1): 48-70.; Britt MA, Perfetti CA, Sandak R, et al. (1999) Content integration and source separation in learning from multiple texts. *Narrative comprehension, causality, and coherence: Essays in honor of Tom Trabasso*. 209-233.; Burr JE and Hofer BK (2002) Personal epistemology and theory of mind: Deciphering young children's beliefs about knowledge and knowing. *New Ideas in Psychology* 20(2-3): 199-224.; Chinn CA, Buckland LA and Samarapungavan A (2011) Expanding the dimensions of epistemic cognition: Arguments from philosophy and psychology. *Educational psychologist* 46(3): 141-167.; Conley AM, Pintrich PR, Vekiri I, et al. (2004) Changes in epistemological beliefs in elementary science students. *Contemporary Educational Psychology* 29(2): 186-204.; Ferguson LE (2015) Epistemic beliefs and their relation to multiple-text comprehension: A Norwegian program of research. *Scandinavian Journal of Educational Research* 59(6): 731-752.; Ferguson LE, Bråten I and Strømsø HI (2012) Epistemic cognition when students read multiple documents containing conflicting scientific evidence: A think-aloud study. *Learning and Instruction* 22(2): 103-120.; Greene JA, Azevedo R and Torney-Purta J (2008) Modeling epistemic and ontological cognition: Philosophical perspectives and methodological directions. *Educational psychologist* 43(3): 142-160.; Hofer BK (2016) Epistemic cognition as a psychological construct: Advancements and challenges. *Handbook of epistemic cognition*. Routledge, pp.19-38.; Hofer BK and Bendixen LD (2012) Personal epistemology: Theory, research, and future directions.; Hofer BK and Pintrich PR (1997) The development of epistemological theories: Beliefs about knowledge and knowing and their relation to learning. *Review of educational research* 67(1): 88-140.; Kerwer M and Rosman T (2018) Mechanisms of Epistemic change—Under which circumstances does diverging information support epistemic development? *Frontiers in Psychology* 9: 2278.; Kuhn D, Cheney R and Weinstock M (2000) The development of epistemological understanding. *Cognitive development* 15(3): 309-328.; Kuhn D and Weinstock M (2012) What is epistemological thinking and why does it matter? *Personal epistemology*. Routledge, pp.121-144.; Merk S, Rosman T, Muis KR, et al. (2018) Topic specific epistemic beliefs: Extending the theory of integrated domains in personal epistemology. *Learning and Instruction* 56: 84-97.; Muis KR, Bendixen LD and Haerle FC (2006) Domain-generality and domain-specificity in personal epistemology research: Philosophical and empirical reflections in the development of a theoretical framework. *Educational Psychology Review* 18: 3-54.; Perfetti CA, Rouet J-F and Britt MA (1999) Toward a theory of documents representation. *The construction of mental representations during reading* 88108.; Perry Jr WG (1968) Patterns of Development in Thought and Values of Students in a Liberal Arts College: A Validation of a Scheme. Final Report.; Sandoval WA, Greene JA and Bråten I (2016) Understanding and promoting thinking about knowledge: Origins, issues, and future directions of research on epistemic cognition. *Review of Research in Education* 40(1): 457-496.; Schiefer J, Edelsbrunner PA, Bernholt A, et al. (2022) Epistemic beliefs in science—a systematic integration of evidence from multiple studies. *Educational Psychology Review* 34(3): 1541-1575.; Schommer M (1990) Effects of beliefs about the nature of knowledge on comprehension. *Journal of educational psychology* 82(3): 498.; Stahl E and Bromme R (2007) The CAEB: An instrument for measuring connotative aspects of epistemological beliefs. *Learning and Instruction* 17(6): 773-785.

Epistemic beliefs and conflicting health information

As described in the previous section, in the learning sciences, the processing of multiple conflicting information sources has been linked with epistemic cognition, and the latter has been suggested as an important determinant in such process. This leads us to the question how epistemic beliefs may be helpful for laypersons when it comes to health-related decisions? Health is a dynamic and an ever-evolving topic, and people's knowledge about health is tentative. Health research is limited in several ways and, for example, bound by practical (e.g., limited time and financial resources), ethical (e.g., no option for control group as that would imply denying people the best possible treatment) and uncertainty (e.g., lack of generalisability of nutrition research due to highly personal metabolising) issues. Consequently, many health issues are complex, lack "clear cut solutions", and are "problems about which reasonable people reasonably disagree" (Kienhues et al., 2011; King and Kitchener, 2004; Jonassen, 1997; Kammerer et al., 2013). People have to cope with the idea that in health there are alternative treatment options, differing interpretations of symptoms, the underlying pathophysiological explanations of illnesses and risks, and appropriate preventive measures, and that there is uncertainty around side effects and adverse reactions (Han et al., 2019), even in just everyday decisions around e.g., what to eat or drink, or whether to wear sunscreen (Dixon et al., 2014) and whether one should undergo cancer screening (Gibson et al., 2016; Gollust et al., 2021; Han et al., 2009). Consequently, people must cope with the idea that health decision-making is based on a careful weighing of pros and cons, which are often highly personal and time sensitive. It has been suggested that decision-making around such ill-structured, clarity-lacking problems requires informal reasoning, i.e., the generation and evaluation of positions in response to complex issues that lack clear cut solutions" (Sadler, 2004). People require sufficiently adaptive epistemic beliefs to respond in an appropriate and sustainable way to such lack of clear-cut solutions (De Checchi et al., 2022; Knight and Mattick, 2006; Lee et al., 2022). Furthermore, people often turn to the web for answers to their health-related problems (Morahan-Martin, 2004; Wang et al., 2021). Health information is one of the most frequently sought topics online (Finney Rutten et al., 2019), which makes it even more likely that they will have to deal with a wide range and multitude of information and opinions (Kammerer et al., 2013). Several studies have pointed out the importance of epistemic beliefs for dealing with the diversity of information on the Web (Bråten and Strømsø, 2006; Hofer, 2004; Knight et al., 2017; Mason and Boldrin, 2008; Tu et al., 2008).

We analysed the literature identified through the "conflicting health information" search to see if and how they mentioned and used epistemic thinking in their work. First, it needs to be noted that none of the conceptual papers include the concept of epistemic thinking in the processing of conflicting health information. However, few empirical studies directly or indirectly considered epistemic beliefs or thinking in their research. Through an additional specific search and further reference chaining, 20 sources were identified which provide empirical evidence about the role of epistemic beliefs in the

processing of conflicting information in a health context. An overview of the papers, their measurement of epistemic beliefs, and a summary of the information they provide on the role of epistemic beliefs in the processing of conflicting health information is provided in **Table 4**. Most of these papers are from fields other than health, e.g., education, psychology, philosophy and marketing. They are not discussing the concept of conflicting health information but use health as their exemplar context to discuss information processing and decision-making. We believe one of the strengths of this study is the integration of literature across fields that would otherwise remain parallel to each other.

Table 4. An overview of the identified literature that considers epistemic cognition in conflicting information processing in a health context.

Reference	Study aim	Research design, sample and information topic	Measurement/ manipulation epistemic cognition	Findings
Conflicting health information influences epistemic beliefs (n=5)				
Ferguson, L. E., Bråten, I., Strømsø, H. I., & Anmarkrud, Ø. (2013). Epistemic beliefs and comprehension in the context of reading multiple documents: Examining the role of conflict. *International Journal of Educational Research*, *62*, 100-114.	To investigate potential effects of the reading of multiple conflicting documents on epistemic beliefs within dimensions of justification for knowing and the certainty/simplicity of knowledge.	• Experiment in which participants were randomly assigned to experimental and control conditions, that is, to the reading of conflicting and consistent documents, respectively. • N= 122 (71 female) 10th graders in Norway, 14.9 (0.26) years old • Sun exposure and health	Measured students' beliefs about justification for knowing with the Justification for Knowing Questionnaire (JFK-Q) Measured participants' views on the nature of knowledge concerning the specific topic of sun exposure and health by means of a Norwegian adaptation of an eight-item measure originally developed in German by Kienhues et al. (2011).	• Students in an experimental group, who read multiple conflicting documents concerning the issue of sun exposure and health, changed their domain-specific beliefs concerning personal justification (Exp: M= -.43, SD=1.52, Con: M=-.32, SD=1.75, t(63) = -2.24, p= .014, Cohen's d=0.24) and justification by multiple sources (Exp: M=.33, SD=1.68, Con= -.28, SD=1.88, t(119) = 1.87, p= .032, Cohen's d= 0.34) as well as their topic-specific beliefs concerning the certainty/simplicity of knowledge (Exp: M=.59, SD=1.53, Con: M=.24, SD=1.54, t(114) = 1.24, p=.10, Cohen's d= 0.23)), whereas no such changes were observed in a control group, reading multiple consistent documents on the same issue. • Students in the experimental group (M=6.03, SD=2.43) outperformed students in the control group (M=5.23, SD=2.60) on a measure of multiple-documents comprehension (t(118) = 1.73, p= .043, Cohen's d=0.32).
Ferguson, L. E., & Bråten, I. (2013). Student profiles of knowledge and epistemic beliefs: Changes and relations to multiple-text comprehension. *L earning and Instruction*, *25*, 49-61.	To explore potential changes in student profiles from before to after the reading of multiple conflicting texts on an unsettled scientific issue, as well as relations between emerging profiles and multiple-text comprehension.	• Collected the data in two sessions. In the first, 30-min session, the knowledge measure and the justification beliefs measures. One week afterward: participants read the five texts with different perspectives on the issue and responded to the short-essay questions during a 60-min session that took place in computer labs at participants' schools.	To assess beliefs about justification for knowing, the Justification for Knowing Questionnaire (JFK-Q) was used.	• After having read multiple conflicting texts on a science topic, the majority of students increased their knowledge about the topic and lowered their beliefs in personal justification (time 1 (*M*=4.20, *SD*=1.83) to time 2 (*M*=3.76, *SD*=1.74), *t*(63)= −2.24, *p*= .028, Cohen's *d* = .24). • Neither scores on the justification by authority measure, nor on the justification by multiple sources measure, changed statistically significantly from time 1 to time 2,*t*s(63)<1.55, *p*s>.125. • The subgroup (cluster 3) characterized by relatively high level of knowledge and relatively low level of personal justification in combination with strong beliefs in justification by multiple sources performed best on a multiple-text comprehension measure. (cluster 1: *moderate knowledge/moderate epistemic beliefs*: M=5.06(2.28), Cluster 2: *high knowledge/low personal justification/high justification by authority* : M=7.46(2.30), Cluster 3: M=9.22(3.52), *F*(2,61)=10.81, *p*<.001, partial η^2=.26)

		• n=65 (39 girls) 10th graders in Norway, 14.9 (0.24) years old • sun exposure and health.		
Haigh, M., & Birch, H. A. (2021). When 'Scientists Say'Coffee Is Good for You One Day and Bad for You the Next: Do Generic Attributions to 'Scientists' and 'Experts' Amplify Perceived Conflict?. *Collabra: Psychology*, *7*(1), 23447.	To investigate whether the qualifier "some" into genuine news headlines could reduce the consequences of perceived conflict (e.g., confusion and backlash) by making diverging claims easier to reconcile.	• In two pre-registered online (Qualtrics) experiments participants were exposed to 19 genuine news headlines. Both experiments had an identical 2x2 independent groups design. Headline Conflict x Headline Format. • Ex 1: n=294 (126 males, 168 females), (M_{age} = 34.29, *SD* = 12.97); Ex 2: n=400 (150 male, 248 female and 2 neither of those categories) (M_{age} = 33.5, *SD* =12) Prolific report that most participants in the pool were born in the UK or USA. • Human diet and nutrition.	In exp 2: measured "epistemic beliefs about the certainty and development of knowledge" (derived from the scientific epistemological beliefs questionnaire) (Conley, A. M., Pintrich, P. R., Vekiri, I., & Harrison, D. (2004). Changes in epistemological beliefs in elementary science students. *Contemporary Educational Psychology*, *29*(2), 186–204.	• They hypothesized that that exposure to conflicting headlines may have some positive benefits, by creating greater awareness that scientific knowledge is uncertain and constantly developing. However, their conflict manipulation did not affect more global beliefs about nutrition or the development of science, and they were unable to determine whether this effect would be moderated by headline format. • *While brief exposure to conflicting headlines was sufficient to affect topic specific beliefs in Experiment 1, it did not shift the more stable and generalised beliefs measured in Experiment 2. The absence of a Conflict effect on global beliefs suggests that brief exposure to conflicting headlines was not sufficient to temporarily shift global beliefs about science or nutrition even for the short period immediately after exposure.*
Kienhues, D., Stadtler, M., & Bromme, R. (2011). Dealing with conflicting or consistent medical information on the web: When expert information breeds	To investigate how dealing with conflicting versus consistent medical information on the Web impacts on topic-specific and medicine-related epistemic beliefs as well as aspects of health decision making.	• Pre/ posttest experiment with random assignment to 2 intervention groups (searched the web for information to advise a friend. Pre-selected websites provided either conflicting or consistent information) and 1 control group	Measured topic-specific epistemic beliefs with a specially developed 8-item scale (5-point Likert scale). Measured medicine-related beliefs with the instrument on Connotative Aspects of Epistemological Beliefs (CAEB; Stahl & Bromme, 2007).	• The intervention groups differed in topic-specific epistemic beliefs during Web search**.** • The group dealing with conflicting information would show more advanced topic-specific beliefs (M=3.59, SD=0.45) than the group dealing with consistent information (M=3.23, SD=0.81) (t(52.55)=2.01, p<0.05, Cohen's d=0.50). • The medicine-related epistemic beliefs in both intervention groups were more advanced (Mean gain scores: Texture: Conflict group: M=0.30, SD=0.48, Consistency group : M=0.44, SD=0.72, Control group: M=0.06, SD=0.42, F(1.97) = 7.24, p<.01, partial η^2=.07; Variability: Conflict group: M=0.49, SD=0.65, Consistency group: M=0.57, SD=0.75, Control group:

laypersons' doubts about experts. *Learning and Instruction*, *21*(2), 193-204.		(did not conduct a web search). • n= 100 (84% female) university (predominantly in humanities) students 22.57(4.25) years in Germany • Cholesterol		M=0.12, SD=0.56, $F(1, 97)=7.68$, $p<.01$, partial $\eta^2=.07$) while remaining unchanged in controls. • The intervention groups also differed in some aspects of decision making.
Lyons, B. A., Merola, V., & Reifler, J. (2020). Shifting medical guidelines: Compliance and spillover effects for revised antibiotic recommendations. *Social Science & Medicine*, *255*, 112943.	To test the effects of a message that reverses the long-standing advice about the course of antibiotics	• an online-survey experiment • *N*=1263 using a stratified quota sample of adults in the UK ages 16 and older • Antibiotics	Measured epistemic efficacy (*M*=4.27,*SD*=1.26,*a*=0.67) using average agreement with two 7-point Likert items: "I feel confident that I can find the truth about issues in science and medicine," and "If I wanted to, I could figure out the facts behind most scientific and medical disputes"	While the new guideline slightly decreased acceptance of uncertainty about future guidelines (a decrease of 2%, 95% CI: 0.2% to 3.1%, p = .022) and general intention to comply with other guidelines in the future (a decrease of 6%, 95% CI: 2.6% to 8.4%, p < .001); it did not affect perceptions of medical researchers' or doctors' credibility or respondents' epistemic efficacy.
Epistemic beliefs influence the handling of conflicting health information (n=11)				
Attwell, K., Leask, J., Meyer, S. B., Rokkas, P., & Ward, P. (2017). Vaccine rejecting parents' engagement with expert systems that inform vaccination programs. *Journal of Bioethical Inquiry*, *14*(1), 65-76.	To employ a theoretical analysis of trust and distrust to explore how parents with a history of vaccine rejection view the expert systems central to vaccination policy and practice.	• Qualitative interviews • N=27 parents with a history of vaccine rejection in two Australian cities • Vaccination	N/A	• *The parents who ultimately consented to some vaccinations still distrusted the industry and its profit motive and did not follow the schedule on this basis. Their acceptance of some vaccines, however, demonstrates mitigation of this distrust with other factors, such that they came to be sufficiently comfortable with nuance. The pharmaceutical industry remained untrustworthy, with its tendrils infiltrating research, medical professionals, and government negatively, yet parents incorporated contradictory beliefs into their assessments.* • The authors suggest: *ultimately the difference between those who trust "enough" to vaccinate and those who do not, is the absolutism of the worldview that the profit motive facilitates only bad. Here, absolutism is not only the strength of the belief; but also the extent to which it is untempered by other considerations, the comprehension of complexity, and sitting with dissonance.*
Bråten, I., Ferguson, L. E., Strømsø, H. I., & Anmarkrud, Ø.	To examine adolescents' beliefs concerning the justification of	• Two sessions: 1) questionnaire, 2) 1 week later: Each participant read the five	14 items from the Justification for Knowing Questionnaire (JFK-Q)	• Students most strongly believed in justification by authority, followed by justification by multiple sources and personal justification. • Topic knowledge explained a statistically significant amount of variance, R2 = 0.07, F(1, 61) = 4.43, p = 0.039.

(2013). Justification beliefs and multiple-documents comprehension. *European Journal of Psychology of Education*, *28*(3), 879-902.	knowledge claims in the context of reading multiple conflicting documents on the social-scientific issue of sun exposure and health.	documents and responded to the short-essay questions during a 60-min session that took place in a computer lab at the school. (DV: multiple-documents comprehension indicated by essay performance) • n=65 (39 girls) 10th graders in Norway, M=14.9 (SD=0.24) years old • sun exposure and health		• The addition of the three justification belief measures resulted in a statistically significant 21% increment in explained variance, with R2 = 0.28, Fchange(3, 58) = 5.79, p = 0.002. • Personal justification was a strong negative predictor of multiple-documents comprehension (β = −0.49, p = 0.000). • Justification by multiple sources was a positive predictor (β = 0.30, p = 0.013).
Bråten, I., Anmarkrud, Ø., Brandmo, C., & Strømsø, H.I. (2014a). Developing and testing a model of direct and indirect relationships between individual differences, processing, and multiple-text comprehension. Learning and Instruction, 30, 9–24. Doi:10.1016/j.learninstruc.2013.11.002	To test a hypothesized model that specified direct and indirect linkages between the individual difference variables of epistemic beliefs, need for cognition, individual interest, and prior knowledge, the processing variables of effort, deeper-level strategies, and situational interest, and multiple-text comprehension	• Paper questionnaire + 2w later: read 5 texts and respond to multiple text strategy measure and short essay questions (a path analysis tested the fit of the model) • N=279 (62% female) students in Norway, M=16.57 (SD=.36) years old • sun exposure and health	Participants' beliefs concerning the justification of knowledge claims in science were measured with the Justification for Knowing Questionnaire (JFK-Q): only items concerning justification by multiple sources were used.	• students' effort and deeper-level strategies predicted their multiple-text comprehension, with the individual difference variables indirectly affecting multipletext comprehension through their influence on effortful, adaptive multiple-text processing. • justification by multiple sources had statistically significant direct effects on effort (β = .19, p<0.001), deeper-level strategies (β = .12, p<0.05), and situational interest (β = .22, p<0.001). • there were statistically significant indirect effects of justification by multiple sources on multiple-text comprehension mediated by effort (β = .056, p= .004) and deeper-level strategies (β = .023, p= .05), respectively.
Bråten, I., Ferguson, L. E., Strømsø, H. I., & Anmarkrud, Ø. (2014). Students	To examine relationships between epistemic cognition concerning the justification of	• Essay task (advise a friend) with think aloud instruction. Participants entered a browser showing an	justification by authority, personal justification and justification by multiple sources were identified in think-aloud protocols based	• Most participants (n = 42, 82.4%) spontaneously verbalized epistemic cognition concerning justification for knowing during their reading • After controlling for topic knowledge, justification by multiple sources uniquely predicted students' sourcing and argumentation in essays that they wrote after reading the documents, with students trying to justify

working with multiple conflicting documents on a scientific issue: Relations between epistemic cognition while reading and sourcing and argumentation in essays. *British Journal of Educational Psychology*, *84*(1) , 58-85.	knowledge claims and sourcing and argumentation skills on a controversial scientific issue	offline search results page in Google layout listing six search results. (Utterances were coded as epistemic cognition; Coding of sourcing in essays: Coding of argumentation in essays) • n=51 university students (43 women) in Norway, M=22.1 (SD=2.6) years old. • cell phone radiation and health risks	on students' reading of six documents presenting conflicting claims	knowledge claims by corroborating across several sources of information more likely to include explicit source citations (β = .44, p<.01), link sources and contents (β =.44, p<.01), and display better, more integrated argumentation (β = .38, p<.05) in their essays.
Kammerer, Y., Bråten, I., Gerjets, P., & Strømsø, H. I. (2013). The role of Internet-specific epistemic beliefs in laypersons' source evaluations and decisions during Web search on a medical issue. *Computers in human behavior*, *29*(3), 1193-1203.	To investigate the predictive value of epistemic beliefs about knowledge and knowing on the Web for source evaluations and post-search decisions when university students searched the Web to make an informed decision about a conflicting and unfamiliar medical issue.	• Experiment with questionnaire and search task and cued retrospective reporting. • n=80 students (63 female; *M* = 25.40 yrs, *SD* = 3.95) from different majors, Germany • therapies to treat Bechterew's disease. • Note participants were provided with SERPs with different source types and conflicting information	Epistemic beliefs were assessed with 17 items of the Internet-Specific Epistemological Questionnaire (ISEQ)	• Internet-specific certainty, source, and structure beliefs primarily play a role in source evaluation: beliefs in the Web as a reliable resource of accurate knowledge and detailed facts were related to decreased verbal reflection on the credibility and type of sources (β = −.24, p = .02) and decreased attention to the URLs of the search results (β = −.28, p = .01), as well as a greater certainty in the post-search decision (β = .26, p = .01). • Internet-specific beliefs about the justification for knowing primarily play a role in constructing a complete representation of document contents: doubts about the need to check knowledge claims on the Web against other sources, reason, and prior knowledge were related to a more one-sided representation of the conflicting issue (β = .26, p = .01).
Kammerer, Y., & Gerjets, P. (2012). Effects of search interface and Internet-specific epistemic beliefs on source evaluations during Web search for medical	To examine how both the interface of search engines and Internet-specific epistemic beliefs influence novices' source evaluations during Web search on a medical topic, i.e., information on the WWW about two	• Experiment (a three-factorial mixed-model design: interface, search result category, epistemic beliefs). Data were collected through questionnaire and eye tracking during search task.	To assess the extent to which participants believed that the Web contains correct knowledge, a translated and adapted version of the dimension 'certainty and source of knowledge' (8 items; Cronbach's α=0.72) of the Internet-Specific	• students believing that the Web contains correct knowledge showed a **more** appropriate Web search behaviour when solving the given medical problem than students who had doubts about the Web containing such kind of information. • the higher students' epistemic beliefs that the Web contains correct knowledge, the more objective Web pages they accessed (β=0.29, p=0.03) • beliefs that the Web contains (among other types of information) correct knowledge are related to more thoughtful decisions to not select a search result (β=0.23, p=0.08)

information: An eye-tracking study. *Behaviour & Information Technology*, *31*(1), 83-97.	competing, controversially discussed therapies	• n=58 university freshmen (mean age: 20.52, 83% females) (from different majors), in Germany • 'radon therapy' and 'infliximab therapy' for Bechterew's disease (i.e., a chronic inflammatory rheumatic disease affecting the spine).	Epistemological Questionnaire (ISEQ, Strømsø and Bråten 2010) was used.	• there was a marginally significant main effect of epistemic beliefs (β=0.24, p=0.07) on the number of objective arguments in the summaries written by participants
Mason, L., & Boscolo, P. (2004). Role of epistemological understanding and interest in interpreting a controversy and in topic-specific belief change. *Contemporary Educational Psychology*, *29*(2), 103-128.	To investigate the influence of high school students' (10th and 11th grade) epistemological understanding and topic interest on their interpretation of a dual-position expository text about genetically modified food, as well as on the change in their beliefs about the topic.	• Experiment with questionnaire and reading & argumentation task in 2 sessions • n=65 students (38 girls) 10th and 11th grade in Italy • genetically modified food and biological agriculture • Note: An expository dual-position scientific text on the topic was used	The 15-item instrument developed by Kuhn et al. (2000) to measure epistemological understanding was administered. Each item consists of a pair of contrasting statements in five domains (judgments of personal taste, aesthetics, values, truth about the social world, and truth about the physical world) attributed to two individuals	• Univariate tests revealed that epistemological understanding affected students' writing of the conclusion to the dual-position text on transgenic food [F(2,54)=4.16, p<.05, MSe=1.78]. • t-tests on adjusted means showed that both students with more advanced [t(31)=2.60, p<.01] and moderate epistemological thinking [t(49)=3.06, p<.01] interpreted the controversy and the issues of the current debate better than those with less advanced epistemological thinking. • Students with more advanced epistemological thinking wrote more comments on the role of science in society [z=2.134,p<.05] than students with moderate or less advanced epistemological thinking. • Students with a moderate level of epistemological thinking—holding a position around relativism—wrote more comments asking for further scientific investigation [z=2.132, p<.05] than students with greater or less advanced epistemological thinking. • Students with a moderate level of epistemological understanding produced more comments (Doubts about the effective value of GM food [z=2.10, p<.05]) than students with more and less advanced levels of thinking about knowledge and knowing. • After reading, a change emerged in students' beliefs about the topic in relation to their epistemological understanding. Students with a more advanced level of epistemological understanding (Pre: M=2.14, SD=0.66, Post: M=2.92, SD=0.82) changed their personal positions on the topic more than those with moderate (Pre: M=2.71, SD=92, Post: M=2.84, SD=0.84) and less advanced beliefs about knowledge and knowing (Pre: M=2.31, SD=1..10, Post: M=2.36, SD=1.16), who substantially kept their positions
Mason, L., & Scirica, F. (2006). Prediction of students'	To investigate the contribution of overall epistemological understanding to	• Experiment with questionnaire and reading &	The 15-item instrument developed by Kuhn, Cheney, and Weinstock (2000) to measure	• Findings from hierarchical regression analyses show that epistemological understanding was a significant predictor of all three components of argumentation skills for both controversies (for Genetically modified

argumentation skills about controversial topics by epistemological understanding. Le arning and Instruction, 16, 49 2–509. doi:10.1016/j.lear ninstruc.2006.09. 007	argumentation skills, after controlling for topic knowledge and interest.	argumentation task in 3 sessions • N=62 8th graders (30 girls), Italy. N=52 of these students also read the text about the other controversial topic. • global warming and genetically modified food • Note: a two-sided text on each topic was used.	epistemological understanding was administered.	food:: β= 0.39, p<0.01. for argument, β= 0.49, p<0.001 for counterargument and β= 0.36, p<0.01 for rebuttal). • Participants at the evaluativist level (Ev) of overall epistemological understanding generated arguments (for GMO: Ev: M=3.66, SD=0.49, Mu: M=3.00, SD=0.84), counterarguments (Ev: M=3.16, SD=0.57, Mu: M=2.77, SD=0.80), and rebuttals (Ev: M=3.00, SD=0.42, Mu: M=2.22, SD=1.02) of a higher quality than participants at the multiplist level (Mu).
Mourali, M., & Drake, C. (2022). The Challenge of Debunking Health Misinformation in Dynamic Social Media Conversations: Online Randomized Study of Public Masking During COVID-19. *Journal of medical Internet research*, *24*(3), e34831.	To examine the impact of extended back and forth between false claims and debunking attempts on observers' dispositions toward behaviour that science favours.	• An online experiment in October 2020. • n= 479 US residents (53.7% female), M=32.1 (12.3) yrs • Mask wearing during COVID-19	No explicit mentioning of epistemic beliefs, however, to measure perceived objectivity of truth, they asked respondents to consider the question "Should people wear masks in public?" and indicate the extent to which they think there is an objectively true answer to this question. They reported their answers on a 7-point scale (1=*definitely no objective truth*, 7=*definitely an objective truth*).	• Exposure to misinformation had a negative impact on attitudes and intentions toward masking (β=–.35, 95% CI –.42 to –.29; P<.001). • Initial debunking of a false claim generally improved attitudes and intentions toward masking (β=.35, 95% CI .16 to .54; P<.001). • The improvement was washed out by further exposure to false claims and debunking attempts (β=–.53, 95% CI –.72 to –.34; P<.001). • Extended exposure to false claims and debunking attempts appear to weaken the belief that there is an objectively correct answer to how people ought to behave in this situation, which in turn leads to less positive reactions toward masking as the prescribed behaviour.
Murray, G., Willer, C. J., Arner, T., Roche, J. M., & Morris, B. J. (2021). Contextualized Knowledge Reduces Misconceived COVID-19 Health Decisions.	To investigate the role cognitive conflict has on health decision-making. To explore whether explicit and implicit decisions could be predicted by knowledge and context, potentially adding to the field's	• A computer mouse-tracking paradigm alongside geographical information systems (GIS) as a proxy for context (Data were collected in a single session remotely using the FindingFive	No explicit mentioning of epistemic beliefs, however, they measure *science change knowledge* as "scientific evidence is constantly changing vs relatively stable": they assessed general knowledge of science change (True/False), resulting in a science-	• The results support a contextualized-deficit-model framework in which relevant knowledge and context-based factors help individuals override cognitive conflict to make more preventative health decisions. • Science change knowledge (β =0.02, SE=0.05, z=0.48, p>0.05) was not predictive of endorsement of preventative COVID-19 behaviours. • Science change knowledge (*β=0.00, SE=0.15, t=0.03, p>0.05)* did not predict willingness to get the COVID-19 vaccine.

Journal of applied research in memory and cognition, *10*(3), 381-391.	understanding of how best to communicate updated information when it contradicts previously shared information (i.e., explanatory coexistence, cognitive conflict).	platform in Oct-Nov 2020)) • Participants (*n*=306) were recruited from Amazon's Mechanical Turk (MTurk; *n*=270) and an undergraduate participant pool (*n*=24). U.S. residents (women=129, men=175, non-binary=2; M_{age}=37.83yrs, *SD* =12.5) *n*=294 in analysis • Preventive health behaviours and vaccination against COVID-19	change accuracy score (*correct* = 1; *incorrect* = 0).	
Rotshtein, R. (2019). *Coordination of Theory and Evidence and the Role of Personal Epistemology and Prior Knowledge When Reading About the Controversial Topic of Vitamin Supplement Use*. The University of Toledo.	to explore how participants reason about the topic of vitamin supplement use, including how they coordinate theory and evidence when reading articles of varying stances on the issue, as well as how their personal epistemologies and prior knowledge play a role in this reasoning process.	• Qualitative study with a multiple case study design and article evaluation task • N= 34 students (16 undergrad, median age=21; 18 grad, median age=34.5)(33 female) • Vitamin supplements	Measured in two ways: - a personal epistemology assessment to determine absolutist, multiplist, or evaluativist beliefs across various domains. - participants' written responses during the article evaluation task were coded if they reflected absolutist, multiplist, or evaluativist ways of thinking or if the statements were related to other epistemological ways of thinking. These statements are discussed within the context of the task to explore how participants are applying these ideas in their reasoning. Results across the multiple-choice and	• A number of the participants who held evaluativist beliefs across most or all of the three relevant domains went on to make written statements that aligned with absolutist or multiplist views. Thus, the ways in which participants answer assessment items about their epistemological beliefs may not always be indicative of the beliefs they express within the context of a reasoning task. • Participants who held evaluativist beliefs across all three domains were more likely to use external sources to support their positions and tended to identify more external pieces of evidence and fewer internal pieces of evidence when compared with participants who exhibited other epistemologies. The two participants who explicitly remarked on the importance of citing sources to ensure the quality and validity of information were also in the evaluativist group. Thus, holding more evaluativist beliefs seemed to be an indicator of a greater awareness of the sources of knowledge and more suspicion about the validity of evidence that isn't linked to a reliable source. • Participants in the evaluativist group were also more likely to discuss the need for more scientific research to be conducted in order to justify making recommendations to consumers about the safety and effectiveness of vitamin supplements.

			written response components are then summarized and integrated.	
Experiments on effect of manipulation of epistemic beliefs on handling of conflicting health information (n=4)				
Han, P., Scharnetzki, E., Scherer, A. M., Thorpe, A., Lary, C., Waterston, L. B., Fagerlin, A., & Dieckmann, N. F. (2021). Communicating scientific uncertainty about the COVID-19 pandemic: Online experimental study of an uncertainty-normalizing strategy. Journal of Medical Internet Research, 23(4), e27832.	To evaluate whether an "uncertainty-normalizing" communication strategy—aimed at reinforcing the expected nature of scientific uncertainty about the COVID-19 pandemic—can reduce ambiguity aversion, and to compare its effectiveness to conventional public communication strategies aimed at promoting hope and pro-social values.	• an online (Qualtrics) factorial experiment conducted from May-June 2020 • n= 1497 US adults (40% college graduate or higher, 50% female) • Covid-19	Participants read one of five versions of an informational message describing the nature, transmission, prevention, and treatment of COVID-19, but varying in level of expressed scientific uncertainty and supplemental focus (uncertainty-normalizing, hope-promoting, prosocial).	• The communication of scientific uncertainty about the COVID-19 pandemic increased perceived likelihood ($F_{4,1492}$=2.95; η^2=0.008; P=.02) and worry ($F_{4,1492}$=3.65; η^2=0.01; P=.006) about COVID-19, consistent with ambiguity aversion, but did not affect intentions for COVID-19 risk-reducing behaviours (η^2=0.002; P=.49) or vaccination (η^2=0.005; P=.14). • The uncertainty-normalizing strategy, but not the hope-promoting or pro-social strategies, reduced these cognitive and emotional manifestations of ambiguity aversion; when scientific uncertainty was communicated along with uncertainty-normalizing language, levels of COVID-19 risk perceptions (likelihood: (d=–0.04; P=.66)) and worry (d=–0.10; P=.21) did not differ from the control message that did not communicate uncertainty. • Intentions regarding COVID-19 risk-reducing behaviours (η^2=0.002; P=.49) and vaccination (η^2=0.005; P=.14) showed no significant differences between any of the experimental conditions. However, prespecified contrasts revealed higher vaccination intentions in both the *uncertainty* (d=–0.17; P=.04) and the *uncertainty + uncertainty-normalizing* (d=–0.18; P=.03) conditions compared to the *control* condition, suggesting that the communication of uncertainty itself motivated vaccination intentions and that the addition of uncertainty-normalizing language preserved this motivation. • Age ($F_{20,1445}$=1.86; $\eta\rho^2$=0.025; P=.01) and political affiliation ($\eta\rho^2$=0.010; P=.06), respectively, moderated the effects of uncertainty communication strategy on intentions for COVID-19 risk-reducing behaviours and worry about COVID-19.
Rogers, Z. F., & Gould, S. J. (2015). How do you know that? The epistemology of consumer health decision making under	Two experiments to investigate how different consumers handle the challenge of conflicting information by considering consumers' epistemic beliefs.	Ex 1: • 2 (supplement type: vitamin E vs. CQ10) × 2 (texture epistemic beliefs: high–low) × 2 (variability epistemic beliefs:	Epistemic beliefs were measured using the Connotative Aspects of Epistemological Beliefs measure (CAEB; Stahl & Bromme, **2007**). Manipulation in study 2:	• Consumers' epistemic beliefs (both when measured and when manipulated in their experiment) influence the assessment of conflicting risk-benefit information about health supplements and diet. • Ex1: for those with low-variability and high-texture epistemic beliefs, being given risk–benefit information about the less (more) familiar CQ10 (vitamin E) led to greater (lesser) thinking about the risks (effect = −0.11, CI [−0.283, −0.012]) and the benefits (effect = −0.31, CI [−0.681,

conditions of risk–benefit conflict. *Psychology & Marketing*, *32*(4), 450-466.	Study 1 investigates how measured epistemological beliefs influence consumers' attitudes toward and risk–benefit assessments of the two health supplement products vitamin E and CQ10, which are presented with the same conflicting risk–benefit information. Study 2 manipulates epistemic beliefs to understand responses to 2 health diets, assessments of their risks and benefits and willingness to follow the diet.	high–low) between-subject design study. • n= 355 (195 female) (137 undergraduate students recruited through a marketing subject pool and 218 consumers recruited online through Amazon Mechanical Turk).(M= 32 yrs, range 18-74 yrs). • Vitamin E and CQ10 supplements Ex2: • 2 (type of diet: Mediterranean diet vs. high-protein diet) × 2 (texture epistemic beliefs: high vs. low) × 2 (variability epistemic beliefs: high vs. low) between-subject design study. • n=378 (226 female) recruited online via Amazon Mechanical Turk. M= 35yrs, 18-81 yrs. • Diet	Participants were presented with 2 different statements about the knowledge they have about how to lead a healthy lifestyle. These statements corresponded to the manipulations for texture epistemic beliefs ("the knowledge we have about how to lead a healthy liefestyle has been demonstrated to be (not) simple and straightforward") and variability epistemic beliefs ("the knowledge we have about how to lead a healthy lifestyle has been demonstrated to (not) vary quite a bit"). The statements were followed by as hort writing task.	−0.046]) involved, leading to a lower (Ŷ=2.76) (greater (Ŷ=5.16)) likelihood of taking the supplement. • Ex2: Analysis revealed that the texture manipulation had a significant impact on the texture score ($F(1,373) = 10.71$, $p = 0.001$; $M_{High} = 3.90$ vs. $M_{Low} = 3.60$), when health consciousness, food knowledge, and nutrition knowledge were included as covariates. Analysis revealed that the variability manipulation had a marginally significant impact on the variability score ($F(1,373) = 3.46$, $p = 0.06$; $M_{High} = 4.60$ vs. $M_{Low} = 4.44$), when health consciousness, food knowledge, and nutrition knowledge were included as covariates. • Ex2: For those in the low-variability and high-texture epistemic belief condition, being given risk–benefit information about the high-protein (Mediterranean) diet led to greater (lesser) thinking about both the risks (effect = −0.26, CI [−0.531, −0.062]) and the benefits (effect = −0.17, CI [−0.400, −0.037]) involved, leading to a lower (Ŷ =4.04) (greater (Ŷ=4.21)) likelihood of following the less (more) familiar diet. • Consumers' epistemic beliefs differentially impact their reactions to and intentions toward health-related choices that involve conflicting risk–benefit information.
Simonovic, N., & Taber, J. M. (2022). Psychological impact of ambiguous health messages about COVID-19. *Journal of Behavioral*	To examine the effect of ambiguous health information about COVID-19 on health cognitions and vaccination intentions, and test a "normalized-uncertainty" intervention	• 2 online (Qualtrics) experiments with random assignment to one of three health messages • Ex 1: online adult sample n=299 US adults (53.8% female; 76.6% white; Mage = 56.36; education: 5% high	Participants were randomly assigned to read one of three health messages about COVID-19 that emphasized what was currently unknown (ambiguity condition), what was currently unknown but *that scientific uncertainty is expected* (intervention condition), or what was	• Contrary to hypotheses, participants randomly assigned to receive **a** normalization of uncertainty intervention—consisting of statements that it is normal and expected for scientists not to have all the information necessary at the start of an outbreak and that there is never absolute certainty when it comes to health risks—did not report lower perceived ambiguity about COVID-19 (M=2.94, SD=0.45) compared to participants who read unambiguous messages (M=2.49, SD=0.56) or ambiguous messages without the normalization intervention (m=3.06, SD=0.58). • The intervention also did not have a unique effect on any other health cognitions.

Medicine, *45*(2), 159-171.		school or less, 28.8% high school graduate; 26.8% some college or associated degree completed; 30.1% college degree; 9.4% post graduate or professional degree) Ex2: undergraduate US sample n=150 (76% female; 77.3% white; Mage = 19.93; year in school: 46% freshman, 22.7% sophomore; 14.7% junior, 16.7% senior) March-April 2020 • Covid-19	currently known (control condition)	• Contrary to hypotheses, there was little evidence that tolerance for ambiguity, optimism, or health literacy moderated how individuals responded to the health messages.
Stadtler, M., & Bromme, R. (2007). Dealing with multiple documents on the WWW: The role of metacognition in the formation of documents models. *International Journal of Computer-Supported Collaborative Learning*, *2*(2), 191-210. Stadtler, M., & Bromme, R. (2008). Effects of the metacognitive computer-tool met. a. ware on the web search of laypersons. *Comp*	To test the assumption that the use of metacognitive strategies is crucial to the formation of documents models and that successfully dealing with multiple documents on the World Wide Web requires readers to form documents models; that is, to form a representation of contents and sources.	• Experiment with random assignment to one of four groups that worked with different versions of *met.a.ware* or with a simple text window. • N=79 undergraduate students, which were laypersons in the field of medicine (M_{age}=23.65yrs, *SD* =3.37) (58 female) • Cholesterol	*Met.a.ware* is a metacognitive tool that encourages laypersons to monitor their comprehension and critically evaluate information by the means of metacognitive prompting. To measure participants' ability to justify their credibility judgments after Internet research, participants were requested to rate their three most preferred web sites in terms of credibility and subsequently give reasons for their judgments.	• To investigate the effects of metacognitive prompting the researchers systematically varied the availability of prompts between the groups working with *met.a.ware*. Participants received either evaluation prompts (evaluation group), monitoring prompts (monitoring group), both types of prompts (evaluation+monitoring group). These conditions were compared with a group that did not receive metacognitive prompts (no prompts control group) • They found no effect of evaluation prompts on comprehension of the subject matter as shown by a non-significant contrast between the evaluation group and the no prompts control group, F(1, 75)=0.28, p=0.60, η^2_{part}=0.004. Contrary to their expectations, planned contrasts also failed to reveal any significant differences between the monitoring group and the no prompts control group, F(1, 75)=1.71, p=0.20, η^2_{part}=0.02, and the evaluation+monitoring group and controls, F(1, 75)=0.30, p=0.59, η^2_{part}=0.004. • Both the evaluation group (*M*=45.33, *SD*=10.80), F(1, 75)=3.35, p=0.07, η^2_{part}=0.04, and the evaluation+ monitoring group (*M*=44.92, *SD*=13.82), F(1, 75)=2.99, p=0.09, η^2_{part}=0.04, showed a trend towards better knowledge about source characteristics compared to the no prompts control group (*M*=37.97, *SD*=13.43). • Laypersons in the evaluation+monitoring group (*M*=65.42, *SD*=42.86) significantly outperformed controls (*M*=37.46, *SD*=40.55) with respect to sourcing of arguments in their essays, F(1, 75)=4.49, p=0.04, η^2_{part}=0.06. • Laypersons in both conditions that received evaluation prompts produced more arguments focusing on the author of a web site than controls.

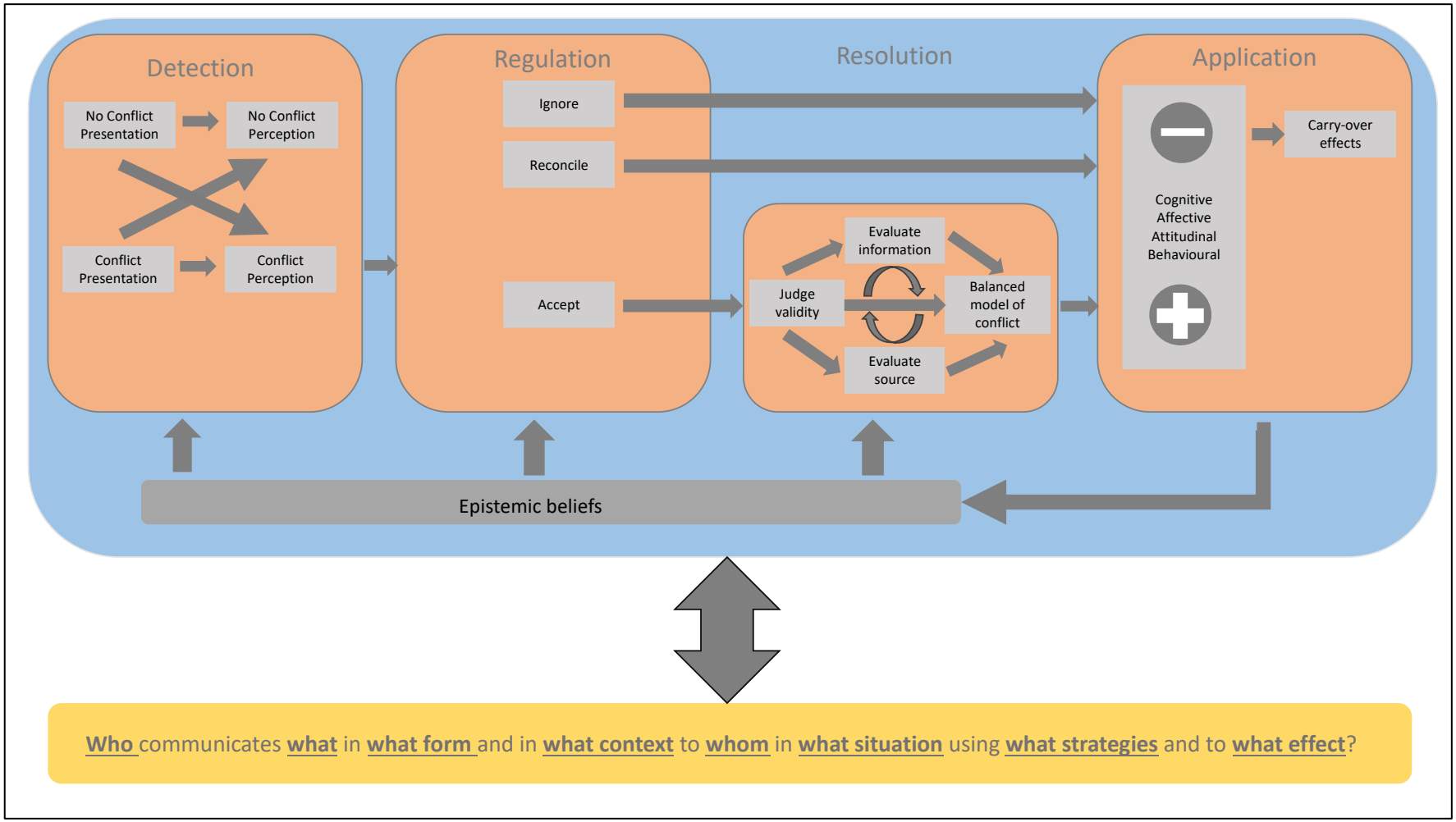
uters in Human Behavior, *24*(3), 716-737.	However, they did not produce more arguments with regard to content and the web site's layout • The *met.a.ware* tool also provided the option to classify notes, laypersons using the ontological classification had better structured notes and stored more information in *met.a.ware*.

2.2.4. Bringing together the insights from the literature review

The integrated framework, we introduce below identifies stages, paths, strategies and determinants related to the processing of conflicting health information. The framework draws on existing models, with major contributions derived from the content-source integration model (Stadtler and Bromme, 2014), the two step validation model (Richter and Maier, 2017), the integrated model of epistemic beliefs and multiple-document processing (Bråten et al., 2011), and the integrated framework of multiple text use (List and Alexander, 2019), combined with findings and concepts in the health communication context (e.g., Carpenter et al., 2016; Carpenter and Han, 2020; Chang, 2015; Han et al, 2019; Lee et al., 2018; Nagler, 2014) and the Lasswell model for communication (Lasswell, 1948).

The following paragraphs guide the reader through the model for the processing of conflicting information. For a visual aid, **Figure 7** provides a representation of the model. The paragraphs are separated based on the phases people go through when exposed to conflicting information; in each phase we describe different pathways people can take. Throughout the process, there are different strategies people may use to cope with conflicting information and determinants that influence which strategy one uses and pathway one follows. In the next subsection, we aim to provide a structured way to classify these determinants based on their role in the communication; "Who communicates what in what form and in what context to whom in what situation using what strategies and to what effect", which is presented in **Table 5**.

Figure 7. The processing of conflicting health information



Note: This figure represents the authors' integration and interpretation of the models for multiple source integration and the conceptual work from the health communication literature. The model visualises the three phases (detection, regulation and resolution) as described in the CSI model (Stadtler and Bromme, 2014) and shows the importance of epistemic beliefs in the process. Within the first phase "Detection", the model adds and emphasises the different paths between presentation and perception. A fourth phase "Application" was added, which represents the different outcomes of exposure to conflicting health information. The whole process interacts with source and individual-related determinants, which can be classified based on their role in the communication (in the yellow box).

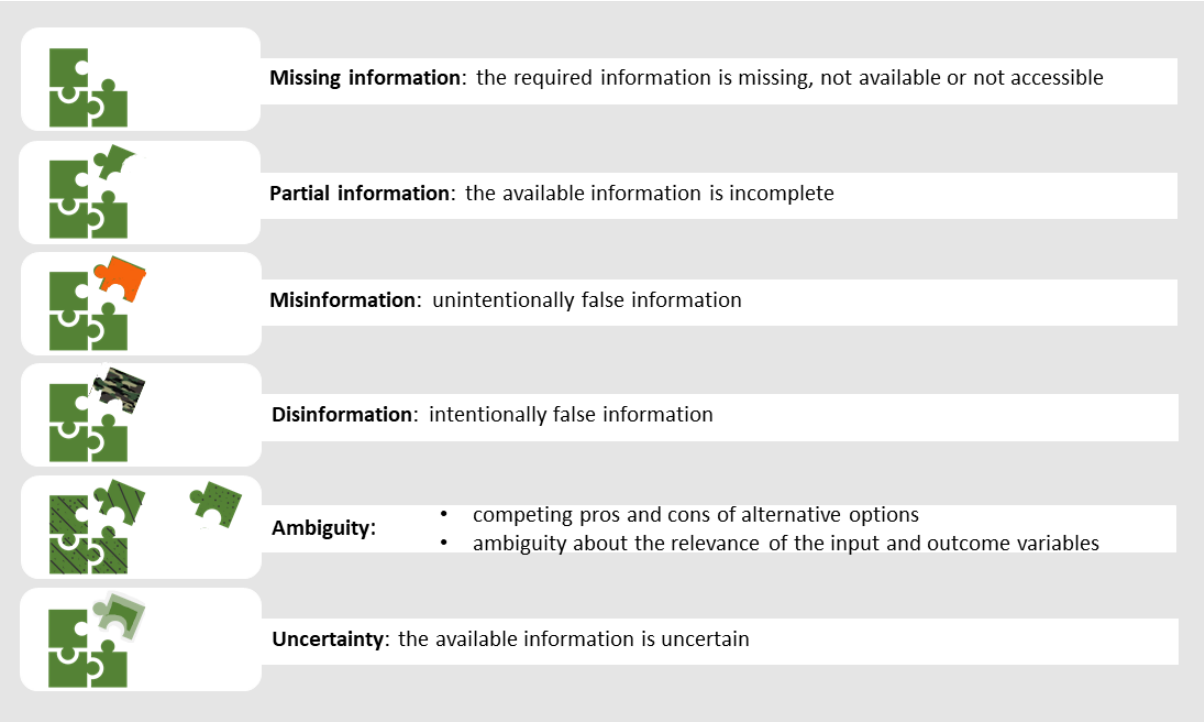
PHASE 1: PERCEIVING CONFLICTING INFORMATION

Conflicting information has previously been defined as "information about a single behaviour producing two distinct outcomes (Nagler, 2014) or "advice provided by two or more sources that consists of propositions that are logically inconsistent with one another" (Carpenter et al., 2016; Carpenter and Han, 2020). Thus, receiving conflicting information results in a situation where an individual cannot engage in or believe both/all propositions at the same time. However, the perception of conflict may be caused by features other than direct informational disagreement (Carpenter et al., 2016). For example, when information is missing or has not been available, one may perceive this as conflicting. Also, when sources state competing pros and cons of alternative options, or in other words, when X is associated with a positive (health) outcome Y and a negative (health) outcome Z, these two propositions are not logically inconsistent but may nevertheless lead a person to perceive this as conflicting information. For example, one source may say that the consumption of red wine is associated with a lower risk of heart attack whereas another source may state that wine consumption is associated with an increased risk of breast cancer. This may leave the individual with the question of whether to drink wine. However, the information is not conflicting per se since two different outcome variables were investigated. Similarly, there may be ambiguity about the input variable (rather than the outcome variable as described in the previous example). For example, one may find a source stating alcohol has no beneficial health effects and another source stating wine may have a positive effect on cardiovascular health. Here the input variables are different (alcohol vs wine) and thus the information is not conflicting per se, however, they are likely to make people perceive these sources as conflicting. Consequently, in these examples, the nature of the conflict is not informational, but rather decisional (Carpenter et al., 2016; Lee et al., 2018). Outside of the health information context, this distinction has also been described in consumer research as "knowledge uncertainty" (uncertainty regarding information about each alternative) versus "decision uncertainty" (uncertainty about which alternative to choose) (Osimani, 2012; Urbany et al., 1989). Acknowledging the differences between whether certain information falls under the definitions for informational or decisional conflicting health information as described by Carpenter et al. (2016) or Nagler (2014), or would be defined as misinformation, disinformation, ambiguity, confusion, uncertainty, or missing information, is useful and certainly a part of the understanding of the concept of conflicting information for both researchers and for laypeople's ability to deal with such information. A visual presentation of the types of (perceived) conflicting information can be found in **Figure 8**. However, those differences are perhaps less relevant when attempting to model the process of handling conflicting information because regardless of what definition would apply, the information may be *perceived* as conflicting and therefore be processed and handled as such. Furthermore, even where decisional and informational conflicts exist, people may not detect them (Stadtler et al., 2013).

Consequently, we distinguish four pathways; whether one perceives a conflict or does not for both scenarios, i.e., whether conflicting information is presented or not.

Textual determinants intersect with individual determinants to produce a source representation of the conflict, underpinned by the individual's memory. That is, to be able to see a lack of coherence between two or more sources, they need to be present in one's memory (Stadtler et al., 2013). As information is added, the representation of a topic or issue in one's memory evolves, and the individual needs to continuously evaluate its level of coherence (Epstein et al., 1984; Van Den Broek and Kendeou, 2008; Rouet and Britt, 2011; Saux et al., 2021). These factors are related to the extent to which people rely on heuristics rather than cognitive effort (Bråten et al., 2014; Ferguson, 2015; Vardeman and Aldoory, 2008).

Figure 8. Types of perceived conflict



PHASE 2. REGULATING A PERCEIVED CONFLICT

Factors such as motivation based on time and effort, personal salience of the information, and features of the sources themselves, may influence whether people follow one of three pathways:

- ignore the conflict; that is, not engaging in any activity that could help with the interpretation of the conflict (Stadtler and Bromme, 2014).
- reconcile the conflict; that is, when a conflict is perceived and the information is considered relevant, one may try to restore coherence in a few ways (Stadtler and Bromme, 2014).
- or accepts the conflict; that is, accepting the concept of different perspectives and including the conflict as a part of their topic-representation (Stadtler and Bromme, 2014). Accepting may then lead to the individual trying to resolve the conflict.

PHASE 3. RESOLVING CONFLICTING INFORMATION

Accepting the conflict does, however, not mean that the individual has been able to acquire knowledge to inform decision-making (Stadtler and Bromme, 2014). People will need to resolve the conflict by judging the validity of the differing claims.

The evaluation of the claims may be influenced by an involuntary, passive, unconscious strategy called "epistemic monitoring" by Richter and Maier (2017). Contrary to the earlier mentioned motivated reasoning, this process takes place when the individual tries to comprehend the information (so after the information seeking and selecting) and focuses on consistency between multiple texts rather than consistency with one's prior beliefs (Richter and Maier, 2017). When epistemic monitoring results in the detection of belief-inconsistent information, this may lead to elaboration and judgement of the information depending on the individual's *epistemic beliefs* (Richter and Maier, 2017; Ferguson, 2015).

This judgement process is typically described by two types of evaluation; first-hand evaluation aims to judge the content of the information and addresses the question "What to believe?", and second-hand evaluations aim to judge the source's credibility or the question "Whom to believe?" (Stadtler and Bromme, 2014; Gottschling et al., 2019). Both first and second-hand evaluation may demand more or less thoughtful actions (Bromme et al., 2010), in contrast to dual-process models which imply deeper and shallower reasoning processes. As such, we could distinguish three possible pathways in this phase; 1) evaluation based on the content of the information, 2) evaluation based on the source information, 3) evaluation based on a combination of both.

PHASE 4: APPLYING THE INFORMATION

When perceived conflict is ignored or reconciled, thus not accepted and resolved, it is less likely to lead to beneficial outcomes and may be more likely to result in adverse cognitive (Ferguson, 2015), affective and emotional (Trevors et al., 2016; Muis et al., 2018) effects, which in turn may lead to adverse attitudinal and behavioural outcomes (e.g., further information avoidance, or not engaging in a health behaviour) (Carpenter et al., 2016; Nagler, 2014; Lee et al., 2018). Interestingly, these adverse effects may carry-over to other topics (e.g., F&V consumption, a topic that is not surrounded by conflicting information) (Nagler et al., 2021) or be generalized (e.g., science distrust) (Chang, 2015). Alternatively, with adaptive epistemic beliefs, when a perceived conflict was accepted and followed by resolution strategies, the newly acquired knowledge and the balanced model of the controversy, are less likely to result in adverse effects and more likely to result in beneficial cognitive, affective and emotional outcomes, including advancement or adoption of more adaptive epistemic beliefs (Kienhues et al., 2011; Ferguson et al., 2013). Thus, the communication of scientific information in multiple conflicting sources may affect cognitive, affective and behavioural outcomes regarding the topic at hand, may carry-over to attitudinal and behavioural outcomes regarding other topics and may influence epistemic cognition.

2.2.5. A conceptual framework for understanding the processing of conflicting health information

In sum, people react in different ways; while some wish to neglect or quickly choose one side when demonstrated with two sides of a story, others demonstrate increased and closer consideration of all the information (Cano, 2005; Chinn and Brewer, 1993; Ferguson, 2015; Kienhues et al., 2011; Rogers and Gould, 2015). Therefore, it is key to identify those factors that best predict or determine which pathway an individual will follow when encountering conflicting information.

Several determinants that modify the communication and processing of information can be identified. **Table 3** provides an overview of determinants that influence the way people process conflicting information. To structure the determinants, the Laswell model of communication (Lasswell, 1948) was used; "who communicates what in what form to whom and to what effect". This model has been used in communication research in several contexts (Hsieh et al., 2012; Tomsett et al., 2020; Wenxiue, 2015), including in the communication of uncertainty (van der Bles et al., 2019). In the present model "what context", "what situation" and "what strategies" were added to the original 5W model; Who communicates what in what form and what context to whom in what situation using what strategies and to what effect.

Table 5. A conceptual framework for the processing of conflicting health information through a structured classification of the determinants involved in the process.

Source				Individual (the information receiver)			
who	**what**	in what **form**	in what **context**	to **whom**	in what **situation**	using what **strategies**	to what **effect**
Source information	Content of the information	Form and presentation	Context of exposure	Characteristics of the individual	Situational characteristics	Processing mechanisms	Outcomes
▪ Type of information source ▪ Date ▪ Characteristics expert/informant	▪ Domain ▪ Topic ▪ Type of conflict	▪ Complexity of the information ▪ Information comprehensibility ▪ Degree of novelty ▪ Degree of uncertainty and explicitness about uncertainty ▪ Degree of conflict and explicitness about conflict	▪ Number of sources ▪ Temporal aspects ▪ Heterogeneity of sources ▪ Lexical encodings use	▪ SES ▪ Memory ▪ Cognitive ability ▪ Knowledge and skills ▪ Attitudes and beliefs ▪ Relationship with what is communicated ▪ Relationship with who communicates ▪ Personality traits ▪ Perceived behavioural control	▪ Reading goals ▪ Uncertainty aversion/tolerance ▪ Conflict aversion/ tolerance ▪ Coherence expectations	▪ Conflict ignorance ▪ Psychological/cognitive biased thinking ▪ Conflict explanation ▪ Information avoidance ▪ Motivated reasoning ▪ Conflict resolution ▪ Firsthand evaluation ▪ Second hand evaluation ▪ Epistemic monitoring ▪ Cross-corroboration	▪ Cognitive ▪ Affective ▪ Attitudinal ▪ Behavioural

Note: Overview of the determinants involved in the handling of conflicting health information, classified based on their role in the communication "Who communicates what in what form and in what context to whom in what situation using what strategies and to what effect". To structure the determinants, we were inspired by the Laswell model of communication (Lasswell, 1948). This model has been used in communication research in several contexts (e.g., Tomsett et al. (2020), Wenxiu (2015) and Hsieh et al. (2012)), including in the communication of uncertainty (van der Bles et al., 2019). In the present model, we adapt and expand the original 5W model, and "what situation", "what context" and "what strategies" were added.
The framework aims to present an open, tentative and flexible structure for the classification of the determinants involved in the processing of conflicting health information. This framework aims to provide a starting point and further additions and refinements of the framework are expected and encouraged.

Who communicates?

Laypeople often lack the capacity to answer the question of "What to believe?" and therefore need to rely on the source that seems most credible (Who to believe?), based on the *type of information source* and the *characteristics of the informant,* including the *date of publishing* (Stadtler and Bromme, 2014).

What is communicated?

Different *domains* are perceived in different ways and the way people will try to explain a perceived conflict may differ by domain. For example, Thomm et al. (2017) found that conflicts in biology were mostly attributed to topic complexity and research methods, whereas conflicts in history tended to be attributed to topic complexity and researchers' personal backgrounds and motivations. Furthermore, exposure to the specific *issue* or *topic* at hand may affect conflict perception as some topics' controversy may, for example, have been more dominant in the media than others (Jensen and Hurley, 2012), and different levels of media attention regarding the controversy within a topic may influence people's ability to detect the conflict (Carpenter et al., 2016). Different causes for disagreement (e.g., based on complexity versus motivational causes) that are at the *basis of the dispute* or the conflict (whether presented in the sources or self-generated) may also influence the way the information is processed (Thomm et al., 2015).

In what form is it communicated?

The level of *complexity of the information* will influence whether the individual is able to detect the conflict (Carpenter et al., 2016; Scharrer et al., 2019). *Text easiness/ comprehensibility* may moderate the extent to which one uses second-hand evaluations to judge claim validity (Scharrer et al., 2013; Scharrer et al., 2012; Scharrer et al., 2019). Moreover, Scharrer et al. (2012) found that people agreed more strongly with comprehensible arguments on medical and climate-related topics than incomprehensible texts. Scharrer et al. (2013) investigated the combined effect of comprehensibility and controversiality on lay people's reliance on their own decisions. The presence of controversy showed to reduce the persuasive influence of comprehensibility, suggesting that when facing conflicting information, people are more cautious and less influenced by the text easiness' persuasive effect. Comprehensible information was also perceived as more credible, and these credibility evaluations were not influenced by controversiality (Scharrer et al., 2013). In addition to its effect on the relative contribution of second-hand vs first-hand evaluation of a claim, Scharrer et al. (2019) hypothesized that text easiness might also influence source memory in their studies; however, the findings showed that memory performance was not affected by text comprehensibility. The credibility of the source, on the other hand, did influence the participants' memory of source information. This finding suggests that when an individual perceives

source credibility to be very low, that may also mean that he or she considers that source to be unworthy to be included in his or her mental representation.

The *degree of uncertainty* as well as *how explicit* the uncertainty is presented are relevant form-related determinants for the processing of information as well (van der Bles et al., 2019). For example, Dieckmann et al. (2017a) investigated the concept of elastic justification (Slovic, 1972) in a study with interpretations of imprecise numerical ranges, i.e., the distribution underlying ambiguous numerical ranges. The findings showed that people's interpretations of seemingly precise numbers can vary in idiosyncratic ways (increasing the variance) as well as in terms of biased information processing (they see what they want to see). The latter motivated reasoning, which can be conscious or unconscious, was found to only appear when given the opportunity. That means, when the correct interpretation of information was provided and made clear, the participants did not interpret the uncertain information in a motivated way (Dieckmann et al., 2017a).

Next to the degree of uncertainty, the *degree of novelty* and the *degree of conflict/disagreement/contradiction* that is presented in the information have an impact on people's motivated reasoning, as for example found in (Chang, 2015). In addition, they took it further than the cognitive outcomes and found that the participants were less likely to change their behaviour when exposed to what they perceived as novel and contradictory health research findings as compared to less novel and contradictory (Chang, 2015). The *level of explicitness about conflict and the reasons for the conflict* will influence one's coherence expectations and as such influence the affective (followed by cognitive and behavioural) responses to conflicting information. Explicit mentioning of the cause(s) for conflict in the information sources, warning people about the existence of conflicts, will make them less likely to feel like their coherence expectations are not met and less likely to generate unwarranted inferences or explanations (Baker and Anderson, 1982; García-Arista et al., 1996; Stadtler et al., 2013; Stadtler and Bromme, 2014)

In what context is it communicated?

As a source level, conflicts may be encoded in several ways; there can be differing contexts in which a conflict is presented, and which will influence the perception and further processing of the conflicting information. These determinants include the *number of sources* one encounters (Carpenter et al., 2016; Yoon et al., 2017), *temporal aspects* (asynchronous conflicting information is when the sources are separated by time whereas synchronous is when they exist simultaneously) (Carpenter et al., 2016; Yoon et al., 2017), whether the sources are *heterogenous* (i.e., different types of sources, e.g., a scientific study and a blog post) versus homogenous (i.e., same type of source, e.g., scientific papers) (Carpenter et al.,

2016), and whether the sources use the same *lexical encodings* to refer to a concept may influence whether an individual perceives information as conflicting (Carpenter et al., 2016; Epstein et al., 1984; Stadtler and Bromme, 2014; Wiley and Myers, 2003; Stadtler et al., 2013; Nagler et al., 2020).

To whom is it communicated?

As mentioned, one's *memory* will play a crucial role in conflict detection and is expected to influence regulation and resolution of a conflict. The individual's socio-economic determinants are also often associated with the way they handle conflicting information. This could probably be explained by the associations between education, occupation, and literacy. However, also *gender* has been found to influence the process as well; in a study by (Chang, 2013) men experienced more ambivalent feelings, less favourable attitudes toward the health issues, and lower intentions to adopt the advocated behaviours when reading 2-sided as opposed to 1-sided news, whereas women did not exhibit such differences.

In addition, several individual determinants can be identified, we have classified them under six types of individual characteristics:

- ***Knowledge and skills***

  The individual's *prior knowledge* (factual and procedural or practical) about the topic and domain at hand will greatly influence the way conflicting information is handled (Rogers and Gould, 2015; Stadtler and Bromme, 2014). Both in the regulation (to judge the new information based on conformity) and in the resolution phase (to judge the validity of the content), prior knowledge will be useful (Stadtler and Bromme, 2014). However, people often lack the required knowledge, yet overestimate their abilities (Keil, 2010; Keil, 2012; Stadtler and Bromme, 2014; Scharrer et al., 2019). Additionally, education level and cognitive ability, including reading skills, numeracy and scientific reasoning skills will play an important role in the way people handle conflicting information (Aharon et al., 2021; Kahan et al., 2017; Pickard et al., 2014; Stadtler and Bromme, 2014; Yang, 2017). One's ability to look for and evaluate source features (*sourcing skills*) will assist them in their second-hand evaluation of the information. In a recent study, nurses were found better able to discern credibility of COVID-related information than laypeople. However, they were found to rely on expertise and authority-related cues and lacked the capacity to appraise publisher expertise and the quality of the scientific evidence (Aharon et al., 2021). Similarly, individuals relied heavily on non-scientific criteria of credibility, with references made to third-party recommendations, other patient stories, and their own personal 'feelings' in a study of patients seeking to establish the credibility of claims about Stam Cell Treatments (Petersen et al., 2019). In addition, an individual's

level of *information literacy* (Hicks, 2022), *media literacy* (e.g., Lee and Ramazan, 2021), *science literacy* (He et al., 2021; Sharon and Baram-Tsabari, 2020)*, health literacy* (e.g., Chung and Lee, 2019; Morton, 2019; Nakayama et al., 2022; Pepper et al., 2019) are increasingly important determinants in the way health and conflicting information are handled.

- ***Attitudes***

People's *worldviews* (e.g., worldviews were found to influence the way imprecise number ranges were interpreted in Dieckmann et al. (2017a) and *prior beliefs* about the topic at hand (e.g., Rafkin et al., 2021) will play a role in the way new conflicting information is processed. A lack of *disagreement awareness* may result in an inability to explain the existence of the conflict, which further diminishes the likelihood that the individual will engage in elaborative processing of the information. Disagreements can be caused by a range of reasons. Differing motivations and levels of competence between experts can result in differing results and conclusions. However, next to these informant-related causes, a range of information and uncertainty related causes can be distinguished as well. The quality and availability of evidence, together with ambiguity about the relevance of the investigated variables, may be causes for disagreements between information sources. Doing science in a real world comes with a certain amount of uncertainty, which may cause conflicting information or may be perceived as such. Knowing how and why disagreement may exist, supports the belief that knowledge is uncertain and complex, and needs to be justified. The individual's *epistemic beliefs* are strong determinants of people's conflicting information processing. Epistemic beliefs may influence the development of the intertext base and mental model of information from multiple texts (Ferguson, 2015) and more adaptive, evaluativist beliefs may make people more aware of the need to assess the quality and validity of information, more likely to cross-check sources and more likely to use external sources to support their positions (Rotshtein, 2019). People's epistemic beliefs are found to influence source evaluations during Web searches for medical information (Kammerer et al., 2013; Kammerer and Gerjets, 2012), people's argumentation about conflicting health information sources, including corroboration across sources and likelihood to include explicit source citations (Bråten et al., 2014b), and consumer assessments of conflicting risk–benefit health information (Rogers and Gould, 2015). Furthermore, an evaluativist level of epistemological understanding seemed to be an indicator of a greater awareness of the sources of knowledge, more suspicion about the validity of evidence that isn't linked to a reliable source, and higher likelihood to discuss the need for more scientific research to be conducted in order to justify making recommendations to consumers about the safety and effectiveness of vitamin supplements in Rotshtein (2019) and generated arguments, counterarguments and rebuttals of higher quality about genetically modified

food in Mason and Scirica (2006). In sum, more adaptive epistemic beliefs may assist with detection of conflict, they may affect motivated reasoning, i.e., more advanced or adaptive epistemic beliefs may be able to decrease the level to which one is subject to confirmation bias, and may influence the evaluation and assessments of conflicting health information.

- ***Relationship with what is communicated***

The relationship one has with what is communicated, their *involvement* and *familiarity* with the topic (Kobayashi, 2019; Leung et al., 2019; Rogers and Gould, 2015) and the *salience of the specific information* (Carpenter et al., 2016; Vardeman and Aldoory, 2008; Li et al., 2020), will influence the way one processes health information (Lähteenmäki, 2013; Dohle and Bucher, 2017).

- ***Relationship with who communicates***

Several have focused on the importance of source credibility in the evaluation of sources (Zuo et al., 2022; Long, 2021; Lyons et al., 2020; Liu et al., 2020; Morton, 2019) and how this may be influenced by not only *perceived knowledgeability* but also *trust* (Im and Huh, 2022; Myers, 2017; Gottschling et al., 2020).

- ***Personality traits***

Personality traits and their psychological biases may also influence the process. For example, one's *need for closure* (Yang et al., 2021a) and level of *optimism* (Byrd et al., 2022; Jun and Nan, 2018) will influence how conflicting health information is processed. *Intrinsic desire for information* is a construct which, when high, may mean that one desires factual information to be able to make an autonomous judgement, whereas low intrinsic desire for information is associated with seeking reassuring information or avoiding information and hand the decision-making to someone else (Åström et al., 2000; Duggan and Bates, 2000; Osimani, 2012). Furthermore, affective responses and satisfaction about received information were also shown to be dependent on the patient's desire to receive it: providing information about medicines to patients who desire it made them feel more satisfied and empowered, whereas providing the same information to those who do not want it made them feel more anxious and less empowered (Duggan and Bates, 2000). Notably, this desire for information is somewhat fluid and greatly influenced by one's perceived level of control (Afifi and Weiner, 2004).

Furthermore, personality aspects may interact with the type/ cause or basis of dispute. For example, personality traits like need for closure (Webster and Kruglanski, 1994), need for control, need for predictability may have a bigger impact on disagreement that comes from inherent uncertainty (about

an unpredictable future) than on disagreement based on epistemic uncertainty (van der Bles et al., 2019).

- ***Perceived behavioural control***

  Whether you perceive your health and health information seeking, understanding and applying as your responsibility (internal *locus of control*) rather than externally located (Ramírez and Carmona, 2018), and whether you feel that you are able to be in control of your health and health behaviours, including health information behaviours (*self-efficacy*) (Chen et al., 2018; Li et al., 2020; Yang et al., 2021a; Zimbres et al., 2021; Zimbres, 2021; Byrd et al., 2022; Martinez-Maldonado et al., 2016) will greatly determine the way one processes conflicting health information. We note that self-efficacy is both a (relatively) stable individual trait and a situational characteristic (see below). In addition, it is worthwhile to note that the level of perceived self-efficacy may be influenced by past encounters with conflicting information (Marshall and Comello, 2019).

In what situation?

The specific situation the individual finds themselves in, based on factors such as the resources (e.g., amount of time) one has available, and their level of volition or willingness and motivation (highly influenced by, e.g., the salience of the information, but potentially also influenced by feeling the need and/or urge to complete a certain task), will determine the individual's goals in terms of reading, in particular the amount of effort put therein. These *reading goals* will greatly influence what information is considered relevant and therefore is more likely to be elaborated on (Kaakinen et al., 2002). In addition, and regardless of initial conflict detection, one's reading goals have been found to influence conflict recall and regulation (Stadtler et al., 2012).

An individual factor, typically called uncertainty tolerance - defined as "the set of negative and positive psychological responses—cognitive, emotional, and behavioural—provoked by the conscious awareness of ignorance about particular aspects of the world" (Hillen et al., 2017, p. 70) - will affect the various psychological responses to perceived uncertainty, which may accompany or follow from perceived uncertainty. A related concept is "tolerance for medical ambiguity" (e.g., Simonovic et al., 2020), with ambiguity defined as present when information is conflicting or there is not enough information to draw adequate conclusions, thus including both uncertainty and conflict. These concepts are related to Ellsberg (1961)'s work in decision theory, characterizing subjective perceptions of ambiguity as important influencers of decisions and judgments of risk alternatives. The work described the concept of "ambiguity aversion" as a human tendency to choose against highly uncertain options (Ellsberg, 1961). When faced with conflicting health information, high ambiguity aversion or low ambiguity tolerance can manifest into

elevated risk perceptions, lower self- and response-efficacy, and lower intentions to engage in healthy behaviours (Byrd et al., 2022; Clark et al., 2019; Marshall and Comello, 2019; Nagler, 2014). *Uncertainty and conflict aversion/tolerance* can be viewed as stable individual traits, however, situational aspects will influence one's responses to uncertainty or conflict, therefore, viewing such tolerance as a momentary state, thus a situational determinant, may be more appropriate (Han et al., 2019).

A considerable amount of research has shown that people search for information that explains the conflict, and when not presented in the information, they generate explanations themselves (Chinn and Brewer, 1993; Stadtler et al., 2013). While this can be a very valuable strategy, there is a considerable risk that the individual may explain the conflict incorrectly. Some have suggested that high *coherence expectations*, based on a lack of conflict explanations in the information source and beliefs that scientific knowledge is certain and unambiguous, are associated with generation of invalid inferences (Bråten et al., 2011; Stadtler and Bromme, 2014; Stahl and Bromme, 2007; Baker and Anderson, 1982; Chang, 2015; Stadtler et al., 2013).

Based on these situational factors, and of course mediated by the source characteristics and other individual characteristics, people will make an evaluation of the emotional, economic, and cognitive cost relative to the perceived information need, coping capacity/efficacy and outcome, which will influence what strategies are used to deal with the information and the perceived conflict therein.

With what strategies?

Several strategies may be used to handle conflicting health information:

Conflict ignorance: Ignoring the conflict, i.e., not engaging in any activity that could help with the interpretation of the conflict is one possible strategy one can use to regulate a perceived conflict. This can be a successful way to regulate a perceived conflict, accomplish coherence and be free from unexplained conflicts in a very economical manner, i.e., without much mental effort (Kaakinen et al., 2002; Stadtler and Bromme, 2014). However, the resulting mental model is incomplete and inadequate. People are more likely to ignore the conflict when the personal salience of the information is low and the information is considered irrelevant (Stadtler and Bromme, 2014). Furthermore, high levels of multiplicist beliefs and personal justification beliefs may make people more likely to ignore the conflict as the belief that knowledge is inherently subjective and expert claims are expert's personal opinions, may mean there is no need to deal with a perceived conflict in information or between experts.

Cognitively biased thinking: The processing of a perceived conflict may be influenced by psychological/cognitive biases. For example, people may be more likely to believe what they read first (e.g., anchoring), or what they read last (e.g., recency) (Regan et al., 2014).

Motivated reasoning and confirmation bias: When a conflict is perceived and the information is considered relevant, one may try to restore coherence (as opposed to accepting the conflict) by inappropriately reconciling the conflict based on congruence with prior knowledge and beliefs (Chang, 2015). High levels of personal justification beliefs, i.e., reliance on internal sources such as gut-feeling or prior knowledge and beliefs as a way to validate knowledge claims, may make people more likely to engage in motivated reasoning (Ferguson, 2015; Greene et al., 2008).

Information avoidance: Depending on factors such as personality traits and perceived self-efficacy, one may opt for information avoidance as an outcome in order to reduce fear and avoid having to respond/deal with the information (Witte, 1996). This could be explained by the concept that additional information may decrease *epistemic uncertainty* while at the same time it increases *emotional uncertainty* (Osimani, 2012). Osimani (2012) further identified "decision sensitivity" (the expected benefit in terms of capacity to change the decision) as an explanation for the choice to avoid information despite a perceived knowledge gap. Theoretical insights, from a consumer behaviour point of view, in the process underlying information avoidance can be found in Woolley and Risen (2021). For example, consumers may avoid calorie information to better enjoy their meals (Thunström et al., 2016) or may avoid medical testing out of fear for a positive diagnosis (Dwyer et al., 2015; Oster et al., 2013). Information avoidance has been investigated in health information seeking (Wedderhoff et al., 2021; He and Li, 2021) and in the processing of ambiguous health information (Simonovic, 2020), contradictory health information (Kim et al., 2018), and conflicting recommendations about electronic cigarettes (Yang et al., 2021b) . It may be associated with *fatalism* beliefs (He and Li, 2021) and rather than opposing information seeking behaviour, information approach and avoidance may vary in the same direction, i.e., people who actively select information that confirms their existing beliefs are also likely to reject information that contradicts their beliefs (Kim et al., 2018). Participants in Barbour et al. (2012) avoided health information to (a) maintain hope or deniability, (b) resist overexposure, (c) accept limits of action, (d) manage flawed information, (e) maintain boundaries, and (f) continue with life/activities. Furthermore, they suggested a link between previous experience with serious illness and health information avoidance. Building on uncertainty management theory, this study demonstrated that health information avoidance is situational, relatively common, not necessarily unhealthy, and may be used to accomplish multiple communication goals (Barbour et al., 2012).

Conflict explanation: The generating of conflict explanations is particularly relevant when the individual has high coherence expectations. These expectations may be influenced by source features, e.g., if there are no explanations for conflict present in the information source, this may create higher expectations for coherence. In addition, given the lack of explanations in the source, the individual will generate

explanations for the perceived conflict by themselves (Stadtler and Bromme, 2014; Bromme et al., 2015; Dieckmann and Johnson, 2019; Dieckmann et al., 2017b; Katz et al., 2018; Thomm and Bromme, 2016; Thomm et al., 2015). For example, based on heuristic cues such as the way the information and the author are presented (Katz et al., 2018; Thomm and Bromme, 2016). Or they may attribute the conflict to the authors' conflicts of interest (Bromme et al., 2015; Dieckmann and Johnson, 2019; Thomm et al., 2015; Dieckmann et al., 2017b). While this can be an effective strategy in some occasions, the resulting mental model is prone to errors as the explanations are not necessarily grounded in evidence.

Conflict resolution: When a conflict is accepted, i.e., accepting the concept and existence of different perspectives and including the conflict as a part of their topic-representation (Stadtler and Bromme, 2014), this may then lead to the individual making an effort to resolve the conflict. The individual will need to resolve the conflict by judging the validity of the differing claims. The evaluation of the claims may be influenced by an involuntary, passive, unconscious strategy called 'epistemic monitoring' by Richter and Maier (2017). The then following judgement process is typically described by two types of evaluation: first-hand and second-hand evaluation.

Epistemic monitoring: The evaluation of the claims may be influenced by an involuntary, passive, unconscious strategy called 'epistemic monitoring' by Richter and Maier (2017). Contrary to motivated reasoning, this process takes place when the individual tries to comprehend the information (so after the information seeking and selecting) and focuses on consistency between multiple sources rather than consistency with one's prior beliefs (Richter and Maier, 2017). When epistemic monitoring results in the detection of belief-inconsistent information, this may lead to elaboration and judgement of the information depending on the individual's epistemic beliefs (Richter and Maier, 2017; Ferguson, 2015).

Firsthand evaluation: This type of evaluation aims to judge the content of the information and addresses the question "What to believe?" Stadtler and Bromme, 2014; Gottschling et al., 2019).

Cross-corroboration: Judging the content of the information may be done by checking and comparing across the multiple sources of information to ensure the veracity of knowledge claims. People with high level of *justification by multiple sources* beliefs may be more likely to engage in this strategy (Ferguson and Bråten, 2013; Ferguson et al., 2012; Ferguson et al., 2013)

Second hand evaluation aim to judge the source's credibility or the question "Whom to believe?" (Stadtler and Bromme, 2014; Gottschling et al., 2019). High justification by authority beliefs, i.e., the reliance on external sources of knowledge, may make people more likely to engage in second hand evaluation (Ferguson, 2015; Greene et al., 2008). Both first and second-hand evaluation may demand

more or less thoughtful actions (Bromme et al., 2010), in contrast to dual-process models, which imply deeper and shallower reasoning processes.

To what effect?

The perception of conflicting information may result in several cognitive, affective, and attitudinal and behavioural outcomes. Exposure to conflicting health information may degrade *attentional mechanisms* responsible for accurate and prompt responding to incoming information (Barnwell et al., 2022) and will influence *comprehension* of information (Ferguson, 2015) and *integration* of multiple views (Anmarkrud et al., 2014). In addition to that, the combination of the models from text comprehension with a model such as the Content Source Integration (Stadtler and Bromme, 2014) model also includes that the individual may experience *affective* and emotional responses such as confusion or annoyance, fear, anger or guilt (Vardeman and Aldoory, 2008; Mason et al., 2017; Trevors et al., 2016) when faced with conflicting information. The perception of conflicting health information can cultivate adverse responses such as beliefs that, for example dietary behaviours do not effect health outcomes, i.e., fatalistic thinking (Ramírez and Carmona, 2018; Ramondt and Ramírez, 2017), negative perceptions of, for example, nutrition recommendations i.e., nutrition backlash (Jensen et al., 2020; Nagler, 2014; Jensen et al., 2017; Patterson et al., 2001) and generalized scepticism towards the media or science. The perception of conflicting information can also have a beneficial effect on the individual's beliefs, more specifically it may lead to more adaptive epistemic beliefs. In addition, the CSI model further extends the cognitive responses by including that the individual will consciously or unconsciously *select a strategy* to deal with the conflict and judges the information and takes a position so that they can *make a decision* (List and Alexander, 2019). The newly acquired knowledge may, through changed beliefs and *attitude*, affect *intention* (Nagler, 2014; Lee et al., 2018; Chang, 2013; Nagler et al., 2021). Intention is a proximate determinant of actual *behaviour*; however, there are still a myriad of pre-motivational (such as perceived subjective norm and behavioural control) and post-motivational factors that influence the intention-behaviour gap (De Vries, 2017; Kremers, 2010).

2.2.6. Discussion

Implications for research and practice

The general public is increasingly aware of the link between lifestyle, health behaviours and health outcomes and the usefulness of health promoting lifestyle choices, and health behaviour information and advice are very prevalent in day to day live (Nutbeam, 2019). In addition, asymmetrical one-way

communication from the health professional to the patient is being replaced with a shared-decision making model where the health professional functions as 'a broker of choice' (Kasper et al., 2012). Rather than functioning as an absolute expert and controller of the decision-making process, the health professional shares uncertainty with the individual, exposing that scientific knowledge is no longer to be seen as certain or stable, nor as being accessible only to experts (Kasper et al., 2012). Furthermore, the internet provides a platform to discuss and distribute health information and makes a tremendous amount of information available and accessible to a large proportion of the population. While this access to information can be a massive advantage, the challenge lies in the evaluation of the sources and integration of the information to come to decision-making and behaviour. Consequently, knowing how to handle conflicting information is an essential aspect of health literacy (Sørensen et al., 2012). To support formation of appropriate mental models of an issue, people need to embrace disagreement and positively engage with conflicting information. We suggest that there are modifiable determinants within the source and the individual that could be addressed by health communicators and health educators respectively.

The individual

People's understanding of a topic that is surrounded by scientific disagreement and conflicting information, will depend on their understanding and appreciation of the processes by which science is conducted (Dieckmann and Johnson, 2019). A more accurate understanding of the role scientists play in the construction of knowledge may allow the public to appreciate why experts may disagree about some topics and express certainty and unanimity over others. Therefore, next to informing the public about what scientists know, it is equally as important to educate lay people about what scientists do (Shapin, 1992). When people are aware why conflicting information may exist, understand how experts may disagree, and understand that this is a normal aspect of science, adverse cognitive and emotional effects are less likely, and they are more likely to accept the conflict and engage in elaborative processing of the information to come to decision making based on a balanced mental model of the controversy (Han et al., 2021). The increased dispute awareness and more adaptive epistemic beliefs may moderate the natural tendency towards motivated reasoning (i.e., seeking and evaluation of information that is consistent with prior knowledge and beliefs) and instead lead to better strategies to handle and process the information (Ferguson, 2015).

Research in developmental psychology suggests that epistemic beliefs can and often do change, and this happens naturally over time along with age, education level, and socioeconomic status. One may develop from more absolutist ("Assertions are facts that are correct or incorrect in their representation of reality.") or multiplicist ("Assertions are opinions freely chosen by and accountable only to their owners.") beliefs

to evaluativism ("Assertions are judgments that can be evaluated and compared according to criteria of argument and evidence."), i.e., more adaptive beliefs (Kuhn et al., 2000). Furthermore, such change may happen through educational intervention. Through a reading task that encourages reflection on the epistemic implications of thought-provoking and conflicting written information, one's beliefs about knowledge and knowing may change and advance. So far, only a limited amount of research has investigated this idea of influencing epistemic beliefs through a short-term text-based intervention (Ferguson et al., 2013; Kerwer and Rosman, 2020; Kienhues et al., 2011; Knight and Thompson, 2020; Rogers and Gould, 2015; Rosman et al., 2019; Kienhues et al., 2008; Han et al., 2021; Kerwer and Rosman, 2018). In a health context, recent studies aimed to manipulate epistemic beliefs about the certainty of knowledge (Han et al., 2021; Rogers and Gould, 2015; Simonovic and Taber, 2022). While Simonovic and Taber (2022) found no significant effects of the uncertainty-normalisation intervention, Rogers and Gould (2015) and Han et al. (2021) did find significant results. In Han et al. (2021), the communication of scientific uncertainty about the COVID-19 pandemic increased perceived likelihood and worry about COVID-19. However, these cognitive and emotional manifestations of ambiguity aversion were reduced when scientific uncertainty was communicated along with uncertainty-normalizing language: levels of COVID-19 risk perceptions did not differ from the control message that did not communicate uncertainty.

Therefore, future research may wish to investigate such manipulation of epistemic beliefs. More specifically, this could involve a short intervention where subjects are confronted with conflicting information, e.g., a set of texts with multiple and opposing views, and consequently are given a multiple document processing task. Through the task, subjects are encouraged to engage with the information to explain and resolve the conflicts, and to reflect on their beliefs. As such, subjects are expected to acquire more advanced and adaptive epistemic beliefs (Ferguson, 2015; Kienhues et al., 2011). In addition, through such learning by doing approach, there may be an impact on their perceived behavioural control as well, i.e., increased self-efficacy concerning their ability to evaluate sources' credibility and validity, together with an increased perception of the locus of control to be within themselves.

In addition, investing in educational efforts to improve objective topic knowledge, skills and literacies remains a critical interventional target.

The communicator

An understanding of this processing may be helpful for both communication senders and receivers. Especially, an awareness of the factors that may determine what strategies are used, may help communicators to shape their message more effectively, for example, being more explicit about

uncertainty or about why their message is in contrast with other. While an author may be reluctant to admit complexity and uncertainty for personal reasons or to express uncertainty out of fear for people's misinterpretation or other adverse effects, we suggest that authors aim to create sources that explicitly address complexity and uncertainty issues and their causes. In order to find the optimal way to present uncertain and conflicting information, an author may wish to consider criteria such as comprehension (e.g., text easiness but also how understandable are the numbers displayed in a source), convenience (e.g., is the provided information easy to attend to and use), usefulness to make decisions or complete a task, and the extent to which an expression (e.g., about uncertainty) leads to motivated reasoning and biased inferences based on the individual's prior knowledge and beliefs (Dieckmann et al., 2017a). Consequently, it is recommended to reduce ambiguity about the interpretation in a given communication context (by clearly providing the correct interpretation next to e.g., a boxplot (Dieckmann et al., 2015) or numerical range (Dieckmann et al., 2017a), while being explicit about the existence of uncertainty and disagreement (by clearly providing the origin of the information and how this could cause potential conflicts with other sources) (Gottschling et al., 2019; Stadtler and Bromme, 2014), in order to nudge people towards elaborated evaluation of the information and away from biased processing.

The development of tools, such as checklists as developed by Oxman et al. (2020), to assist authors with the communication of evidence-based health information, and the dissemination and uptake of those may be of benefit.

Strengths and limitations

Past research on *conflicting health information* tended to be either atheoretical or using a rather narrow focus on particular aspects of the concept that reflected the main interests of the researchers, their disciplines, and a specific research question. In this study we draw on rich data from literature from different disciplines relevant to the processing of conflicting information. The study aims to present a theoretical framework that shows how these different fields can help us better understand how people handle conflicting health information. Strengths of this framework are its a) holistic approach (by providing an overarching framework): Recent expert work identified the need for a holistic framework for conflicting health information (Carpenter et al., 2016; Carpenter and Han, 2020; Han et al., 2019). Our aim here was to develop a better understanding of the phenomenon conflicting health information. While we believe investigation of such broad phenomenon is crucial, this, however, does not mean that we assume that knowledge always translatable across topics. (Note that the topic and domain are identified determinants in our framework.) Differing health topics may need different focuses, and theory building within particular health topics will be of interest in future research (Carpenter et al., 2016; Katz et al.,

2018). The conceptual understanding of a phenomenon is hoped to inform and assist with further topic-specific work.; b) transdisciplinary nature: Handling conflicting health information is a complex phenomenon that encompasses a broad range of concepts, which creates the need, and opportunity, for a critical synthesis and integrative theoretical perspective. In this paper, insights across and beyond various disciplines were integrated to create a framework of the phenomenon "conflicting health information" and ultimately benefit society, i.e., develop a better understanding of the concept, which is required if we wish to assist the public with the handling of conflicting health information, a process they likely have to do on a daily basis. The multidisciplinary approach supports the IUHPE's recommendation that greater collaboration between related fields will benefit the health literacy research agenda (Bröder et al., 2018). However, an understanding of a concept such as conflicting health information, may not only benefit the health field or the education field. Instead by recombining heterogenous information elements related through the operation of a transdisciplinary interface, we aim to encourage the emergence of new knowledge transcending disciplinary boundaries (Choi and Pak, 2006a; Schroeder, 2022); c) its usability (i.e., by proposing an open yet structured way to represent the process and to classify the determinants involved in that process); Rather than empirically testing a theory, we aimed to provide descriptive work on a rigorous and thoughtful collection and organization of observations. In accordance with recent thoughts by Greene (2022) on educational psychology's potential contribution to theory development scholarship, we believe descriptive aspects of theory have a crucial role in the pursuit of knowledge. By presenting the process and determinants in a structured way yet leaving space for further iterations and refinement, the framework aims to provide an overview and structure, guiding further inquiry in future research in the conflicting health information space and for practice as it may inform health communication and education. We emphasise the role of epistemic beliefs and suggest opportunities for educational intervention.

In accordance with the CIS methodology, we wish to explicitly acknowledge the authors' voices in this work, and their influence on the selection, analysis and interpretation of the concept, the literature, and the findings (Dixon-Woods et al., 2006). Furthermore, we wish to acknowledge and emphasise that a conceptualization is always imperfect, incomplete, and subject to regular updates and refinements over time. Consequently, we propose this work as a starting point rather than a final destination. Much future work will be needed. Empirical work to further test several aspects identified in the framework will be required, including work on the development, and testing of reliable measures as well as work on causal pathways. Further refinement of the overall conceptual framework will be needed and is encouraged. As argued by Greene (2022) and in accordance with the reporting practices for the CIS by Dixon-Woods et al. (2006) and Depraetere et al. (2020), we have aimed to provide a high level of transparency in the entire

lifespan of this framework and its development. The findings discussed in section 3, including specific information about the conceptual contributions of different parts of the literature, and the various epistemic iterations that occurred in the process of developing this framework, aim to inform the reader and encourage future scholarly work on further refinements. That is, by detailing the generation, iteration, and development of the current version of the framework, but also by providing information on paths not taken, and ideas potentially worth reconsidering (Greene, 2022).

2.2.7. Conclusion

We have summarized key insights from past research across fields and explored conceptual models and empirical research, identifying gaps in the literature and the need for a holistic view. We develop a framework that can help guide future research to bridge these gaps. Based on critical synthesis and integration, we propose an open, tentative, and flexible framework for the understanding of the processes involved in the handling of conflicting health information. We classify determinants influencing the way people handle conflicting health information in a useable structure based on their role in the communication. People's epistemic beliefs may play a crucial role in the way they handle conflicting health information and could be targeted through intervention. The framework aims to promote a more systematic approach to research on conflicting health information, and to explore promising starting points and future directions for health communication and education research and practice.

3. A conceptualisation of expert disagreement

3.1. Introduction to chapter 3

To effectively navigate scientific conflicts to make informed decisions, it is essential to grasp the underlying causes of such conflicts (Barzilai and Ka'adan, 2017; Barzilai et al., 2020; Thomm et al., 2017). Therefore, gaining insights into why and how experts may hold differing views becomes a fundamental requirement for adeptly managing information (Williams et al., 2023). In addition to conveying scientific knowledge to the public, it is equally important to educate lay individuals about the roles and activities of scientists in constructing knowledge (Shapin, 1992; Thomm et al., 2017). Nevertheless, there exists a gap in the existing frameworks for comprehending the multitude of factors contributing to any potentially perceived contradictions or conflicts between experts. The creation of a comprehensive framework or taxonomy would greatly aid people in navigating these conflicts. A more precise understanding of the roles played by science and scientists in the construction of knowledge will enable the public to comprehend why experts may diverge on certain topics while exhibiting consensus on others. Consequently, this chapter is focused on establishing an overview of the reasons behind expert disagreements in the context of health and delves into the perspectives of experts regarding the utility of a disagreement taxonomy in assisting individuals in managing conflicting information.

In this second study, the aim was to conceptualise experts' views on expert disagreement and the range of potential reasons or causes for the existence of expert disagreements. Based on a literature review and expert interviews, a taxonomy of disagreements was developed.

Through a literature study encompassing the review of conceptual work, empirical evidence, and case studies of expert disagreement around health topics, an initial conceptual model of the taxonomy was constructed. The taxonomy was then further developed, adapted, and evaluated though semi-structured interviews with experts from a variety of disciplines.

The findings describe a taxonomy of disagreements, which classifies ten different causes for expert disagreement. In addition, the potential use of the taxonomy in research and communication and education practice are discussed.

A paper in the form of a journal article based on this study was prepared for *Public Understanding of Science* and has been published in this journal. With permission of the journal, the content of the paper is included in this thesis as it has been published in *Public Understanding of Science*. The original publication can be found here: Deroover, K., Knight, S., Burke, P. F., & Bucher, T. (2023). Why do

experts disagree? The development of a taxonomy. *Public Understanding of Science*, *32*(2), 224-246. https://doi.org/10.1177/09636625221110029

3.2. Study 2: Why do experts disagree? The development of a taxonomy

Abstract

People are increasingly exposed to conflicting health information, and must navigate this information to make numerous decisions, such as which foods to consume, a process many find difficult. Although some consumers attribute these disagreements to aspects related to uncertainty and complexity of research, many use a narrower set of credibility-based explanations. Experts' views on disagreements are underinvestigated and lack explicit identification and classification of the differences in causes for disagreement. Consequently, there is a gap in existing literature to understand the range of reasons for these contradictions. Combining the findings from a literature study and expert interviews, a taxonomy of disagreements was developed. It identifies ten types of disagreement classified under three dimensions: informant-, information-, and uncertainty-related causes for disagreement. The taxonomy may assist with adoption of more effective strategies to deal with conflicting information and contributes to research and practice of science communication in the context of disagreement.

Keywords

conflicting information, consumer decision making, epistemic beliefs, expert disagreement, health communication, health literacy, information literacy, multiple document processing, perceived conflict, scientific disagreement

3.2.1. Introduction

A web search for information by an individual on any health and nutrition issue often results in a large number of varying sources, of which many express differing perspectives on the issue (Lee et al., 2018; Vardeman and Aldoory, 2008). While some of these perspectives will not involve experts, others will, and exposure to conflicting expert provided health information has been found to be associated with confusion and expert backlash, i.e., rejection of expertise as relevant in information processing (Carpenter et al., 2016; Nagler, 2014). This is particularly relevant as such backlash may generalize beyond the target topic to other – non-conflicting – topics, impacting other health behaviours and health promotion messages (Chang, 2013; Nagler, 2014). For example, Nagler (2021) found in a longitudinal experiment that exposure to conflicting information reduces receptivity to other, unrelated, health messages. As such, exposure to conflicting expert information is prevalent among the public, influencing their everyday decisions such as dietary choices (Carpenter et al., 2016; Nagler, 2014).

The way people make informed health decisions is influenced by their engagement with the process and findings of health research (Schapira et al., 2016; Bromme and Goldman, 2014) and an essential aspect of health literacy (Sørensen et al., 2012). Two key issues underpin the challenge of navigating support for lay understanding of expert conflict, as we discuss in the following paragraphs. First, laypeople's explanations for conflicting expert advice rest on a very narrow set of explanations. Second, there is no conceptual model that unifies and explains the range of reasons underpinning expert disagreement in a way that supports the reader with handling perceived conflicting information. Therefore, to support laypeople (non-experts on a given topic) in navigating expert disagreement (information providers who have or are perceived to have relevant expertise on a given topic), this paper aims to develop such a taxonomy.

Narrow Scope of Lay Explanations for Expert Conflict

To address the first issue, prior research in the public understanding of science has confronted consumers with expert disagreements and investigated how they perceive and explain the existence of such disagreements (Thomm and Bromme, 2016; Thomm et al., 2017; Thomm et al., 2015; Bromme et al., 2015; Dieckmann and Johnson, 2019; Dieckmann et al., 2017b; Kajanne and Pirttilä-Backman, 1999). These studies typically use a survey instrument to collect self-reported data on the likelihood of three to four pre-identified causes for disagreement. While the exact findings differ, generally, laypeople tend to rely on a relatively narrow set of explanations. For example, research suggests that laypeople are not able to distinguish between conflict based on the expert's competence versus differences in the research

processes, nor between disagreement that arises from motivational differences in perspective versus interests (Thomm et al., 2015; Dieckmann and Johnson, 2019; Johnson and Dieckmann, 2018).

Experts often question their models, expect to disagree, and acknowledge that science is fundamentally social and cooperative inquiry where progress takes place not in spite of but thanks to a plurality of scientific perspectives (Kuhn, 1962b; Shanteau, 2000). However, many laypeople have a different view of what an expert is, how science is practiced, and how it informs knowledge (Beebe et al., 2019). Therefore, it has been suggested that next to informing laypeople about what scientists know, it is equally as important to educate laypeople about what scientists do (Shapin, 1992). A more accurate understanding of the role scientists play in the construction of knowledge may then allow laypeople to appreciate why experts may disagree about some topics and express certainty and unanimity over others (Barzilai et al., 2020; Douglas, 2015; Smith and Scharmann, 1999; Solomon, 2021). So, while experts have no expectation of agreement, laypeople's perceptions of disagreement are narrow in scope and do not reflect the scientific process; addressing this gap is the aim of this work.

Ambiguities and Gaps in Conceptualising Expert Conflict

Across research in this space, conflicting health information has been defined as two or more health-related propositions that are logically inconsistent with one another in such a way that one cannot engage or believe in both at the same time (Carpenter et al., 2016). This, however, raises an important issue, i.e., laypeople may perceive disagreement where experts do not. For example, when a source states, "coffee is bad for your heart" or "wine is good for your heart" and another source says, "coffee prevents type 2 diabetes" or "wine increases your risk for cancer", the information in these sources is not logically inconsistent, but still leaves the reader with the question "Should I drink coffee/wine?". As such, the conflict is decisional rather than informational but is nevertheless perceived as conflicting and may therefore result in the same processing mechanisms as "actual disagreement" (Carpenter et al., 2016; Weinberger and Bradley, 2020). Therefore, we need ways to support laypeople in conceptualising such conflict and, for example, effectively defeating merchants of doubt (Oreskes and Conway, 2011). To support the public in navigating expert disagreement, a first step is to know why such disagreements may arise.

However, there is little research conceptualising expert disagreement from an expert's perspective (as noted by, for example, Feldman and Warfield (2010) and Matheson and Bryan (2018), although there has been growing recent interest in the topic (e.g., "Disagreement in science", a special issue in Synthese (Dellsén and Baghramian, 2020)). Within philosophy (Dellsén and Baghramian, 2020), science and technology studies (Martin and Richards, 1995; Reiss, 2020), public understanding of science (Yearley,

1994) and within the health context (Carpenter et al., 2016; Carpenter and Han, 2020), the concept of disagreement or conflict between experts has been acknowledged. However, the few papers that take the conceptual approach have not attempted to model this disagreement in a taxonomy and have tended to focus on narrow slices of the problem. Early perspectives on expert knowledge suggest consensus as a requirement for expertise and consequently propose that when experts disagree this is caused by incompetence or due to differing motivations based on ideology, worldviews, or interests (Einhorn, 1974; Hammond and Adelman, 1976). More recently, these traditional perspectives have been complemented by more alternative views of sources of disagreement which recognise the fundamental limits of human judgement (Massimi, 2019; Mumpower and Stewart, 1996; Chociolko, 1995), uncertainty (van der Bles et al., 2019; Kattirtzi and Winskel, 2020; O'Reilly et al., 2011), and the dynamic nature of science and knowledge construction (Barrotta and Montuschi, 2018; Shanteau, 2000; Shapin, 1992; Stoto, 1982; Yearley, 1994). There is, however, a need for an overview of possible causes for expert disagreements that recognises the more commonly known concepts such as *competence* and *conflict of interest* and considers aspects such as the effect of the cultural, social, economic and political context of the experts and their institutions in an overarching manner.

The present study

In sum, literature in the fields of philosophy, education and information processing, health literacy and communication, and the public understanding of science provides some insights into the concept of expert disagreement and how this is perceived by laypeople, however, there is a gap in the literature when it comes to a theoretical understanding of the range of reasons why contradictions may exist or may be perceived. Given the prevalence of conflicting information and the necessity for efforts to improve laypeople's information literacy skills to catch up with the increasing information load and subsequent need and personal responsibility for decision making, such theoretical understanding is timely.

The primary aim of this paper is to provide an overview of the range of possible causes for expert disagreements. To the best of the authors' knowledge, this approach is novel in the sense that it takes an overarching position rather than a theoretical discourse of a specific type of disagreement or the discussion of a certain case where disagreement is perceived. Therefore, this paper contributes to the existing literature through a) the description of a taxonomy development method in the conceptualization of expert disagreement; b) an original overview (i.e., taxonomy) that provides a structure or framework that is usable for researchers and practitioners; and c) to propose the use of this taxonomy as a tool in education practice.

Two research questions are identified: RQ1: What are the causes for expert disagreement? Literature has suggested a need for educating the public about the nature of science (Shapin, 1992; Smith and Scharmann, 1999; Solomon, 2021; Khishfe et al., 2017). A better understanding of the role scientists and experts play in knowledge construction may lead the public to appreciate why experts may disagree and to adopt more adaptive beliefs about the uncertainty of knowledge (Barzilai et al., 2020), which in turn may result in more effective strategies to deal with conflicting information (Ferguson, 2015). Therefore, the second research question is; RQ2: What are experts' perspectives on the use of a taxonomy of disagreement in supporting people with handling conflicting information? To address these research questions, a taxonomy of disagreements was developed. A taxonomy is a sharable structured representation of knowledge that provides a shared terminology, and the development of a taxonomy ideally comprises a conceptual part that is grounded in the literature that is complemented with an empirical part (Nickerson et al., 2013). Therefore, to support the taxonomy building and evaluation process, semi-structured interviews with experts were conducted to collect their views on the concept of expert disagreement. To explain the categories in the taxonomy we use examples within the field of health and nutrition. The health and nutrition context is particularly relevant given the high exposure levels and high stakes, i.e., individual and public health. A particular field or topic may influence the way the conflicts are perceived (e.g., through the level of salience of the information) and the relative weight of the different categories within the taxonomy (e.g., in the nutrition context, the influence of the industry and therefore, the potential for conflicting interests may be more prominent than in other fields). While it is essential to acknowledge the specific context, topic, field and domain one may be perceiving disagreement in, this taxonomy is expected to remain valid across differing domains. That is, the overview remains valid, but it will be the relative weight, or frequency of occurrence, of the categories within the taxonomy that will be different across topics and domains.

The remainder of the paper proceeds as follows; first, the methodology used to establish the taxonomy is described. Second, the dimensions and characteristics of the taxonomy are described narratively. Third, views on how to help people navigate conflicting information and the usability of the proposed taxonomy are discussed. Finally, the limitations of the present study are discussed.

3.2.2. Methodology

In this paper, we use the term "taxonomy" to refer to a classification that can help researchers and practitioners with the understanding and analysing of a complex phenomenon by providing a structure for organising knowledge (Nickerson et al., 2013; Oberländer et al., 2019). The taxonomy development method by Nickerson et al. (2013) was used. This approach has been suggested as a rigorous method for

systematically developing taxonomies (Oberländer et al., 2019; Szopinski et al., 2019) and has been widely used, including in multidisciplinary enquiry within the health context (Hors-Fraile et al., 2018; Yang and Varshney, 2016). The method by Nickerson et al. (2013) describes an iterative approach integrating a conceptual and empirical approach. As such, this iterative approach combines top-down and bottom-up analysis to come to a useful taxonomy. The seven steps (Nickerson et al., 2013), including an initial conceptualisation grounded in the literature and an empirical part based on expert interviews, are presented in **Figure 9**. Further information on the expert sample and interview question outline can be found in **Table 6.** Ethics approval was obtained for this research project, and all participants provided informed consent for their participation.

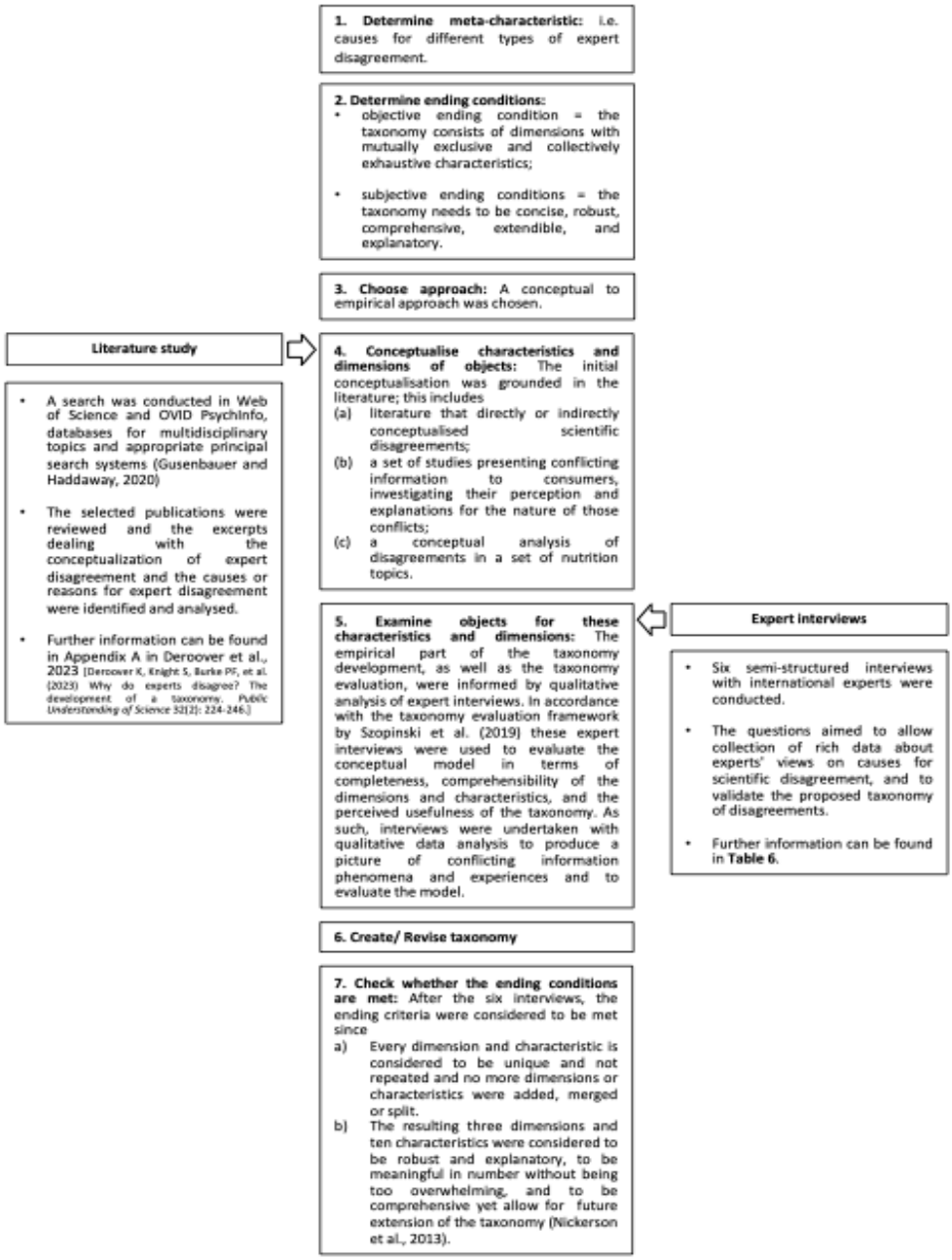


Figure 9. Methods for taxonomy development.

Note: The figure presents the method for taxonomy development used in the present study. The taxonomy development method by Nickerson et al., (2013), which identifies seven steps, was applied. Our approach includes an initial conceptualisation grounded in the literature and an empirical part based on expert interviews.

Table 6. Expert interviews

Description of the expert sample's background and expertise

Purposive sampling technique was used to select experts based on their experience and respective knowledge with regard to science communication and comprehension across a range of contexts.

	Field	*Relevant expertise with regard to (the public understanding of) expert disagreement*
E1	Educational psychology	Public understanding of science, Expert controversies in science
E2	Nursing	Health literacy, Health information evaluation
E3	Consumer behaviour	Health behaviour change, Risk perception and communication
E4	Social cognition	Health psychology, Consumer psychology, Cognitive dissonance
E5	Nutrition science	Science communication
E6	Education	Epistemic cognition, information processing

Interview guideline

The interviews were conducted in person or via video calling and lasted 55 - 95 minutes. These interviews were audio-recorded upon approval of the participants. To conduct the interviews, the researchers prepared an interview guide with a mixture of open and closed questions.

Experiences with conflicting information and scientific disagreement:

- What are your experiences with conflicting information in your daily life? (give concrete examples)
- What are your experiences with conflicting information in your professional life? (give concrete examples)
- How would you describe these conflicts? Could you give that description a label or theme?
- Thinking about those labels, or types of conflict, can you give examples of *different* types of conflict?

Review model

Views on the proposed model:

- Are you able to retrieve all the types you discussed before in this model?
- Would you like to add any other variables that help us to categorise types of disagreement?
- Looking at the model, can you think of examples of different types of conflict for each of the variables identified?
- What are your thoughts on the terminology used? If you think other terms would be better, please annotate.

Views on how to help people navigate conflicting information/ the usability of the proposed model:

- Which of these types of conflict or variables do you think is most important for people to understand?
- Which of these types of conflict or variables do you think people find hardest do navigate or resolve?
- What strategies do you think people use to cope with conflicting information?
- What strategies do you think people should use to cope with conflicting information?
- How do you think this model could be used in practice?
- Do you think it could be adapted to better fit purpose in practice?
- Any other thoughts or comments?

Analysis

NVivo 12 was used to collect, organise, code, and categorise the interview transcripts. As the interviews were semi-structured and aimed to complement the literature review and conceptual analysis, the interview guide functioned as the initial coding framework. Thematic analysis was performed. Through the use of the coding framework, note-taking, and the continuous iterative and reflective process and comparison with theoretical thoughts and field notes, themes were searched, reviewed, defined and named (Nowell et al., 2017).

3.2.3. A taxonomy of causes for expert disagreement

The resulting taxonomy distinguishes three groups of causes; informant related causes, information related causes, and causes based on the uncertainty of doing science in a real world. The taxonomy and its ten categories are presented in **Figure 10.** The resulting characteristics of the taxonomy are described in the following paragraphs. Where deemed appropriate, quotes and examples from the literature and the expert interviews are presented in **Table 7** to support the descriptions in the paragraphs below. Further details on the analysis underlining the taxonomy development can be found in Appendices A and B. A visual representation of the taxonomy is available via an online interactive. There, each category is further explained using the Frayer model (Frayer et al., 1969), describing the definition, characteristics, examples and non-examples. This approach provides a flexible method to both define and illustrate items, while also supporting differentiation between the different categories.

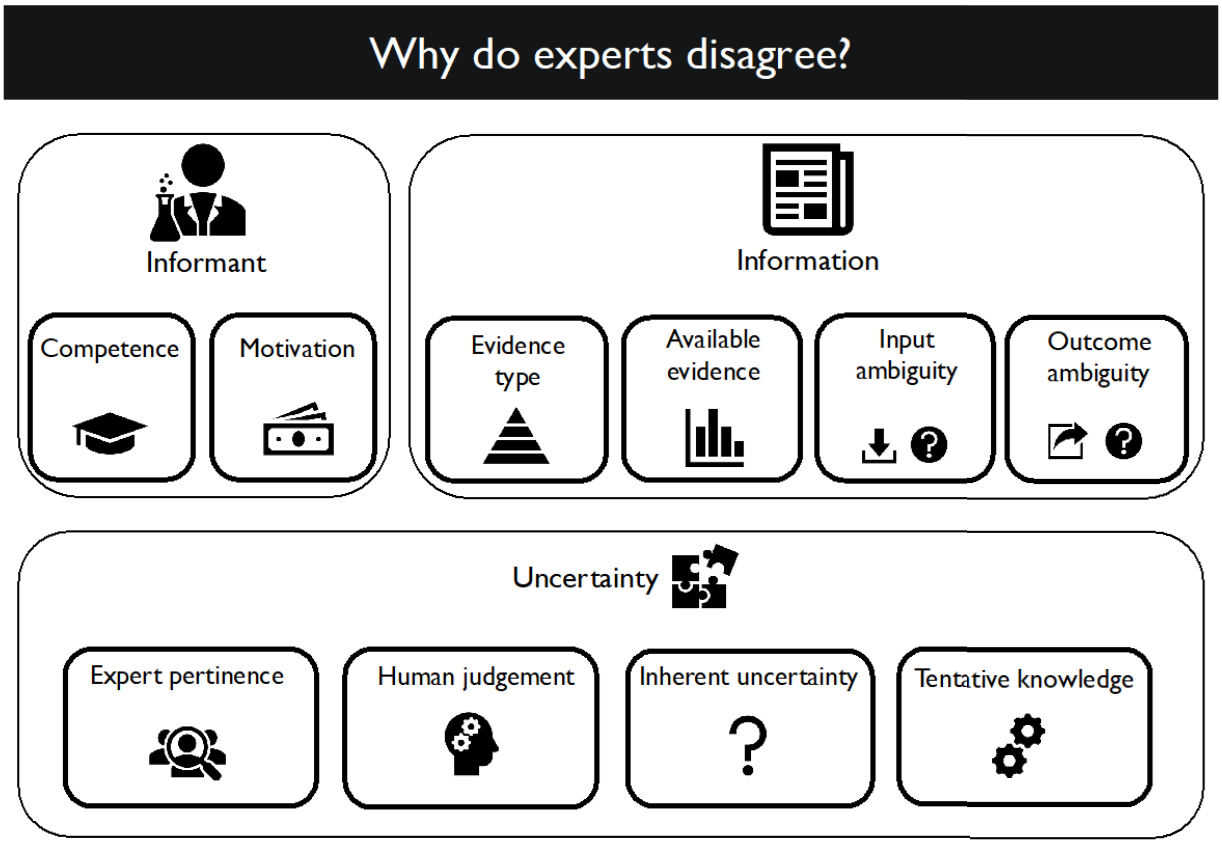


Figure 10. Causes for expert disagreement: ten categories are classed into three groups: Informant-, Information-, and Uncertainty-related causes.

Table 7. Quotes and examples from the expert interviews and literature study to explain the characteristics of the taxonomy.

Taxonomy characteristics	Quotes from expert interviews	Examples from the literature
	Informant-related causes	
Competence	"*If you correlate everything with everything in a large enough sample, you will find correlations that actually have no meaning. Consequently, it may not be possible to replicate the results as it was just coincidence. Inadequate acknowledgement of such scientific uncertainty may be a cause for scientific disagreement based on incompetence*." [E3]	*"Besides the unreliability that may be intrinsic to a complex, ambiguous task such as forensic evaluation, research has identified multiple extrinsic sources of expert disagreement. One such source is limited training and certification for forensic evaluators. While specialised training programs and board certifications have become far more commonplace than in the early days of the field in 70s and 80s, the training and certification of typical clinicians conducting forensic evaluations today remains variable and often poor (De Matteo et al., 2009)."* (Guarnera et al., 2017)*
Motivation based on interests	"*Non-industry funded academics depend on highly competitive research funding schemes. They may feel pressured to publish at a high pace, as track record influences the likelihood to be awarded such funding. In that way it is not only about image but rather financial interest as well*." [E1]	Examples of industry funding biasing outcomes have been described in the food industry (Nguyen, 2020)* and the tobacco industry (Murphy, 2001)* (Krimsky, 2019)*. Furthermore, as described in *Merchants of Doubt*, the narrative around nicotine addiction is an example where the tobacco industry purposely obfuscated the evidence and generated the perception of lack of consensus, specifically using science to make its case (Oreskes and Conway, 2011)*. Another example of the influence of interests concerns the way academic research is organised and the impact of *publish or perish* pressure (Grimes et al., 2018)*. One may also be influenced by non-material interests, i.e., image or status-related interests, such as reputation and recognition.
Motivation based on perspective	"*You really want to find your hypothesis. This can make you blind for other results*." [E3]	Examples of literature describing or referring to the concept of the informant's motivation based on perspective include Althubaiti, 2016*; Jussim et al., 2015*; Massimi, 2019; Montpetit, 2011; Robb, 2020; Weaver and Miller, 2017). Previous literature has referred to this explanation by using the term "ideology" (Mumpower and Stewart, 1996; Yearley, 1994). However, during the taxonomy development, the term "ideology" was replaced by "perspective" as the latter seems to better comprise the collection of worldviews, values and beliefs.
	Information-related causes	
Evidence type	*"You need to think about the body of knowledge and not base your ideas on just one study."* [E1] "*Especially in nutrition science, a lot of evidence is based on correlational research. In large samples such associations are hard to interpret and can be caused by many factors."* [E3] *"An RCT is, however, not always the best. For example, vitamins may be synergistic with other foods. Such interactions may be missed in the experimental setting of RCTs."* [E3]	Although subject to controversy on itself, there is a broad agreement on the relative level of scientific evidence (Parkhurst and Abeysinghe, 2016)*. Often, an RCT is touted as the golden standard, especially in medical research. However, such trials have flaws as well, for example due to their highly controlled experimental, and therefore unnatural, context (Deaton and Cartwright, 2018)*. Weaver & Miller (2017) elaborated on this need within clinical nutrition research*; "Randomized controlled trials in humans are relevant, allow causal inference, and minimize confounding but typically suffer from poor compliance, are of inadequate duration to have disease outcome measures, and are criticized for being artificial compared with the human experience. Epidemiology attempts to find relations in the context of usual behavior and, thus, may fulfill the desire to study steady-state phenomena. On the other hand, results are associational and not causal. Teasing out the role of 1 nutrient or food or a diet pattern from the milieu of confounders is a daunting task. Moreover, the methodologies to capture what individuals eat remains crude. Each line of evidence provides insights, but none are perfect or ideal in nutrition research."*

Availability of evidence	*"Not all experts have the same access to the same data, including both theory and data. So, actually, it's about availability and accessibility of evidence."* [E1]	For example, as described by Carpenter et al.,(2016), one has been advised to take a supplement by expert A, and later on, is advised by expert B that such supplement may cause side effect x. Expert A did not say that the supplement would not cause side effect x, thus both experts did not present contradictory propositions. However, for the individual taking the supplements, this situation may be perceived as expert disagreement (Carpenter et al., 2016). *"Conventionally, public health professionals seek evidence from the published literature. However, in the case of tobacco, much research was done by the industry with the explicit intention that it not be published."* (Rosen et al., 2010)*
Input ambiguity	*"An example in psychology could be the research around self-control and its effect on wellbeing where the definition of self-control is ambiguous and different experts define this construct differently, for example, whether or not that is something you do to reach a long-term goal."* [E3]	An example of input ambiguity was found in the evidence about vitamin D and osteoporosis: *"[…] Most studies show that a lack of vitamin D increases the risk of osteoporosis and the likelihood of hip and other non-spinal fractures. […] Some studies include only women, others both men and women; some include only frail, elderly, or institutionalized subjects, others physically active people; some use vitamin D alone, others a combination of D and varying doses of calcium; and some administer 400 international units (IU) of vitamin D a day, others up to 800 IU a day[…]"* Vitamin D and your health: Breaking old rules, raising new hopes, May 17, 2019. (Harvard Health Publishing, 2019)*
Outcome ambiguity	"*It is so hard to say that the studies we did focus on the same dependent variable. They use similar variables that actually represent the same kind of construct, but they focus on slightly different aspects.*" [E1]	In a health context, surrogate markers and composite outcomes can be used in research, which may be causes for (perceived) disagreement. Surrogate markers are indirect measures that are expected to correlate with the actual outcome variable, and are used because they can, for example, be assessed more quickly and easily (Healthnewsreviews.org). Perceived conflict may, however, arise when an intervention influences a surrogate marker (e.g., bone density) which turns out not to produce a meaningful clinical outcome (e.g., bone fractures). A potential issue with composite outcomes, i.e., when several measurable outcomes are combined into one result, is that it can make a treatment or intervention look more effective than it really is (Healthnewsreviews.org); *[…] Suppose a drug leads to a large reduction in a composite outcome of "death or chest pain." This finding could mean that the drug resulted in fewer deaths and less chest pain. But it is also possible that the composite was driven entirely by a reduction in chest pain with no change, or even an increase, in death […](Cordoba et al., 2010)*)*
	Uncertainty-related causes	
Expert pertinence	"*What dieticians think is important differs from what nutrition scientists think is important. Dieticians and nutrition scientists can vary a lot; a dietician will care a lot more about how you measured something and what the error is of your measurement methods or devices. I think nutrition scientists are happy for devices to have a bit more error."* [E5] *"When I compare basic and applied research, I see that basic research wants to show an effect and it does not matter how big or small that effect is. In applied research however, it is only interesting if it concerns a large effect that can make an impact in real life."* [E3]	*"[…] Basic scientists prioritize finding a molecular mechanism for what a nutrient does or how nutrient status influences molecular machinery. Without that, they are not convinced of the phenomenon. Critics of this approach disagree. What is learned from in vitro studies may not represent the human condition and may very well be an artifact of the manipulated environment. Animal models provide the distinct advantage of allowing long-term controlled diet designs with disease outcomes. However, no animal model is a completely satisfactory model of a human disease. […]"* (Weaver & Miller, 2017)
Human judgement on problem structure	*"So what is the real problem here? Why something emerges or what to do about it?"* [E4]	Expert disagreements may arise when experts use different problem definitions caused by fact-value confusion (Elliott, 2019*; Parkkinen et al., 2017*).

	"*Researchers often only deal with one small part of something and are then asked to make conclusions and recommendations for much bigger things. However, they often have no idea how to implement findings in politics or interventions."* [E3] *"One needs to decide on the kind of factors to observe and on the interpretation of the findings. This interpretation happens on two levels; the interpretation of the study data and the interpretation of the overall pattern of results as you not only refer to your own results but also to the findings of other researchers."* [E1]	*"[…] Most studies show that a lack of vitamin D increases the risk of osteoporosis and the likelihood of hip and other non-spinal fractures. But there is considerable disagreement about how much supplements reduce the risk of fractures. […]* (Harvard Health Publishing, 2019)* Consequently, in this example, the conflict may not be caused by a disagreement about the question "what is?" (there is a link between vit D and osteoporosis) but is instead a result of disagreement about the question "what should be done about this?" (are vit D supplements recommended?) or the social value and implications. It may be noted that this fact-value confusion may be endorsed by the idea that while experts, in fact, may wish to solely discover new phenomena and answer the "What is?" question, others often expect them to inform policymaking (Holst and Molander, 2018)*.
Inherent uncertainty	"*There is always another finding that could disapprove your findings, especially in human sciences, you're never 100% sure.*" [E4]	*"[…] Conflicting information about the effects of coffee abound. […] Perhaps the reason so many studies come up with so many different conclusions is that every person is different to a degree, especially in the way they metabolize substances. […]" (ZME Science, 2019)**
Tentative knowledge	*"Our findings changed as we've gotten better at measuring and testing, and the research process changed over the years."* [E5] *"We're still figuring it out, but we can't wait for perfect information to be able to make a decision."* [E5]	*"[…] Conflicting information about the effects of coffee abound. Until not too long ago, the WHO classified coffee as "possibly" carcinogenic, but later reversed the statement stating that evidence for the association between coffee and cancer is inadequate. . […]"(ZME Science, 2019)** The general public typically expects science to provide sound and definitive information. Many readers seem to associate references to tentativeness with reduced credibility (Flemming, Feinkohl, Cress, & Kimmerle, 2015)*.

Note: The references marked with an (*) can be found in the reference lists in Appendix B.

Dimension 1: Informant-related causes

In a first dimension, we identify the informant's competence, interests and perspective as possible causes for disagreement. While differences in competence and motivation are possible causes for scientists to disagree with one another, it is essential to acknowledge that there is no scientific method that bypasses all hurdles, avoids all biases and distinguishes "good" scientific practices from "bad". Often evidence from several types of research is needed to be able to triangulate claims. Furthermore, as we discuss further in the taxonomy elements "evidence type" and "human judgement" below, experts must make judgements all along the scientific process, many of which may be equally "correct". This point is independent of differences in methodology that are based on competence or motivation, which are the focus of informant-related causes. This distinction reflects the nature of science as contested and evolving even among those with the same levels of expertise and motivations (epistemic peers). That is, disagreement can arise when experts interpret and weigh values in different but equally rational ways (Kuhn, 1962b; Seidel, 2019). Nevertheless, both competence and motivation are important features of informant-related disagreement, as we outline.

Competence

Experts may have different levels of competence based on their educational/ professional background, experience and scientific expertise. Their level of competence may influence the methods or research process they use to answer a research question; This includes the way they interpret the problem, and the way data are collected, integrated, analysed, and interpreted (Gerrits et al., 2019). The methodology used in research is subject to several types of bias. Different methods may be able to avoid these biases to a greater or lesser extent and may, therefore, come to different findings and conclusions. Next to background and experience, experts' competence may also be influenced by one's ability to invest the required amounts of time and effort to make well-informed, reasoned decisions.

Motivation

Although fundamentally competent, an expert may not be willing or able to provide correct and sufficient information because of underlying motivations. It is, however, worthwhile noting the importance, but complexity, of distinguishing between misconduct, honest error and scientific disagreement (Resnik and Stewart Jr, 2012). Expert disagreement can be caused by differences in motivation, which can be influenced by interests and perspectives. Experts, or the business/organisation the experts are associated with, may be influenced by ***interests***. Interests could be material or financial; for example, an expert working in the industry may have a financial interest in reporting only those findings that are in favour of the product that the industry produces or offers. Differences in interests may result in selective reporting

of findings or may affect the expert's willingness to admit uncertainty about reported findings. For laypeople, it may be of interest to consider the potential of personal interests when evaluating information sources and recognise the ways funding environments and political factors may influence research topics and outputs. Perhaps often on a more unintentional level, experts (or the business/ organisation the experts are associated with) may be influenced by their ***perspectives***, including their worldviews, values, and beliefs about social, ethical, cultural, religious or political aspects (Montpetit, 2011; Weaver and Miller, 2017; Massimi, 2019). Such beliefs or preconceived ideas about the topic may, intentionally or unintentionally, cause a tendency to confirm one's prior beliefs or hypotheses.

Dimension 2: Information-related causes

Next to informant-related causes for disagreement, we identify four types of information-related causes. Differing types, as well as availability, of evidence, could be causes for expert disagreement and are typically evident for experts, however, as discussed in the introduction, less frequently identified by lay people. In addition, in some cases, it is not the probability of certain information that is questioned, but instead, expert disagreement may be caused by ambiguity about the relevance of the input or outcome variable.

Evidence type

Not all scientific evidence has the same level of strength, quality and rigour, and such differences can be a cause for differing findings and conclusions. In constructing a mental model of a problem space, people should consider the type of evidence present, and its quality for addressing the problem. For example, different weights should be given to evidence that is based on a study that describes a single case versus a study that combines the findings of multiple studies and includes an indication of the quality of those studies. Several experts emphasised the difference between correlational and causal research and the importance of this difference in the evaluation of evidence. While the evidence hierarchy may be useful to show the higher level of strength of a meta-analysis versus a case report, it may be better to evaluate evidence based on the knowledge of different research designs and their relative ability to answer the research questions rather than using a fixed hierarchy.

Availability of evidence

Missing information, while seemingly causing gaps in understanding – rather than disagreement – may nevertheless lead to the perception of conflict. Such information gaps related to an expert missing information, could be due to unavailability or inaccessibility of that information to the expert, at the

particular time. Not all experts always have access to the same evidence, including both the theory and data. Academic papers are not always published in open-access databases, which may make them inaccessible for some. Alternatively, accessibility may be temporarily enabled due to a delay in the dissemination of new data. In the case of business-generated data, there may even be interests or incentives to withhold information from others (Rosen et al., 2010). Consequently, experts may not have access to the most relevant and recent information.

Input ambiguity

In some cases, it is not the probability of certain information that is questioned, but instead, expert disagreement may be caused by ambiguity about the relevance of the input variable, i.e., we need to define clearly what 'x' is in claims like: 'x' causes 'y'. This may be relevant for subcategories within a certain input variable. For example, when talking about the health impact of wine consumption, up to what extent are studies on the health impact of alcohol in general, and not specifically wine, then relevant? Standard wine contains alcohol, and wine consumption may, therefore, be subject to many of the outcomes that are associated with alcohol consumption. However, wine, and the wine consumer, could differ from other alcoholic beverages and their consumers, for example, through the presence of certain phenolic compounds and the concept that wine is often consumed with food and in moderation (Klatsky et al., 2003). Consequently, expert disagreement may arise from the ambiguity around the relevance of studies that used alcohol consumption as the input variable for the discussion about the health impact of wine.

Outcome ambiguity

The relevance of the outcome variable can be subject to ambiguity as well, i.e., there is a need to define clearly what 'y' is in claims like: 'x' causes 'y'. Often concepts like health or wellbeing are ultimately the outcome variable of interest, however, such variables are hard to define and may depend on personal and contextual differences. As such, experts may define the same construct differently.

Dimension 3: Uncertainty-related causes

Doing science in a real world involves a high degree of uncertainty. This uncertainty may come from the randomness of the world, the need for human judgement in the scientific process and the limitations of people's knowledge. Experts are often uncertain about their own estimates and findings, and discussion of competing explanations or interpretations is considered an essential aspect of the scientific ethos (e.g., "organised scepticism" in Merton and Merton (1968)). Laypeople may perceive this openly displayed

uncertainty with cynicism and consequently conclude that the issue/expert must, therefore, not be science/an expert after all (Flemming et al., 2020; Shapin, 1992). Knowing what can cause the uncertainty in experts may help people to appreciate communicated uncertainty (Jensen, 2008; Jensen et al., 2011).

Expert pertinence

Even when an expert is competent, and bias does not appear to be a problem, there can be uncertainty about the relevance of that expert to answer a specific question. This is particularly relevant for complex topics where several fields are involved, which may have different ways to look at a certain topic. For example, in policymaking around alcohol consumption, experts from different fields, such as the beverages industry, health promoters, politicians, social workers, etc., are involved, but there can be doubt about the relative weights of their voices.

Human judgement on problem structure

Experts may have differing ideas about how best to conduct science as a social endeavour in which they draw on, and contribute to, networks of expertise (Cranor, 2005). Experts have to make judgements about the way a) the problem is defined and b) the information is integrated (Mumpower and Stewart, 1996). Differences in the way the problem is seen by different experts may lead to differing problem definitions, research methodology, interpretation of the findings and formulation of conclusions. Different ways in which an expert organises and integrates information can also be a cause for disagreement. An expert's judgement on organising principles is required at different levels; 1) the construction of a mental model, including the identity of variables and the direction of causality and relative importance of factors; 2) the use of a cognitive process to judge information, for example, the use of an analytical versus an intuitive approach to select and assess information; 3) the employment of organising and integrative models, for example, different types of model may suit different expert's judgement processes in a better way (Mumpower and Stewart, 1996). Recently, Lichtenstein (2021) pointed out that theory choice is often based on pursuit-worthiness, more than whether it is the most successful theory to address a question or phenomenon. Consequently, scientists' beliefs in the current epistemic or explanatory value of a theory they pursue may be overestimated when one fails to note that theory choice is influenced by considerations of the scientific process, including developmental promise, problem salience, and methodological approach (Lichtenstein, 2021).

Inherent uncertainty

Inherent uncertainty refers to uncertainty due to the randomness of the world. It distinguishes itself from epistemic uncertainty, which refers to the type of uncertainty that is about how much one knows about something. This inherent uncertainty resembles with what has been called "aleatory uncertainty" by some,

who defined it as the probability associated with future outcomes (van der Bles et al., 2019). Where inherent uncertainty refers to the future, epistemic uncertainty is about the certainty we have about present issues and represents the recognition of the limitations of people's knowledge. Epistemic uncertainty refers to knowledge about phenomena that is currently incomplete but theoretically attainable. Consequently, epistemic uncertainty can be reduced, for example, through changes in the scientific methodology, whereas aleatory or inherent uncertainty cannot (Dieckmann et al., 2017b).

Tentative knowledge

As experts a) work in dynamic situations with evolving conditions and constraints, and b) keep building upon existing knowledge, they keep revising and updating ideas, theories, and concepts (Shanteau, 2000). This dynamic nature of knowledge means that the "facts" of today may tomorrow be obsolete and regarded as the flaws of yesterday. Furthermore, social (need for policies) and financial (lack of funding) factors may hasten the process to come to solutions quickly and pressure scientists not to engage in debates or express uncertainty (Shapin, 1992; Yearley, 1994).

3.2.4. Views on how to help people navigate conflicting information and the usability of the proposed taxonomy

While the dimensions and their elements discussed above are individually recognised in both the literature, and the expert interviews, the purpose of the taxonomy is to bring these dimensions of disagreement together to provide a shared conceptualisation (as Table 2 demonstrates). As described in section 2. Methodology, in the expert consultation component of the taxonomy development, a part of the interview focused on the use of the taxonomy in practice and the potential barriers that may come with that. In the following we present and discuss these findings.

Relative importance and difficulty of the different characteristics

Experts were prompted to discuss issues around the types of conflict or variables that are "most important" or "hardest to navigate or resolve". These questions provide important insight into how the taxonomy might be used to support lay understanding of expert disagreement, and the areas to which attention should be paid in developing resources. The informant- related causes, i.e., Competence and Motivation, together with Evidence type, were most frequently considered the most important categories to understand, followed by Inherent uncertainty, and the Tentativeness of knowledge and Outcome ambiguity. Outcome ambiguity, Evidence type and Inherent uncertainty were most frequently indicated as the hardest categories to understand. In addition, Input ambiguity was the second most frequently

indicated category that is hard to understand, followed by Expert Pertinence, Human judgement, and the tentativeness of knowledge.

Coping strategies

Five non-mutually exclusive illustrative strategies people may use to cope with conflicting information that may be adaptive, emerged from the interviews, along with determinants that may influence these coping strategies, as illustrated with quotes in **Table 8**:

(1) Evaluation of the information, to identify which claims may be replaced, complemented, or mixed;

(2) Evaluation of the source information, for example for credibility or competence markers;

(3) Motivated reasoning or the reliance on one's prior knowledge and beliefs to evaluate the new information;

(4) Heuristic cues such as source authority (i.e., status) or authoritativeness (i.e., status symbols) to help them decide rather than basing their decision on evaluation

(5) Psychological biases, such as recency and primacy effects

Next to these strategies people may use to cope with conflicting information, the interviews also identified factors or determinants that may influence the way people cope with conflicting information. Contextual factors, such as the readability of a text, may influence the strategies used, but also the domain in which the topic is situated may have an important influence on the strategies used. Individual factors, such as personality traits (e.g., tolerance for uncertainty, need for closure, etc.) will play a role in the way people deal with conflicting information. In addition, topic involvement or the relevance of the information to the reader may influence their information processing.

These strategies and determinants are features of how people deal with conflicting information. It is therefore important that we understand them and potentially help laypeople and experts to become aware of these features in the context of disagreement. As the data from the interviews suggests, knowledge and awareness of this taxonomy may assist people directly with the evaluation of the source and content of the information, and indirectly by facilitating an awareness of the ways people may deal with conflicting information. Further elaboration on the coping strategies people may use, and the mechanisms that may play when faced with conflicting information and expert disagreement is outside the scope of this paper. However, it is important to note that several textual, contextual, situational and individual determinants play roles in determining how one engages with scientific information, thinks critically about health claims, and how conflicting information is processed (Stadtler and Bromme, 2014; Walton, 2017; Kahan,

2012), as well as the extent up to which this taxonomy may be able to assist with that. For example, concerning individual characteristics, it is likely that in practice, some elements may be more salient among certain subgroups within the public relative to others. Some may be more likely to recognise that experts disagree because of their educational background if they themselves have been exposed to a variety of professional and educational settings. Also, people may perceive and experience uncertainty differently as a result of their lower need for cognitive closure (Webster and Kruglanski, 1994), a trait which provides them with an ability to confidently sit with disagreement and ambiguity. Additionally, cultural cognition, or one's tendency to form risk perceptions that are in accordance with their values, has been shown to shape individuals' beliefs about the existence of scientific consensus and the soundness of information (Kahan et al.,2011). Further research should investigate the effect of such individual differences.

Table 8. Quotes by the interviewees to illustrate their views on how people cope with conflicting information.

Strategies	Psychologically biased thinking	Recency and primacy effects	"*They believe that what they first read is right, or sometimes what they last read*." [E4] "*People believe what they first heard more than what they hear afterwards*" [E5]
		Heuristic cues	"*We put different weights on the information depending on who's delivering it and whether or not we trust them and whether they present with confidence."* [E5] "*When people read media, they often follow heuristic cues. For example, "I believe the Professor because his status makes him more believable." People will look for cues."* [E3]
		Motivated reasoning	"*They go with the info they want to believe in. People invest in the answer they want it to be. It will be hard to work around that emotional aspect."* [E2]
	Critical evaluation of the information	Evaluation source	*"First, they would use sourcing strategies; so, who wrote it, what are the author's credentials? Then they would hopefully be looking for markers of reliable knowledge production."* [E6]
		Evaluation content	"*People don't discriminate between evidence-based and anecdotal. In fact, a narrative can be very powerful."* [E2]
Determinants	Contextual factors	Presentation	"*I think the context will greatly determine the strategies one uses. For example, format and lay-out, but also readability and the ease of information retrieval will play an important role."* [E4]
		Domain/field of the topic	"*People may cope with conflicting information in different ways depending on the domain they are in. For example, medical or scientific fields like medicine are perceived to only use more objective research methods and be more objective in their standards while in social science the knowledge is perceived to be more subjective, more personal, more derived through opinions."* [E1]
	Individual factors	Personality traits	"*One's personality traits will also have an important effect on the strategies that person uses to cope with conflicting information. For*

	example, people have different levels of tolerance for uncertainty." [E4]
Relationship with the information	"*Involvement with the topic and relevance of the information will influence how people cope with conflicting information."* [E4] "*The appearance of a disagreement will depend on the relevance of the info to the reader*." [E4]

Note: Analysis of the experts' answers to "What strategies do people use to cope with conflicting information?". Five non-mutually exclusive illustrative strategies people may use to cope with conflicting information emerged from the interviews, along with determinants that may influence these coping strategies, as illustrated with quotes.

Use of taxonomy to inform practice

The taxonomy presented in this paper aims to list and classify possible causes for disagreement and suggests a terminology to use in the communication about disagreement. As such, it provides researchers with a framework and terminology to use in future research. In addition, we propose that the taxonomy may be used to inform practice. For communicators (those on the providing end of a message), it can help them framing their message so that it assists the reader in the evaluation of the source and the information itself and promote more effective science communication efforts. For readers (those on the receiving end of a message), it may support the handling of conflicting information.

For readers to effectively process conflicting information we must support them; a key component of this is education regarding the existence of conflict and its causes (Smith and Scharmann, 1999; Solomon, 2021). When experts are viewed as guardians of the truth and messengers of certain and unambiguous information, exposure to expert disagreement may result in confusion and rejection of the information (Nagler, 2014; Shapin, 1992). In such cases, exposure to conflicting information may also impact the readers' general beliefs about the credibility of scientists, science, and their advice (Chang, 2015; Lee et al., 2018; Nagler, 2014). The characteristics in this taxonomy may be used in raising awareness about what scientists do, how that informs knowledge and the normalcy of expert disagreement. Such awareness may result in more adaptive epistemic beliefs, i.e., the belief that knowledge is uncertain and dynamic and that knowing requires justification, e.g., cross-corroboration between multiple sources (Flemming et al., 2020). Epistemic beliefs are thought to play an important role in the way people process information and handle conflict (Knight et al., 2017). Those with more adaptive beliefs are expected to be less likely to discredit health advice or science in general and being less likely to ignore the information but instead actively engage with the information on both sides of the disagreement to come to well-informed decision-making (Ferguson, 2015; Rogers and Gould, 2015).

> "*These days, in health, there is a movement to empower the patient and give them options. We say these are the costs, risks, and benefits, you make the decision*." [E2]

"*I think it is very important to help people understand the normalcy of expert disagreement*." [E3]

Previous research has found that lay people tend to use a very narrow set of attributes to explain the existence of expert disagreement (Dieckmann and Johnson, 2019; Dieckmann et al., 2017b; Thomm et al., 2017; Thomm et al., 2015). This taxonomy may educate people about additional possible causes for disagreement, e.g., it may inform them that next to informant-related causes, there are a range of information and uncertainty- related causes that could explain the perceived disagreement. Being able to explain a conflict may then help readers to resolve a perceived conflict. However, resolution may depend on the type of disagreement, sometimes implying 'becoming comfortable with', for example uncertainty and ambiguity, and in other cases implying resolution via improved understanding of expertise relevance. Further research on how lay people navigate resolution of conflict in the context of the taxonomy types is warranted.

> "*This taxonomy may help people with understanding that there are a lot of different potential causes for disagreement. Whether it also helps them resolving a specific conflict that they encounter will depend on the specific type of conflict that is present; if the disagreement is based on differences in motivation, this could be a direct explanation or direct strategy to dismiss this point. But, for example, when they explain the disagreement as due to complexity or uncertainty, it becomes much more difficult for them because being able to explain it does not mean that they are able to resolve it. So, there is also a different quality in the explanations whether they actually indicate already a strategy to resolve or whether they need other strategies to resolve the explanation*." [E1]

We propose the use of this taxonomy in combination with reading and writing tasks that encourage reflection upon opposing views, as such the taxonomy would ideally function as an instrument that helps or guides such reflective cognitive efforts in a learning-by-doing context.

> "*This taxonomy can be used as part of a curriculum. Students could be shown media reports and asked to investigate the information by using the taxonomy. Media training is now done at school. Science, information, and health literacy can be added to the school curriculum*." [E3]

> "*For students, it is very important to think explicitly about what knowledge is. This taxonomy helps to unpack that for them. It facilitates an understanding of the complexity and the many factors that play in knowledge construction*" [E6]

Dispute awareness, adaptive epistemic beliefs, and knowledge about causes for expert disagreement, as for example acquired through this taxonomy, are only one part of information literacy. Supporting people to learn how to think critically and make balanced judgements about information requires a multi-faceted approach, including reading skills, numeracy and scientific reasoning skills (Pickard et al., 2014).

Barriers

Some may question whether teaching people about the causes for expert disagreement should be seen as a part of science, and health, literacy, based on a concern that it would feed people's scepticism about science and scientists rather than advancing their beliefs (Simis et al., 2016; Frewer et al., 2003; Flemming et al., 2020). Fostering a cognitive state where people recognize that all information is provisional and contested, and consequently encouraging people to question absolutely everything, may make them cynical rather than critical. As a result, people may adopt overly multiplicist epistemic beliefs ("there are many ways to be true") or even collapse into "anti-science-ism", just like the dispute-unaware with highly absolutist beliefs would ("truth is fixed and singular"). Further research will be essential to investigate the influence of knowledge and beliefs about the causes for disagreement on the way people process conflicting information, their level of health literacy, their decision-making and health-related behaviours (Dieckmann et al., 2017b). More specifically, further investigation of the fine line of productive evaluativism in between unproductive ignorance and unproductive relativism is needed ("knowledge is justified through evolving, imperfect, methods"). In addition, investigation of the practical usability of this taxonomy to encourage evaluation of information to come to an accurate and balanced assessment of information will be necessary.

3.2.5. Limitations of the present research approach

This research contributes a taxonomy of disagreements, grounded in a taxonomy development methodology comprising review of the literature and expert interviews. To support the validity and reliability of this qualitative analysis several approaches were taken. First, to increase credibility, transferability, dependability and confirmability of the qualitative data analysis, the methodology for thematic analysis by Nowell et al. (2017) was used. Second, an established rigorous method, detailing ending criteria, was used for systematic taxonomy development as per Nickerson et al. (2013) and for evaluation of the comprehensibility, completeness and perceived usefulness of the taxonomy as per Szopinski et al. (2019). Third, the interviewees were selected based on their expertise and relevance to discuss expert disagreement, which is a requirement in taxonomy building and evaluation (Szopinski et al., 2019). Nevertheless, the small sample size and such purposive sampling method also have important

limitations regarding representativeness and generalizability. Furthermore, we wish to acknowledge that a best, correct or finished taxonomy may be undefinable and should not be seen as the aim or target, as it may very well be a moving target. Instead, this taxonomy aims to be extendible, and to provide a tool to raise awareness, spark discussion, and encourage further research. Future research should test the use of this taxonomy as a tool in the design of educational interventions that aim to improve people's handling of conflicting information. Finally, it is essential to acknowledge the direct and indirect influence of the researcher on the interview and in the qualitative data analysis. We believe, however, that an understanding of the concept of expert disagreement ideally arises from multiple views from the researchers and interviewees, which are all acting on the basis of their subjective knowledge and context-dependent reality, and therefore view this collaborative approach on the constructivist side of the research paradigm continuum an asset rather than a limitation (Guba and Lincoln, 1994).

3.2.6. Conclusion

Conceptualising expert disagreement is a crucial step in supporting lay understanding of such disagreement to mitigate against rejection of expert information and reduce confusion. This paper aims to contribute to the conceptualisation of disagreement and to facilitate an awareness of the differences therein. Based on the taxonomy development approach, including expert interviews and literature review, undertaken in this paper, this taxonomy identifies ten characteristics. It classifies these under three dimensions: informant-, information-, and uncertainty-related causes for expert disagreement. The primary use of the present taxonomy is to provide a theoretical base for further research and communication around expert disagreement. Additionally, knowledge about the range of causes for discerning information may help with an effective evaluation of, e.g., health, information, and the developed taxonomy may inform and help both communicators and readers with the transfer of evidence-based information.

4. An experiment with conflicting health information sources

4.1. Introduction to chapter 4

Research within the field of educational psychology suggests that individuals' adaptive epistemic beliefs, whether adaptive, may hold the key to understanding their capacity to integrate and comprehend conflicting information (Anmarkrud et al., 2014; Barzilai and Ka'adan, 2017; Bråten et al., 2011; Ferguson, 2015; Kienhues et al., 2016b). Furthermore, it has been proposed that these epistemic beliefs are not fixed and can undergo changes over time, particularly through reflection on the epistemic implications of encountering conflicting information from various sources (Ferguson, 2015). However, there is a paucity of studies exploring the impact of short-term text-based interventions aimed at enhancing people's metacognitive awareness of these beliefs (Barzilai et al., 2020; Rogers and Gould, 2015).

This chapter describes a third study within this thesis. The study aims to investigate the role of epistemic beliefs and the handling of conflicting health and nutrition information through the collection of empirical data. This study aims to explore the role of people's epistemic beliefs and their beliefs about why experts may disagree in the handling and processing of conflicting information sources. The study investigates the relationships between these factors through the conduct of an experiment with a multiple document processing (MDP) task. By employing a mixed methods approach, qualitative and quantitative data are collected to gain more insight in people's handling of conflicting health information. Next to exploring potential associations between people's beliefs and their capacity to integrate conflicting information sources, the study also explores the potential of a novel intervention method that uses our previously developed taxonomy of disagreements.

This study aims to achieve two primary objectives:

a) Investigate potential correlations between individuals' beliefs about knowledge and the reasons behind scientific disagreements, assessed through psychometrically validated scales, and their performance in a task involving the integration of information from multiple sources.
b) Examine the influence of an educational intervention on participants' beliefs and their ability to handle conflicting health information. This intervention entails presenting participants with information regarding the causes of expert disagreement, utilizing the taxonomy developed in Study 2, and guiding them through a task involving the processing of multiple documents, which encourages reflection on the epistemic implications of encountering thought-provoking and conflicting written information.

Note: The term “epistemic beliefs” is widely used in the literature and therefore also throughout this thesis. “Epistemic beliefs” and “epistemological beliefs” are used by different authors to refer to the same concept (abbreviated: EBs), i.e., one’s beliefs about what knowledge is and what it is to know something (Hofer and Pintrich, 1997). However, it has been argued by some that “*epistemological beliefs* characterise a personal theory of knowledge and the process of knowledge acquisition”, whereas “*epistemic* is about the (cognitive) processes concerning the validation of knowledge” (p2 in Klopp and Stark (2022b)). Based on these definitions and given that attention to such distinction may be more appropriate in this third study, throughout the paper presented in section 4.2., the terms “epistemological beliefs” (abbreviated as EBs), “epistemological stance” and “epistemic practices” are used. In addition, in “epistemological beliefs”, *beliefs* is used as an umbrella term for different concepts, including one’s understanding, position, thinking and skills (p2 in Klopp and Stark (2022b)). The study described in 4.2. uses the Epistemic Thinking Assessment (ETA) scale as a measure for people’s EBs. As, previously detailed in **Table 3**, “Epistemic thinking” can be defined as a process involving dispositions, beliefs, and skills regarding how individuals determine what they actually know, versus what they believe, doubt, or distrust (Chinn et al., 2011; Hofer and Bendixen, 2012) and thus a multi-faceted concept (Barzilai and Zohar, 2014; Barzilai and Zohar, 2016), including *epistemic cognition* (=Consideration of the epistemic status and properties of specific information, knowledge claims, and their sources, as well as engagement in strategies and processes for thinking and reasoning about specific information, knowledge claims, and sources) and *epistemic metacognition* (=Knowledge, skills, and experiences related to the nature of knowledge and knowing) (Barzilai and Ka’adan, 2017).

With regard to other related terms as well, different versions are used in the literature. For example, multiplist, multiplicist, and multiplicistic EBs are terms used in different publications. In the paper presented in 4.2., the terms “absolutism”, “multiplicism” and “evaluativism” are used.

4.2. Study 3: Epistemological beliefs (EBs) and processing conflicting health and nutrition information: An experiment.

Abstract

The paper presents an investigation of the intricate interplay between individuals' EBs, their explanations for disagreements among experts, and their ability to handle conflicting health and nutrition information. The study utilizes a mixed methods approach, combining psychometrically validated scales and content analysis of participant responses in a multiple document processing (MDP) task. In addition, a survey measured participants' demographics, topic familiarity, information literacy and healthy lifestyle behavioural intentions. A 3 x 3 design was used with experimental condition (guided, exposed and control) as between-subjects factor and time (pre, post, and follow-up) as within-subjects factor. The primary objective is to gain empirical insights into how people comprehend and justify their understanding of multiple conflicting sources of health information. Part 1 of the study explores participants' EBs and their beliefs regarding reasons for expert disagreements and examines how these beliefs relate to their performance on the MDP task. The findings reveal that participants with more robust EBs exhibited more proficient epistemic practices, resulting in improved performance on the MDP task. Part 2 introduces a novel intervention method, a multiple source processing task based on a taxonomy of disagreements, to shed light on its role in shaping participants' perspectives. Notably, participants in the guided group were more likely to present an evaluativist stance in the MDP task. While the guided group exhibited a decrease in absolutist beliefs and an increase in evaluativism, these changes were not statistically significant within or between groups. Further, the study did not observe significant between-group differences in self-reported reasons for disagreement, information literacy, or behavioural intentions. These findings underscore the complex nature of handling conflicting health information and emphasize the need for tailored interventions that consider individuals' EBs and their perspectives on expert disagreements. Ultimately, this research contributes to a deeper understanding of how people navigate the challenging terrain of health and nutrition information, with implications for enhancing health communication and information literacy initiatives.

4.2.1. Introduction

Handling scientific information is increasingly a part of health literacy, which in turn is an increasingly important factor in public health: people's ability to seek, understand, evaluate and apply health information is instrumental (He et al., 2021; Hicks, 2022; Kickbusch et al., 2013; Nutbeam et al., 2018; Sørensen et al., 2012). Health information, however, is often complex, uncertain and ambiguous, as

knowledge about health is ill-structured, surrounded by uncertainty and tentativeness (Kienhues et al., 2011; Carpenter et al., 2016; Han et al., 2019; Han et al., 2021; Sadler, 2004; Jonassen, 1997; Kimmerle et al., 2015). Therefore, different sources of health information can be conflicting or perceived as conflicting (Carpenter et al., 2016; Carpenter and Han, 2020; Lee et al., 2018; Nagler, 2014; Vijaykumar et al., 2021b). In order to effectively handle the abundance, complexity and uncertainty of health information, people require adequate and adaptive EBs (De Checchi et al., 2022; Knight and Mattick, 2006; Lee et al., 2022; Huang and Yang, 2020; Kimmerle et al., 2015; Roex et al., 2009; Kienhues et al., 2011). In addition, awareness and understanding of the causes for expert conflict may be associated with having more or less adaptive EBs and with one's ability to integrate information from multiple conflicting sources (Thomm et al., 2017). Therefore, investigation of the role of EBs and beliefs about reasons for expert disagreement in people's handling of conflicting health information sources is needed and investigation of potential efforts that promote more adaptive EBs for more effective handling of health information is timely.

4.2.1.1. Background

Epistemological beliefs (EBs)

Research in educational psychology has proposed the importance of EBs as a way to explain how people process and comprehend information (Bråten et al., 2011; Bråten et al., 2014b; Ferguson, 2015; Kienhues et al., 2016; Pieschl and Sivyer, 2021; Knight et al., 2017). EBs are beliefs about the nature of knowledge, the process of knowledge acquisition and what it is to know something (Hofer and Pintrich, 1997). Adaptive EBs have been shown to correlate with better comprehension and ability to synthesize information from diverse and contradictory texts; EBs have been demonstrated to play an important role in people's information processing (Kardash and Howell, 2000) and thinking and argumentation around scientific information (De Checchi et al., 2022; Rosman et al., 2019; Klopp and Stark, 2022a; Kuhn, 2001). Moreover, evaluativist beliefs (i.e., the belief that knowledge is based on weighted evidence) are a prerequisite for advanced scientific argumentation and evaluation; They are required for critical evaluation of new information and play a central role in handling scientific evidence claims (Feinkohl et al., 2016; Mason and Scirica, 2006).

Measuring EBs

There have been two main approaches to the understanding and conceptualisation of EBs. From a developmental point of view, EBs develop as a sequence of qualitatively different levels, which are universal and reflect an *absolutist* view (one account of knowledge is correct), a *multiplicist* view (many possible accounts of knowledge) or an *evaluativist* view (accounts of knowledge are constructed on

evidence (Kuhn, 2001; Kuhn et al., 2000). According to this approach, these are discontinuous stages and the following stage is superior to the former stage; one may develop from absolutism over multiplicism to evaluativism (Kuhn et al., 2000). Evaluativist beliefs are required to handle and understand information conflicts and handle ill-defined knowledge structures (Rosman et al., 2017).While in the past, higher evaluativist beliefs have been called more advanced or more sophisticated EBs, such terminologies have been critiqued for lacking specificity and being goal and topic insensitive, i.e., evaluativist beliefs may be inappropriate for certain learning goals or knowledge topics (Elby and Hammer, 2001). Therefore, we wish to talk about adequate ("satisfactory in quantity and quality") or adaptive EBs instead (as per Kerwer and Rosman (2018)).

In the dimensional approach, EBs are conceptualised as dimensions of the nature of knowledge and knowing; *Certainty* of knowledge, *Simplicity* of knowledge, *Source* of knowledge (Hofer and Pintrich, 1997) and *justification* of knowledge, e.g., personal justification beliefs (Greene et al., 2008), justification beliefs about the authority of the source (Greene et al., 2008), and beliefs about the need for cross-checking multiple sources (Ferguson et al., 2012) (Schommer, 1990; Hofer and Pintrich, 1997). Thus in this approach, EBs are viewed as more or less independent dimensions of inter-individual differences that refer to subjective assumptions about knowledge and knowledge acquisition (Hammer and Elby, 2002; Hofer and Pintrich, 1997). It should, however, be noted that there is ongoing debate about the specific dimensions (Chinn et al., 2011; Hofer, 2016).

The dimensional approach and the developmental approach can be viewed as two sides of the same coin (Klopp and Stark, 2022a; Schiefer et al., 2022) and have recently been integrated into one framework (Barzilai and Weinstock, 2015; Weinstock, 2006; Greene et al., 2008). As such, the different developmental levels are viewed as profiles of several dimensions. In the work by Barzilai and Weinstock (2015), levels of epistemological development are measured as profiles of nine dimensions: certainty of knowledge, source of knowledge, nature of knowledge, structure of knowledge, the role of multiple perspectives, justification for knowing, reliable explanation, attainability of truth, and expertise. This integrated approach allows viewing the EBs on a continuum and assesses the levels of absolutism, multiplicism and evaluativism simultaneously (Weinstock, 2006; Barzilai and Weinstock, 2015). Given the ill-defined knowledge structure of health knowledge, and the presentation of a multitude of uncertain, tentative, and conflicting health information, especially evaluativist beliefs may be beneficial in the handling of such health information. Therefore, in the present study we use the integrated model by Barzilai and Weinstock (2015) that allows us to assess the individual degree of absolutism, multiplicism, and evaluativism for each dimension.

Epistemic change

Absolutism may hinder people in their handling of conflicting health information as the idea that only one account can be correct, is hard to collide with multiple different perspectives. Multiplicism may make people think there is no need to justify a claim with evidence as scientific claims are scientists' personal opinions, thus there may not even exist any conflict. Evaluativism enables people's awareness and recognition of the importance of weighing evidence and integrating multiple, potentially conflicting, knowledge claims. Therefore, it is indicated to foster evaluativist beliefs and lower absolutist and multiplicist beliefs at the same time. Literature suggests that EBs can change over time and Bendixen and Rule (2004) described a process model for personal epistemology development. To develop from the current EBs to more adaptive beliefs, there are three mechanisms described: epistemic doubt, epistemic volition and resolution strategies (Bendixen and Rule, 2004; Rule and Bendixen, 2010). Epistemic doubt may occur when one experiences a dissonance between their current EBs and a new experience or information. Epistemic doubt may be caused by confrontation with multiple conflicting information sources. Epistemic volition refers to the level of effort based on time and motivation one puts in to reconcile the experienced dissonance and overcome the epistemic doubt by reflecting on and changing their EBs (Rule and Bendixen, 2010). Epistemic volition may be strongly determined by personal relevance, i.e., up to what level is the new information relevant to the individual at that time (Stadtler et al., 2012; Stadtler et al., 2020). The third mechanism as described by Bendixen and Rule (2004) refers to strategies that help one with reflecting upon their current beliefs and their implications caused by experiencing epistemic doubt. In other words, resolution strategies aim to reduce the epistemic doubt by integrating the past experiences, current EBs and new experiences, and as such may assist with changing one's EBs towards more evaluativism or more adaptive EBs.

4.2.1.2.Short term text-based interventions

Literature suggests that the relationship between EBs and multiple text comprehension could be bi-directional; Having more or less adaptive EBs could explain or predict one's ability to integrate and comprehend conflicting information, and, in addition to that, could a reading task that encourages reflection on the epistemic implications of thought provoking and conflicting written information, change one's beliefs about knowledge and knowing (Kienhues et al., 2008; Kienhues et al., 2016; Kienhues et al., 2011; Ferguson, 2015; Ferguson and Bråten, 2013; Ferguson et al., 2013; Bråten et al., 2011; Stadtler and Bromme, 2014).

Only a limited, however, growing body of research has investigated this idea of influencing epistemological beliefs or perspectives through a short term text-based intervention (e.g., Barzilai et al.,

2020; Ferguson and Bråten, 2013); Iordanou, 2016); Kerwer and Rosman, 2020); Kienhues et al., 2008); Klopp and Stark, 2022b); Klopp and Stark, 2022a); Porsch and Bromme, 2011); Rosman et al., 2019); Zavala and Kuhn, 2017)). Most of those studies investigated specific student populations and their EBs related to their particular domain, most often psychology. Given the relevance of health information to the general population, it is of interest to investigate a sample that is lay in terms of their expertise related to health information. Very few have aimed their intervention efforts specifically at fostering more advanced and adaptive EBs about health knowledge (Stadtler and Bromme, 2007; Han et al., 2021; Rogers and Gould, 2015; Simonovic and Taber, 2022).

4.2.1.3.Reasons for expert disagreement

Explaining why experts disagree or consideration of the reasons for expert disagreement is an essential part of the evaluation of conflicting sources and may assist with effective and efficient integration of conflicting information sources (Thomm and Bromme, 2016; Thomm et al., 2017; Thomm et al., 2015; Dieckmann and Johnson, 2019; Dieckmann et al., 2017b; Johnson and Dieckmann, 2018; Kajanne and Pirttilä-Backman, 1999). Indeed, disagreement explanations may help people with the sense-making of expert conflict and thus may assist with resolving the conflict (Barzilai et al., 2020; Thomm et al., 2017; Thomm and Bromme, 2016). However, people often rely on a very limited set of explanations and, for example, easily attribute perceived expert disagreement to a lack of competence or a conflict of interest (Thomm et al., 2017). Furthermore, awareness of the normalcy and legitimacy of expert disagreement is often lacking in the public, however, essential for better appreciation of the prevalence of expert disagreement (Thomm et al., 2015; Dieckmann and Johnson, 2019; Dieckmann et al., 2017b; Johnson and Dieckmann, 2018; Chakravartty, 2022). People may benefit from a better understanding of the strengths and limitations of science and expert knowledge, and the idea that expert disagreement is to be expected and can be a valuable characteristic of productive science (Solomon, 2021). Especially, knowledge and understanding of the idea that next to informant-related causes, there are information- and complexity & uncertainty-related causes for perceived expert disagreements may make people better able to appreciate such disagreement and better equipped for the handling of conflicting information for sustainable decision-making (Deroover et al., 2023) (also see chapter 3). Consequently, there may be merit in raising awareness and understanding about the range of possible causes for expert disagreement (Deroover et al., 2023; Barzilai et al., 2020). A task that encourages reflection about alternative viewpoints and why those may exist, i.e., why research may come to differing conclusions and experts may disagree, may contribute to a better understanding and appreciation of the normalcy and legitimacy of such expert disagreements and conflicting information sources, and in turn may lead to better coping strategies for the handling of such information. Only few have aimed to explore the associations between conflict explanations and

epistemological perspectives and the effect of the provision of conflict explanations on people's evaluation of conflicting information, e.g., in history and biology (Barzilai et al., 2020; Thomm et al., 2017) and in psychology (Klopp and Stark, 2022b; Klopp and Stark, 2022a). Within the health context there have been explorations with uncertainty-normalising interventions (Han et al., 2021; Simonovic and Taber, 2022; Rogers and Gould, 2015), however, to the best of our knowledge, no interventions with explicit provision of conflict explanations, i.e., possible reasons for expert disagreements, have been conducted.

4.2.2. Study rationale and research questions

Part 1: Associations with MDP task performance

The present study's goal was to gain knowledge about participant's understanding of multiple conflicting sources of health information, and their justifications for that understanding. More specifically, this study aimed to shed light on participants' EBs and how they associate with their performance on a multiple document processing (MDP) task. In addition, we explored if there are significant associations between people's task performance and measured parameters, i.e., their prior beliefs and involvement with the topic and the time they spend on the task. The research questions are:

1) *Do adults with more adequate EBs perform better on a MDP task?*
2) *Are there significant associations between people's task performance and a) their prior beliefs and involvement with the topic and b) the time they spend on the task?*

A better understanding of the ways in which people explain perceived conflict between experts in daily life can inform educational and communication approaches to foster effective and sustainable evaluation of such expert disagreements. Consequently, some research efforts have been directed to the development of scales to measure people's explanations for expert disagreement (Thomm et al., 2015; Dieckmann and Johnson, 2019). Furthermore, it has been suggested that people's EBs could be a metacognitive resource that they use in the shaping of conflict explanations, however, only very few have investigated this relationship (Thomm et al., 2017; Bromme et al., 2008), and to the best of our knowledge, not in the health context. Therefore, a third RQ includes:

3) *Are there significant associations between conflict explanations and EBs?*
    a) *Are participants with more adequate EBs more likely to address an explanation for the disagreement in their MDP writing task and more likely to attribute expert disagreements to information- and complexity and uncertainty-related causes in their MDP writing task?*

b) *Are participants with more adequate EBs more likely to self-report complexity and uncertainty as reasons for disagreement rather than competence or motivation?*

We were also interested to explore people's perceived information literacy self-efficacy (Kurbanoglu et al., 2006). Not only does it provide us with information about people's confidence and belief in their capabilities to handle information, self-efficacy beliefs also provide us with an indication of motivation (Bandura, 1977; Bandura et al., 1999). When people believe something exceeds their capabilities, they don't feel motivated to act. However, they do undertake activities when they believe that their actions can help them achieve the desired outcome (Bandura, 1977; Bandura et al., 1999). Furthermore, self-efficacy beliefs may be associated with people's perseverance and resilience in the face of difficulties and how much effort they will expend on an activity (Kurbanoglu et al., 2006). Therefore, in the present study, we wish to explore:

4) Are there significant associations between people's EBs, task performance and information literacy self-efficacy?

And could people's MDP task performance be explained through their EBs, information literacy self-efficacy, time spent on the task, experience with reading scientific lit and familiarity with the topic?

Part 2: Exploring the effect of an educational intervention.

Part 2 aims to provide information about the role of a multiple source processing task based on a taxonomy of disagreements as a novel intervention method; The study aims to investigate the effect of an intervention (i.e., an educational activity with information on causes for disagreement and a series of tasks based on a set of conflicting sources) on their EBs and their performance on a multiple document processing task. It has been suggested that presenting epistemological features of the domain, such as reasons why controversies, conflicts and disagreements exist can function as a sensitisation for domain-specific epistemological doubt (Klopp and Stark, 2022a) and may foster epistemic change (Bendixen and Rule, 2004; Porsch and Bromme, 2011). In the present study, we wish to investigate an intervention with an earlier developed taxonomy of causes for expert disagreement related to health (Deroover et al., 2023). The presentation of the taxonomy is then followed by a set of questions and exercises that required participants to apply the knowledge about causes for disagreement to a set of conflicting information sources. Thus, we explore the use of such educational task about causes for disagreement as a resolution strategy for dealing with the topic-specific epistemological doubt that comes from the exposure to a set of conflicting sources and the domain-specific epistemological doubt through the information about reasons

for disagreement, and whether it influences epistemic change and the way people integrate those conflicting sources.

The research questions are:

1) *Are participants' EBs different after the intervention as compared to before? And are there differences between the experimental conditions?*

2) *Are there differences between the experimental conditions in terms of performance on the MDP task?*

3) *Are there differences between the experimental conditions in terms of the reasons for disagreement people indicate?*

4) *Are there differences between the experimental conditions in terms of self-reported information literacy self-efficacy?*

Previous research on the effects of exposure to conflicting health information has suggested the existence of carry-over effects caused by such exposure, i.e., people may be less receptive to subsequent unrelated health messages and less likely to engage in the recommended health behaviours (Nagler, 2014; Nagler et al., 2021). Therefore, in the present study, we wish to explore:

5) *Are participants' intentions to engage in healthy lifestyle behaviours different after the intervention as compared to before? And are there differences between the experimental conditions?*

We hypothesise that, relative to the other groups, participants in the guided group:

1) present changes towards more adequate beliefs.

   This means, we hypothesise that the intervention for the participants in the guided group will decrease their absolutist and multiplicist beliefs and increase their evaluativist beliefs.

	Absolutism	Multiplism	Evaluatism
Guided	-	-	++
Exposed	0	+	+
Control	0	+	+

2) score higher on the MDP task performance measures

3) are more likely to indicate complexity and uncertainty as reasons for disagreement

4) score higher on the self-reported information literacy self-efficacy

4.2.3. Methods

Design and procedure

A mixed methods (including qualitative and quantitative measures) approach with a 3 x 3 design was used with experimental condition (guided, exposed and control) as between-subjects factor and time (pre, post, and follow-up) as within-subjects factor. **Figure 11** presents an overview of the study design.

Approval from the relevant human research ethics committee was obtained before commencement of the research. All participants provided written informed consent before participation in the study. The study was designed in *Qualtrics* and all participants completed the study parts online from their home in March-May 2021. This online study consists of both quantitative (e.g., questionnaires) and qualitative (e.g., written justification) measures. There are three study parts: Pre-intervention measurement; Intervention and post-intervention measurement (1week after part 1); Follow-up measurement (4weeks after part 2). Before data collection started, participants were informed of the expected study duration (in total 40–60 min) and were instructed to complete the survey in a quiet place of their own choice. Participants were automatically randomly assigned to one of three groups by Qualtrics. Participants in the guided group were provided with a set of documents on topic A (health impact of wine consumption) and were guided through a set of tasks that informed them about causes for disagreement and encouraged them to reflect on those, their EBs, and the provided information on topic A. The exposed group was provided with the set of documents on topic A, however, was not provided with any tasks or information on reasons for expert disagreements. The control group was not provided with the documents on topic A nor any additional information. Potential changes in EBs were measured through validated scales and based on their performance on a multiple document processing task on topic B (health impact of multivitamin supplementation). Additionally, participants' beliefs about reasons for expert disagreement, involvement with the different health topics, lifestyle behaviours (i.e., intentions about diet and physical activity for the next year), and information processing self-efficacy were measured through scales (Further detail is provided in section "Measures", p118-121.). Participants' responses to survey questions, to open questions, and the time they take to complete tasks were collected and recorded through Qualtrics.

Participants were debriefed at the end of the study. They were informed about the purpose of the study and were all provided with the information on causes for expert disagreement (i.e., the taxonomy of disagreements was presented as an interactive slide with further information on each of type of disagreement and examples for further explanation).

Participants

The aim was to measure a potential change in EBs (measured through the Connotative Aspects of Epistemic Beliefs (CAEB) scale and the Epistemic Thinking Assessment (ETA) scale). Based on prior research, we expected to see medium effects, however ability to detect small to medium effects was desirable. (See attached document for extracts from previous research)

A design with three groups with approximately 33 participants each is expected to allow detection of small to medium effects within groups (n=99; f = 0·13, alpha = 0.05, Power = 0.80, nr groups & number of measurements=3) and between groups (n= 99; f = 0·26, alpha = 0.05, Power = 0.80, nr groups & number of measurements=3). Therefore, we aimed to recruit approximately 100 participants. This study sample size was estimated based on considerations regarding power and practicality. Given the level of commitment (i.e., 3 measurement points in time) and the level of effort (i.e., the study requires active engagement with the materials and the writing of a short text), it was expected that recruitment may be challenging.

The participants were recruited through the university's behavioural lab. An invitation was sent via email and was published online (on a learning platform and relevant university website). Participation was voluntary. If interested, participants could follow a link in the invitation that took them to the information sheet and consent form and the first part of the study. After completion of part 1, participants' email address was collected in Qualtrics to allow the system to send them the invitation for the next part. Participants recruited through the behavioural lab received a study credit for full completion of the study (all three parts). Marketing students can participate in studies at the behavioural lab to get up to three study credits. At the behavioural lab, a time commitment of approximately 1 hour spent on study participation equals 1 study credit. As the completion of the total study, including three parts, was expected to take approximately 1 hour, students received 1 credit for their participation in this study. For these marketing students, participation in research studies has an educational benefit as well as it gives them the opportunity to learn about the connection between research and learning about consumer practices (in this case health information consumer practices).

Intervention

The intervention consists of different aspects: (a) the exposure to conflicting sources, aiming to induce (topic specific) epistemological doubt, (b) "an epistemological sensitisation measure: i.e., information on the potential reasons for expert disagreement, aiming to inform about the epistemological features of knowledge, how it is constructed by science, and the normalcy of the existence of scientific conflicts/ expert disagreement/conflicting information about health and nutrition, thus aiming to pave the road

towards a more evaluativist view, raising (domain specific) epistemological doubt, and (c) guidance through a set of tasks to encourage reflection on topic-related beliefs and EBs, aiming to provide resolution strategies. Thus, the intervention yields a deeper elaboration and more elaborate processes, and spending more time on the task, which, in turn, is expected to be beneficial for epistemological change (Pieschl et al., 2008). The three aspects are assumed to be beneficial in fostering EBs towards evaluativism, while, at the same time, absolutism and multiplicism are reduced (Bendixen and Rule, 2004; Klopp and Stark, 2022b).

Consequently, in the guided group, participants were provided with a set of documents with different viewpoints on wine and health and were asked to read the information, rank the sources, and write a recommendation for a friend, which is expected to encourage them to integrate the information from the different sources and develop a balanced mental model of the topic. Additionally, the participants were provided with information on causes for expert disagreement, i.e., our earlier developed taxonomy of disagreements, and an exercise that made them identify types of disagreement in the provided set of documents.

Documents: seven sources with information about the health impact of wine consumption were collected. The sources presented different perspectives on wine consumption and health and include scientific peer-reviewed articles, non-peer reviewed articles and blog posts. Three of the sources had a more positive view on wine and health, three had a negative perspective on the health impact of wine and one aimed to provide a balanced two-sided view on the issue. Several types and causes for disagreement were presented in this set of sources; they showed informational versus decisional conflict, and presented examples of inherent uncertainty, outcome ambiguity, input ambiguity and different levels of scientific evidence. (See **Appendix 2** for an out print of the intervention design in Qualtrics)

<table>
<tr><th>Sessions</th><th>Control group</th><th>Exposed group</th><th>Guided group</th><th>Time estimation</th></tr>
<tr><td>Pre-test</td><td colspan="3">Measures:
1. Connotative aspects of epistemic beliefs (CAEB) (i.e., Texture and Variability)
2. Socio-demographics
3. Intention diet and PA
4. Topic familiarity and involvement assessment (topic A,B,C)
5. Epistemic thinking assessment (ETA) (i.e., Absolutism, Multiplicism, Evaluativism) (topic A = wine)</td><td>5-10min</td></tr>
<tr><td colspan="4">One week break</td><td></td></tr>
<tr><td rowspan="3">Instruction</td><td></td><td colspan="2">Read conflicting sources topic A</td><td rowspan="6">Control: 20min
Exposed: 30min
Guided: 45min</td></tr>
<tr><td></td><td></td><td>Writing task topic A</td></tr>
<tr><td></td><td></td><td>Guide about causes for disagreement with instructions</td></tr>
<tr><td rowspan="3">Post-test</td><td colspan="3">Read conflicting sources topic B</td></tr>
<tr><td colspan="3">Writing task topic B</td></tr>
<tr><td colspan="3">Measures:
1. Multiple document processing (MDP) performance assessment (topic B)
2. Epistemic thinking assessment (ETA) (i.e., Absolutism, Multiplicism, Evaluativism) (topic B = multivitamins)
3. Science Dispute Reasons (SDR) (topic B)</td></tr>
<tr><td colspan="4">Four weeks break</td><td></td></tr>
<tr><td>Follow-up (FU)</td><td colspan="3">Measures:
1. Perceived self-efficacy information literacy
2. Intention diet and pa follow
3. Epistemic thinking assessment (ETA) (i.e., Absolutism, Multiplicism, Evaluativism) (topic c = coffee)
4. Connotative aspects of epistemic beliefs (CAEB) (i.e., Texture and Variability)</td><td>5-10min</td></tr>
</table>

Figure 11. Overview of the study design

Measures

EPISTEMOLOGICAL BELIEFS, EPISTEMIC THINKING AND EPISTEMIC PRACTICES

Participants' beliefs about health-related knowledge were measured through the psychometrically validated scale, Connotative Aspects of Epistemic Beliefs (CAEB) (Stahl and Bromme, 2007). The CAEB measures two dimensions of EBs, texture, and variability, through 17 bipolar items of connotative aspects. The dimensions texture and variability encompass a mixture of the dimensions, certainty, simplicity, and source. Texture includes beliefs about structure and accuracy of knowledge, whereas variability encompasses beliefs about the stability and dynamics of knowledge (Stahl and Bromme, 2007). For this scale the following Cronbach's Alphas were calculated: Texture Pre: 0.67, Texture FU: 0.70; Variability pre: 0.50, Variability FU: 0.56.

Participants' meta-level understandings of the nature of knowledge and knowing was assessed through the scenario-based Epistemic Thinking Assessment (ETA) (Barzilai and Weinstock, 2015). The ETA is a topic-specific measurement of Kuhn's three main epistemic perspectives (Kuhn, 1991). It integrates the developmental and the dimensional approach to EBs; the three developmental levels of EBs are considered as a multidimensional composition of the following nine dimensions: Right answer, Certainty of knowledge, Attainability of truth, Nature of knowledge, Source of knowledge, Multiple perspectives, Evaluate explanations, Judge accounts, and Reliable explanation (Barzilai and Weinstock, 2015). For each of these dimensions, absolutism, multiplicism, and evaluativism were assessed. Sample questions and responses are presented in **Figure 12**. They were assessed on a six-point scale on which participants indicated their agreement with the item statement. The items in the ETA refer to a scenario and are formulated in such a way that they prompt the participants to reason about a problem that refers to a specific topic provided in the scenario. The original scenarios used in the ETA scale were situated in the domains of history and biology. As occurring in previous studies (Klopp and Stark, 2022b), we adapted the scenarios to the domain of interest, i.e., health and nutrition and used three scenarios on three conflicting nutrition topics (wine, multivitamins and coffee). These topics are known for their perceived expert disagreement and have been investigated in prior research related to effects of exposure to conflicting health information (Nagler, 2014; Nagler et al., 2021). The scenarios can be found in **Appendix 3.** We tested the structure of the ETA scale through the procedures described by Barzilai and Weinstock (2015). Based on that, the multiplicism items for "Right answer" were dropped. (The factor analysis can be found in **Appendix 4**). Scales were constructed using the means for all the items associated with the respective perspective. The scales yielded good internal consistencies in terms of Cronbach's Alpha; Absolutism pre: α = .81, post: α = .82, follow up: α = .84; Multiplicism: pre: α = .83, post: α = .86, follow up: α = .89; Evaluativism: pre: α = .79, post: α = .85, follow up: α = .83.

With certain tasks, people manifest specific actions and strategies from which their epistemologies can be inferred, which has been conceptualized as *epistemic practices* (Chinn and Sandoval, 2018; Chinn et al., 2014). For example, absolutists believe in the authority of the informant and only one account can be correct, thus wish to find a reliable expert. Multiplicists believe science is based on opinions and everything is subjective and therefore may not acknowledge the existence of a conflict and may see no need to evaluate the source. Evaluativists believe in the need to critically evaluate any knowledge claims. In the present study, participants' written recommendation and justification were analysed to assess their argumentation, coverage, rationale, and explanation, and their overall epistemological stance (i.e., the predominant epistemic perspective presented in the writing task). Further details are described in section 2.6.

Figure 12. Examples of questions and responses in the ETA scale

Epistemic Thinking Assessment				
		Responses		
Dimension	**Question**	**Absolutism**	**Multiplicism**	**Evaluativism**
Source of knowledge	What should be the source of knowledge of those who study this topic?	The source of knowledge should be only in evidence that can be gathered.	The source of knowledge should be mainly in peoples' opinions and ideas.	The source of knowledge should be mainly in how people interpret the evidence that was gathered.
Judge accounts	What is the best way to judge different accounts about the topic?	The best way is to check if the account is based only on the facts.	The best way is to check which account is most reasonable according to the reader's worldview.	The best way is to check which interpretation best explains the available data.
Certainty of knowledge	Can there be certainty about the topics?	Eventually one could know for certain.	One could never know for certain because it is impossible to find out what happened.	There is never full certainty, but it is possible to improve the degree of certainty.

Note: Participants' meta-level understandings of the nature of knowledge and knowing was assessed through the scenario-based Epistemic Thinking Assessment (ETA) by Barzilai and Weinstock (2015).

INFORMATION LITERACY SELF-EFFICACY

To measure participants' self- reported self-efficacy to handle information, we used a selection of the items of the Information literacy self-efficacy scale by Kurbanoglu et al. (2006); i.e., the items D (measuring assessing and comprehending information) and items E (measuring interpreting, synthesising and using information). Participants indicated their level of agreement with the following statements (1= Strongly Disagree; 7 = Strongly Agree); "I feel confident and competent to …"; Use many resources at the same time to make a research; differentiate between fact and opinion; recognise errors in logic; classify the information; recognise interrelationships among concepts; determine the authoritativeness, currentness and reliability of the information sources; evaluate information critically; select information most appropriate to the information need; identify points of agreement and disagreement among sources; evaluate www sources; synthesise newly gathered information with previous information; synthesise and summarise information gathered form different sources; paraphrase the information; interpret the visual information (i.e., graphs,

tables, diagrams). A high Cronbach's Alpha coefficient of 0.917 was calculated as a measure of internal consistency for this scale.

BEHAVIOURAL INTENTION TO ENGAGE IN HEALTHY LIFESTYLE BEHAVIOURS

Respondents reported their intentions to adhere to two healthy lifestyle recommendations: fruit/vegetable consumptions and exercise. Intention to adhere to healthy lifestyle recommendations were measured on a 1-5 scale: "How likely is it that you will have five or more servings of fruits and vegetables most days in the next year?"; and, "How likely is it that you will exercise at least three times in most weeks over the next year?". These measures have been used in research to investigate the carry-over effects of exposure to conflicting health information (Nagler, 2014; Nagler et al., 2022).

REASONS FOR DISAGREEMENT BETWEEN SCIENTISTS

People's beliefs about reasons for scientific disputes about the health impact of multivitamins were measured through the Science Dispute Reasons (SDR) Scale (Dieckmann and Johnson, 2019). It aims to measure people's explanations for expert disagreements on three constructs. The scale measures five categories (process, competence, interests, values, and complexity and uncertainty), similar to others (Thomm et al., 2015) but collapsed to three factors (Process/Competence, Interests/Values, Complexity/Uncertainty) based on the empirical validation of the scale through lay responses, and similar to previous findings (Johnson and Dieckmann, 2018). (The factor analysis can be found in **Appendix 4.**) The three constructs showed acceptable to good internal consistencies; Process/Competence: α = .79, Interests/Values: α = .75, Complexity/Uncertainty: α = .62. The SDR scale was selected because of its clear statements and overall user friendliness.

CO-VARIABLES

Socio-demographic measure (i.e., age, gender and education level), participants' familiarity with reading scientific literature, and participants' familiarity and involvement (i.e., their consumption behaviour, information seeking behaviour and their assessment of the health impact) with the topics (wine, multivitamins, coffee) were measured through a questionnaire. The categories within the variables can be viewed in **Table 9** and **Table 10**.

MULTIPLE DOCUMENT PROCESSING (MDP) TASK

The MDP task functions as an assessment of the participants' comprehension, integration and his or her consequent decision-making (Barzilai et al., 2018; Primor and Katzir, 2018; Tarchi et al., 2021). To do so, they were asked an open question, i.e., to write a recommendation for a friend based on the provided sources. It is expected that this question would encourage participants to at least consider each source's claim. The level up to which people consider the sources' credibility and the reasons they mention is variable. Furthermore, this indirect integrative question is expected to encourage the

participants to integrate perspectives across texts. However, due to its indirect nature, the level to which one engages in integration would give an indication of their need for justification by multiple sources, as compared to a more direct question that would, for example, ask the participant to describe the different views.

The instruction was as follows:

Imagine now that a friend has asked you for your views on the use of multivitamins. She is an educated (has an undergraduate degree) professional of about 35 years old but does not work in health or nutrition. Imagine you've searched the internet and found these resources. Based on these sources, what perspective would you give your friend?

Qualtrics recorded the time of the first click on the page of the reading and writing task and the time of page submission. Then, a variable was created that presents the calculated duration of the task.

Data analysis

Data collected through Qualtrics were downloaded and uploaded in SPSS. Statistical analysis was performed with SPSS version 28. Descriptive analyses were used to describe the study population. When examining the ETA scales, eight data points were identified as outliers and removed from further analysis. Means and standard deviations for all measures are reported and compared between groups. One-way ANOVAs were used to compare means between the three groups. When assumption of homogeneity of variance was violated, a Welch ANOVA was conducted. An independent samples Kruskall-Wallis test was conducted when data were not normally distributed as identified through a significant Shapiro-Wilk test. Content analysis was used for the analysis of the qualitative data on task performance, i.e., written recommendation and justification for that recommendation. See further details below. Differences between groups for the MDP measures were examined using Chi-square tests. Correlation analyses were used to explore the associations between the data on task performance, the scale measurements for EBs, and co-variables. Pearson correlation coefficients are reported for continuous variables. For categorical variables and when assumptions for Pearson (r) correlation were violated, the Kendall's Tau (τ_b) correlation coefficient is reported. Analysis of change, between-groups ANOVAs and pre-post paired t-test comparisons were conducted to investigate the intervention effect. For the correlations and paired t-tests, two-sided p values are used to determine significance.

The ETA scale has the advantage that it allows for assessment of all three perspectives at the same time. In addition, we are interested in the relative level of all three perspectives in one overall measure. Therefore, with the measures of the ETA scale, we also calculated a D-score as a multidimensional change towards adequate beliefs. The D-Index is computed as $Evaluativism - 0.5 * (Absolutism + Multiplicism)$, with high scores indicating advanced beliefs in the sense of preferring

evaluativistic positions over absolute or multiplistic positions (Krettenauer, 2005). The D-index was also used in similar settings in previous research (e.g., Kerwer and Rosman, 2018, 2020).

Analysis writing task

Participants' multiple-text processing is measured by means of a composite score aggregated from the assessment of the quality of an essay (i.e., the recommendation for a friend) that required participants to integrate and reconcile the opposing perspectives presented in the texts. In accordance with prior research (Anmarkrud et al., 2014; Anmarkrud and Ferguson, 2013; Anmarkrud et al., 2013), the quality of the answer is considered to be based on the extent up to which it displayed integrative argumentative reasoning that discussed opposing perspectives and the unsettled nature of the issue in an elaborative way (Primor and Katzir, 2018). Due to the online study design and practical limitations, the writing task in the present study consisted of rather short texts (min = 500 characters, max = 3000 characters) as compared to the essays in previous studies (Anmarkrud et al., 2014; Anmarkrud and Ferguson, 2013; Anmarkrud et al., 2013) and thus required an adapted scoring approach.

Consequently, performance on the writing task was evaluated based on: Attempts to verify knowledge claims in the texts by personal justification, for example, by appealing to internal factors such as gut-feeling or personal experience (up to what extent do they rely on prior knowledge and beliefs about the topic), justification by authority, such as, reliance on a reputable, external source or on scientific evidence (do they refer to or consider source features), and justification by multiple sources, representing a reliance on cross-checking, comparing and corroborating across sources (do they consider multiple/ all sources). Additionally, appropriate detection of conflict(s) and the use of attributes to explain the conflicts (including which specific explanations) were considered.

The coding procedure proceeded as follows: The text responses were exported from *Qualtrics* into *Excel* and rated, and later uploaded in SPSS for further analysis. We started with an exploratory approach; the responses were initially coded in an open and inductive manner to gain familiarity with the type and depth of responses, as well as to gain insight into the breadth of participants' comprehension, evaluation and integration practices. The initial coding for the initial 50% of the written responses were then reviewed, evaluated and refined through discussion within the team. Finally, based on the team discussions and informed by theory we developed a coding scheme to align with our research questions and design.

Considering previous work by Mateos et al. (2018) and Tarchi and Villalón (2021), we developed an *argumentation* scoring scheme; 1. One sided answer based on prior knowledge/ beliefs; 2. One sided answer based on external authoritative justification belief; 3. One sided answer without ref to sources; 4. One-sided answer with references to sources; 5. Two-sided/ nuanced answer without

reference to sources; 6. Two-sided/ nuanced answer with reference to sources; 7. Two-sided/ nuanced answer with reference to sources and comparison (weighing up).

An analysis scheme, reflecting the *epistemic level* of the argumentation in the participants' answer, was used in accordance with previous research (Klopp and Stark, 2022a; Klopp and Stark, 2022b; Mason and Scirica, 2006); 1. The participant indicates one-sided, i.e., one side of the controversial topic is correct; 2. The participant indicates one-sided but also indicates that there may be a second point of view, which is equally right.; 3. The participant indicates that both points of view are correct.; 4. The participant indicates that both points of view are correct but there is the possibility that depending on the circumstances, one point of view may be more suited than the other.; 5. The participant indicates that the available evidence has to be evaluated according to the given circumstances, which point of view is correct.; 6. The same as the criterion for five points, but the participant indicates that both points of view may change according to new research. As such, the coding reflects an absolutist (1-2 points), multiplicist (3-4 points) or evaluativist (5-6 points) argumentation. We further refer to this measure as "epistemological stance".

In addition, the following measures were scored: *Recommendation* (1. Take multivitamins; 2. Don't take multivitamins; 3. There's no way to know; 4. Everyone must make their own choice; 5. Seek help from authority), *Rationale* (as a justification for knowing) (1. Prior knowledge; 2. Knowledge from authority; 3. Corroboration; 4. Rules of inquiry), *Coverage* (1. 1 side; 2. 2 sides but 1 side solely talked about in critique (shallow); 3. 2 sides both treated equally, no integration of conflict; 4. 2 sides, conflict is highlighted but unresolved; 5. 2 sides with nuanced weighing up), and *Explanation* (1. No discussion; 2. Different expertise levels; 3. Variations in studies (methods, participant groups, outcomes, etc.); 4. Knowledge may change over time/context).

Following this, a sum score was calculated that aimed to reflect overall performance on the writing task. Argumentation, epistemic level of argumentation, coverage, explanation, and rationale were recoded to equal scales and added up to create the sum score. A high level of internal consistency (Cronbach's Alpha= 0.85) was calculated.

4.2.4. Findings

Sample

A total of n = 166 participants completed parts 1 and 2 of the study, however, n=16 participants were excluded from the analysis because they showed highly implausible response patterns (e.g., no variation in the answers for the questionnaires) or responses that indicated they did not engage with the intervention materials (based on the written responses and the duration recorded in *Qualtrics*). Therefore, n = 150 (Guided: n = 45, Exposed: n = 54, Control: n = 51) were included in the analysis

of parts 1 and 2. A total sample of n = 107 (Guided: n = 28, Exposed: n = 42, Control: n = 37) participants completed all three parts of the study and were included in the analysis that included the follow-up part. The participants were undergraduate marketing students at UTS: Business school, 97% was between 18 and 25 years old and 65% was female. Only 15% of the sample reported to read scientific literature on a regular basis. The majority of participants (84%) assessed the health impact of multivitamin supplementation positively and that of coffee (59%) and wine (58%) consumption negatively. Only 21% of participants reported to have sought information about the health impact of wine consumption in the past. For the health impact of multivitamin supplementation and coffee, 39% of participants reported to have sought information about these topics in the past. Significantly more participants within the guided group had previously sought a lot of information about wine as compared to the other groups ($X^2_{(8, N = 26)}$ = 16.053, p = .042), however, considering the number of conducted tests and the high p value, interpretation of this finding means it should be deemed non-significant. There were no significant differences between groups for any other variables. The sample characteristics are described in **Table 9**. Familiarity and involvement with wine, multivitamins and coffee are presented in **Table 10**.

Table 9. Sample characteristics (with three experimental groups: Guided, Exposed, Control)

	n=150	Guided (n=45)	Exposed (n=54)	Control (n=51)
Age				
18-25	146(97.3%)	45 (100%)	52 (96.3%)	49 (96.1%)
26-35	3(0.02%)	0	1 (1.9%)	2 (3.9%)
36-45	1(0.007%)	0	1 (1.9%)	0
Gender				
Male	50 (33.3%)	11 (24.4%)	21 (38.9%)	18 (35.3%)
Female	98 (65.3%)	33 (73.3%)	33(61.1%)	32 (62.7%)
Prefer not to say	2 (1.3%)	1 (2.2%)	0	1 (2.0%)
Education				
Less than yr12	1 (0.7%)	0	1 (1.9%)	0
Completed yr 12	106 (70.7%)	37 (82.2%)	33 (61.1%)	36 (70.6%)
Tertiary education less than Bach	32 (21.3%)	7 (15.6%)	14 (25.9%)	11 (21.6%)
Bachelor's	11 (7.3%)	1 (2.2%)	6 (11.1%)	4 (7.8%)
How often do you read scientific literature?				
Never	36 (24.0%)	13 (28.9%)	15 (27.8%)	8 (15.7%)
Rarely	91 (60.7%)	24 (53.3%)	35 (64.8%)	32 (62.7%)
Regularly	22 (14.7%)	8 (17.8%)	4 (7.4%)	10 (19.6%)
Very often	1 (0.7%)	0	0	1 (2.0%)

Note:
n= number of cases, percentages (in brackets)
Bach = bachelor's degree
Chi-square tests showed that the proportions did not significantly differ between groups.
Percentages may not total 100 due to rounding.

Table 10. Familiarity and involvement with the health impact of wine, multivitamins, and coffee.

	n=150	**Guided (n=45)**	**Exposed (n=54)**	**Control (n=51)**
How much wine do you consume on average?				
Never	79 (52.7%)	23 (51.1%)	28 (51.9%)	28 (54.9%)
1 glass/w or less	43 (28.7%)	13 (28.9%)	16 (29.6%)	14 (27.5%)
2-6 glasses/w	16 (10.7%)	8 (17.8%)	3 (5.6%)	5 (9.8%)

7 glasses/w	0	0	0	0
More than 7 up to 14 glasses/w	5 (3.3%)	0	2 (3.7%)	3 (5.9%)
More than 14 less than 28 glasses/w	2 (1.3%)	0	2 (3.7%)	0
28 glasses/w or more	5 (3.3%)	1 (2.2%)	3 (5.6%)	1 (2.0%)
Have you actively sought information about the health impact of wine consumption in the past?				
No	119 (79.3%)	38 (84.4%)	39 (72.2%)	42 (82.4%)
Yes	31 (20.7%)	7 (15.6%)	15 (27.8%)	9 (17.6%)
How much information?	$X^2_{(8, N=31)} = 16.053$, $p = .042$			
A very small amount	6 (19.4%)	1 (14.3%)	3 (20.0%)	2 (22.2%)
2	6 (19.4%)	2 (28.6%)	3 (20.0%)	1 (11.1%)
3	11 (35.5%)	0	7 (46.7%)	4 (44.4%)
4	6 (19.4%)	4 (57.1%)	2 (13.3%)	0
A very large amount	2 (6.5%)	0	0	2 (22.2%)
What kind of impact do you think moderate wine consumption has on health?				
Very negative impact	10 (6.7%)	5 (11.1%)	1 (1.9%)	4 (7.8%)
Slightly negative impact	77 (51.3%)	27 (60.0%)	26 (49.1%)	24 (47.1%)
No impact	12 (8.0%)	4 (8.9%)	3 (5.6%)	5 (9.8%)
Slightly positive impact	40 (26.7%)	9 (20.0%)	18 (33.3%)	13 (25.5%)
Very positive impact	8 (5.3%)	0	3 (5.6%)	5 (9.8%)
None of the above	3 (2.0%)	0	3 (5.6%)	0
How much experience do you have with multivitamin supplementation? (*)				
No experience and no intention	41 (27.3%)	14 (31.1%)	12 (22.2%)	15 (29.4%)
I have taken in the past	70 (46.7%)	23 (51.1%)	28 (51.9%)	19 (37.3%)
Currently take	40 (26.7%)	10 (22.2%)	19 (35.2%)	11 (21.6%)
Intend to take in the future	28 (18.7%)	7 (15.6%)	9 (16.7%)	12 (23.5%)
Have you actively sought info about the health impact of multivitamins in the past?				
No	91 (60.7%)	28 (62.2%)	33 (61.1%)	30 (58.8%)
Yes	59 (39.3%)	17 (37.8%)	21 (38.9%)	21 (41.2%)
Please indicate how much info you have sought				
A very small amount	3 (5.1%)	1 (5.9%)	0	2 (9.5%)
2	10 (16.9%)	2 (11.8%)	2 (9.5%)	6 (28.6%)
3	21 (35.6%)	5 (29.4%)	8 (38.1%)	8 (38.1%)
4	22 (37.3%)	9 (52.9%)	9 (42.9%)	4 (19.0%)
A very large amount	3 (5.1%)	0	2 (9.5%)	1 (4.8%)
What kind of impact do you think multivitamin supplementation has on health?				
Very negative impact	2 (1.3%)	1 (2.2%)	0	1 (2.0%)
Slightly negative impact	2 (1.3%)	2 (4.4%)	0	0
No impact	14 (9.3%)	4 (8.9%)	4 (7.4%)	6 (11.8%)
Slightly positive impact	71 (47.3%)	21 (46.7%)	27 (50.0%)	23 (45.1%)
Very positive impact	55 (36.7%)	16 (35.6%)	19 (35.2%)	20 (39.2%)
None of the above	6 (4.0%)	1 (2.2%)	4 (7.4%)	1 (2.0%)
How much coffee do you consume on average?				
Never	47 (31.3%)	15 (33.3%)	16 (29.6%)	16 (31.4%)
1 cup/w or less	23 (15.3%)	6 (13.3%)	9 (16.7%)	8 (15.7%)
Not every day but a couple of cups/w	23 (15.3%)	7 (15.6%)	10 (18.5%)	6 (11.8%)
1-2 cups/d	52 (34.7%)	15 (33.3%)	19 (35.2%)	18 (35.3%)
More than 2 but less than 5 cups/d	5 (3.3%)	2 (4.4%)	0	3 (5.9%)
More than 5 but less than 7cups/d	0	0	0	0
Have you actively sought info about health impact of coffee consumption in the past?				
No	92 (61.3%)	30 (66.7%)	32 (59.3%)	30 (58.8%)
Yes	58 (38.7%)	15 (33.3%)	22 (40.7%)	21 (41.2%)
Please indicate how much info you have sought				
A very small amount	9 (15.5%)	2 (13.3%)	5 (22.7%)	2 (9.5%)
2	13 (22.4%)	3 (20.0%)	4 (18.2%)	6 (28.6%)
3	17 (29.3%)	5 (33.3%)	7 (31.8%)	5 (23.8%)
4	16 (27.6%)	3 (20.0%)	6 (27.3%)	7 (33.3%)
A very large amount	3 (5.2%)	2 (13.3%)	0	1 (4.8%)
What kind of impact do you think moderate coffee consumption has on health?				
Very negative impact	16 (10.7%)	6 (13.3%)	6 (11.1%)	4 (7.8%)
Slightly negative impact	73 (48.7%)	24 (53.3%)	25 (46.3%)	24 (47.1%)
No impact	24 (16.0%)	8 (17.8%)	5 (9.3%)	11 (21.6%)
Slightly positive impact	30 (20%)	5 (11.1%)	14 (25.9%)	11 (21.6%)
Very positive impact	5 (3.3%)	2 (4.4%)	2 (3.7%)	1 (2.0%)
None of the above	2 (1.3%)	0	2 (3.7%)	0

Note: n= number of cases, percentages (in brackets)
Cups/d = cups per day; cups/w = cups per week
Chi-square tests showed that the proportions did not significantly differ between groups except for "How much information have you sought?": $X^2_{(8, N=31)} = 16.053$, $p = .042$. However, considering the number of conducted tests and the high p value, this is considered non-significant.
(*) This question existed of four different parts and participants were able to indicate more than one statement.
Percentages may not total 100 due to rounding.

Associations with familiarity and involvement with scientific literature and the three nutrition topics

Reading scientific literature often was positively associated with previously having sought information about the health impact of coffee consumption ($r = .195$, $p = .036$), the Rationale score ($\tau_b = .224$, $p = .019$) and the Integration score for the writing task ($\tau_b = .181$, $p = .047$), and negatively associated with multiplicism as measured through the ETA scale at the post intervention measurement ($r = -.217$, $p = .037$).

Having sought information about the health impact of wine was associated with having sought information about multivitamins ($r = .292$, $p = .002$) and coffee ($r = .212$, $p = .028$), and having sought information about multivitamins was associated with having sought information about coffee ($r = .265$, $p = .006$).

The perceived health impact of wine was positively associated with multiplicism on the ETA scale with the wine topic ($r = .139$, $p = .032$). Having sought information about the health impact of wine was associated with wine consumption ($r = .181$, $p = .019$). Having sought information about ($r = .272$, $p < .001$) and the perceived health impact of coffee ($r = .253$, $p = .002$) were associated with coffee consumption. Having sought information about coffee was positively associated with multiplicism ($r = .257$, $p = .007$) and evaluativism ($r = .237$, $p = .014$) at the follow-up, measured through the ETA scale with coffee. Having sought information about the health impact of multivitamin supplementation was positively associated with the perceived health impact ($r = .168$, $p = .045$). Participants' self-reported impact of multivitamin supplementation on health was significantly associated ($X^2_{(20, N = 148)} = 37.209$, $p = .011$) with their recommendation score in the writing task.

Time spent on completion of the reading and writing (MDP) task

Qualtrics recorded the time of the first click on the page of the reading and writing task and the time of page submission. Then, a variable was created that presents the calculated duration of the task. The time spent on the task was not significantly associated with the participants' performance on the writing task (SUM score writing task: $\tau_b = .080$ ($p = .176$). There was a significant difference in task duration between the groups ($H_{(2)} = 11.252$; $p = .004$), more specifically, a post hoc Mann-Whitney U tests with Bonferroni correction showed that the control group ($U = -28.888$, $p = .003$) and the

exposed group (U = -21.452, p = .043) on average spent significantly longer on the task than the guided group.

Associations between different EB and MDP measures

ASSOCIATIONS BETWEEN THE DIMENSIONS OF THE ETA SCALE AND THE MDP MEASURES

As a means to check our measures and to assist with the interpretation of the results, **Table 11** shows the significant associations between the items (the three perspectives for each of the nine dimensions) of the ETA scale as the present study's quantitative measure of participants' EBs on the one hand and our qualitative measurement of participants EBs based on their performance on the MDP task through the content analysis of their written recommendation and justification on the other hand.

Table 11. Associations between the items of the ETA scale and the MDP task measures

ETA scale		MDP task						
Dimension	Perspective	Epistemological stance	Argumentation	Recommendation	Rationale	Coverage	Explanation	Sum-score
Right answer	A							
	M	-.141*		X^2 (20, N = 148) =38.458, p= .008				
	E							
Certainty of knowledge	A							
	M		-.199**	X^2 (20, N = 148) =37.420, p= .010		-.221**		-.201**
	E					.180**		.129*
Attainability of truth	A							
	M					-.165*		
	E		.144*			.169*		
Nature of knowledge	A							
	M	-.146*			-.140*	-.185**		-.163*
	E							
Source of knowledge	A							
	M			X^2 (20, N = 148) =37.829, p = .009		-.171*		-.162*
	E							
Multiple perspectives	A	.144*				.146*		.129*
	M					-.157*		
	E							

Evaluate explanations	A					.150*		.136*
	M					-.177**		-.149*
	E		.188**			.204**		.144*
Judge accounts	A			X^2 (20, N = 148) =59.297, p <.001		.147*		
	M		-.152*	X^2 (20, N = 148) =32.236, p= .041		-.228**		-.162*
	E							
Reliable explanation	A		.143*			.164*	0.149*	.157*
	M	-.237**	-.215**		-.157*	-.322**		-.257**
	E							

Note:
First column: The nine dimensions of the Epistemic Thinking Assessment (ETA) scale by Barzilai and Weinstock (2015)
Second column: A: Absolutism, M: Multiplicism, E: Evaluativism
MDP = Multiple Document Processing
Kendall's tau-b correlation coefficients (τ_b) are presented: *p<0.05, **p<0.01
For Recommendation (as a nominal variable), the Chi-Square test (X^2) is presented.
Only significant associations are displayed to facilitate readability of the table.

ASSOCIATIONS BETWEEN THE ETA AND CAEB SCALES

Variability and texture were positively associated (Pre: r = .474, p < .001; Post: r = .217, p = .032) with each other. The measures for the three developmental stages at the three time points were all significantly associated. The correlation coefficients are presented in **Table 12**.

At the pre-intervention measurement, absolutism and multiplicism were significantly negatively associated (r = -.260, p = .010), however, no significant associations with evaluativism were found.

At the post and follow-up measurements, the three developmental stages were significantly correlated with each other; at post: absolutism was negatively associated with multiplicism (r = -.260, p = .010) and positively with evaluativism (r = .273, p = .007). At the follow-up measurement, evaluativism was positively associated with both absolutism (r = .316, p = .002) and multiplicism (r = .317, p = .001).

Table 12. Descriptive, correlation and reliability analyses for the ETA, CAEB and SDR scales.

	M (SD)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1.Abs Pre	4.20(0.68)	*(0.81)*															
2.Multi Pre	2.71(0.73)	**-.260***	*(0.83)*														
3.Eva Pre	4.20(0.69)	.157	.071	*(0.79)*													
4.Texture Pre	3.47(0.61)	-.102	.129	-.009	*(0.67)*												
5.Variability Pre	4.35(0.74)	.065	.000	.119	**.474****	*(0.50)*											
6.Abs Post	4.26(0.68)	**.527****	**-.297****	.110	-.129	.001	*(0.82)*										
7.Multi Post	2.94(1.07)	**-.276****	**.597****	.047	.171	.020	**-.260***	*(0.86)*									
8.Eva Post	4.35(0.68)	.190	**-.218***	**.596****	-.080	.084	**.273****	-.007	*(0.85)*								
9.Abs FU	4.23(0.70)	**.442****	-.152	.114	-.144	.076	**.506****	-.172	.120	*(0.84)*							
10.Multi FU	2.97(1.07)	**-.216***	**.607****	**.237***	.104	.064	**-.284****	**.589****	-.025	-.145	*(0.89)*						
11.Eva FU	4.37(0.65)	.146	.032	**.460****	-.108	.076	.078	.121	**.420****	**.316****	**.317****	*(0.83)*					
12.Texture FU	3.59(0.71)	-.103	.139	-.057	**.262****	.001	-.147	-.102	-.187	**-.237***	.100	-.185	*(0.70)*				
13.Variability FU	4.35(0.73)	.008	-.043	-.082	.196	**.521****	.012	-.110	-.136	-.023	-.105	-.057	**.217***	*(0.56)*			
14. Proc/Comp	3.41(0.77)	.126	-.134	.115	.019	-.028	.162	-.060	.103	.103	-.057	.012	.100	.096	*(0.79)*		
15.Val/ Int	3.07(0.69)	-.077	-.001	**.239***	-.049	.145	-.072	.064	.175	-.018	.145	**.245***	-.059	.173	.038	*(0.75)*	
16. Complex/Uncert	3.29(0.66)	.182	-.084	-.103	.057	.084	.183	-.068	.047	**.205***	-.138	-.062	-.033	.063	**.281****	**-.218***	*(0.62)*

Notes:

Epistemic Thinking Assessment (ETA) scales were answered on a 6-point scale from 1 to 6 with higher values indicating stronger endorsement of the respective belief.

Connotative Aspects of Epistemic Beliefs (CAEB) scales were answered on a 7-point scale.

Science Dispute Reasons (SDR) scales were answered on a 5-point scale.

The table presents the descriptive, correlation and reliability analyses for the ETA (Absolutism (Abs), Multiplicism (Multi), Evaluativism (Eva)) (Barzilai and Weinstock, 2015), CAEB (Texture, Variability) (Stahl and Bromme, 2007) and SDR (Procedure and competence (Proc/Comp), Values and interests (Val/Int), Complexity and uncertainty (Complex/Uncert)) (Dieckmann and Johnson, 2019) scales.

N=98

M=Mean, SD= Standard Deviation

Pre= pre-intervention measure; Post=post-intervention measure; FU: measure at follow-up

Pearson correlation coefficient: * $p<0.05$, ** $p<0.01$, *** $p< 0.001$

(Cronbach's alpha in italics)

ASSOCIATIONS BETWEEN THE MDP MEASURES AND ABSOLUTISM, MULTIPLICISM, AND EVALUATIVISM

All MDP measures were significantly associated with all other MDP measures (see **Table 13**).

The **argumentation** score of the writing task was negatively associated with multiplicism (post: τ_b = -.222, p = .006; follow-up: τ_b = -.177, p = .026) and positively associated with absolutism (τ_b = .266, p < .001) and evaluativism at follow-up (τ_b = .194, p = .015), and positively with the D-score at post (τ_b = .173, p = .029) and follow-up (τ_b = .262, p < .001).

The **epistemological stance** showed a significant positive association with absolutism at post (τ_b = .168, p = .044) and a negative association with multiplicism (post: τ_b = -.170, p = .040; follow-up: τ_b = -.168, p = .041). This EB measure based on the writing task (participants were assigned one of three developmental stages based on the epistemological stance they presented in their written recommendation) correlated well with the D-score (evaluativism -0.5*(absolutism + multiplicism) as measured through the ETA scale) (D-score Post: τ_b = .172, p = .036).

Coverage correlated significantly with all three ETA scales; positively with absolutism (post: τ_b = .179, p = .023; follow-up: τ_b = .243, p = .002) and negatively with multiplicism (post: τ_b = -.307, p < .001; follow-up: τ_b = -.231, p = .003). Coverage also showed significant correlations with the D-scores (Post; τ_b = .291, p < .001; Follow-up: τ_b = .240, p = .002).

Rationale showed a negative association with multiplicism post (τ_b = -.184, p = .030) and a positive relation with absolutism follow-up (τ_b = .209, p = .013).

Explanation did not show any significant associations with any of the ETA scales.

The sum score for the performance on the writing task (including the measures for epistemological stance, argumentation, coverage, rationale and explanation) was positively and significantly associated with the D-score (Post: τ_b = .172, p = .017; Follow-up: τ_b = .156, p = .031).

Multiple linear regression was used to test if the ETA scales, self-reported information literacy self-efficacy, familiarity with reading scientific literature having sought information about multivitamins in the past and the time spent on the MDP task could significantly predict performance on the writing task. The overall regression was statistically significant (R^2 = 0.276), $F_{(7, 87)}$ = 4.747, p < .001). It was found that information self-efficacy (Beta = .525, p < .001) and multiplicism (Beta = -.340, p = .003) significantly predicted task performance. Absolutism (Beta = .092, p < .552), evaluativism (Beta = .060, p = .146), familiarity with reading scientific literature (Beta = .188, p = .248), having sought information about multivitamins in the past (Beta = -.129, p = .525) and the time spent on the MDP task (Beta = .000, p = .168) did not significantly predict task performance.

Table 13. Correlational analysis between MDP measures, ETA Post and FU, familiarity with reading scientific literature, and information literacy self-efficacy.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1.Abs Post															
2. Multi Post	***-.207****														
3. Eva Post	*.163*	*.012*													
4. D-score Post	-.073	**-.371****	**.565****												
5. Epistem. stance	**.168***	**-.170***	.100	**.172***											
6. Argumentation	.139	**-.222****	.066	**.173***	**.544****										
7. Coverage	**.179***	**-.307****	.155	**.291****	**.655****	**.723****									
8. Rationale	.086	**-.184***	.056	.073	**.529****	**.602****	**.546****								
9. Explanation	.124	-.112	.045	.085	**.539****	**.493****	**.509****	**.508****							
10. Perform. task	***.217****	***-.310****	*.104*	**.172***	**.727****	**.746****	**.770****	**.650****	**.658****						
11.Abs FU	***.474****	***-.156***	*.107*	.053	.147	**.266****	**.243****	**.209***	.098	**.208****					
12.Multi FU	***-.254****	***.614****	*-.006*	**-.192****	**-.168***	**-.177***	**-.231****	-.126	-.048	**-.166***	*-.137*				
13.Eva FU	*.129*	***.079***	***.448****	**.213****	.057	**.194***	.137	.003	.054	.079	***.349****	***.295****			
14. D-score FU	.060	**-.239****	**.238****	**.354****	.157	**.262****	**.240****	.044	.056	**.156***	.019	**-.320****	**.433****		
15. Info lit	***.215****	*-.019*	*.103*	.036	**.233****	**.189***	**.232****	**.244****	**.183***	***.359****	***.466****	*-.085*	***.283****	*.105*	
16. Scient lit fam	*.036*	***-.208****	*-.007*	.087	.094	**.202***	.163	**.239***	.047	*.193*	***.118***	*-.031*	*-.015*	*-.053*	*.051*

Notes:

N=91

Kendall's tau/ *Pearson* correlation coefficient: * p<0.05, ** p<0.01, ***p<0.001

ETA: Epistemic Thinking Assessment (Barzilai and Weinstock, 2015). Abs: absolutism, Multi: multiplicism, Eva: evaluativism. D-score = evaluativism -0.5*(absolutism + multiplicism) (Krettenauer, 2005) as measured through the ETA scale. Post: at post-intervention measurement, Epistem. stance: epistemological stance presented in MDP task response, Perform. task: Overall task performance based on a sum score of the MDP measures, FU: at follow-up measurement, Info lit: information literacy self-efficacy, Scient lit fam: familiarity with reading scientific literacy

Reasons for disagreements

Participants' perceptions of the likelihood of different reasons for expert disagreement were measured through the SDR scale with 1: never a cause of disagreements – 5: almost always a cause for disagreements. A total sample mean of $M = 3.41$ ($SD = 0.77$) was found for *process and competence*, and $M = 3.29$ ($SD = 0.66$) for *complexity and uncertainty*, and $M = 3.07$ ($SD = 0.69$) for *interests and values*. The means for the different experimental groups are presented in **Table 14**. No significant differences were found between the experimental groups, nor between the three epistemological stances in terms of which of the three SDR scales was scored the highest, as presented in **Table 15**.

Complexity and uncertainty showed a significant positive association with *process and competence* ($r = .281$, $p = .005$) and a significant negative correlation with *interests and values* ($r = -.218$, $p = .031$).

When investigating their relationship with the ETA scales, evaluativism at pre ($r = .239$, $p = .018$) and follow-up ($r = .245$, $p = .015$) showed significant correlations with *values and interests*. *Complexity and uncertainty* were positively correlated with absolutism at follow-up ($r = .205$, $p = .043$). No significant correlations with *process and competence* were found.

No significant correlations were found between the SDR scales and the MDP measures.

A cross-tabulation between our MDP measures *explanation* and *epistemological stance* is presented in **Table 16**. The Pearson chi-square test showed a significant association between the variables (Chi-square = 55.594, $df = 6$, $p < .001$). Approximately 85% of participants with a predominant absolutist perspective and 61% of those with a multiplicist perspective did not discuss any explanation for the conflict in their writing task response. Most of the participants (78.9%) with an evaluativist perspective did address the conflict in their written task response and tried to explain its existence. Of those, 69% attributed the perceived conflict to variations in studies, 17% to different expertise levels, and (13%) attributed the disagreement to the tentativeness of knowledge.

Table 14. Descriptives (Mean (M), Standard Deviation (SD)) of the three constructs of the SDR scale and comparisons between groups

	Guided	Exposed	Control	
Process/competence	3.53 (0.67)	3.42 (0.74)	3.41 (0.65)	$F_{(2,147)} = 0.444$ $p = .643$
Interests/values	3.15 (0.58)	3.15 (0.71)	3.02 (0.75)	$F_{(2,147)} = 0.617$ $p = .541$
Uncertainty/complexity	3.31 (0.75)	3.17 (0.63)	3.35 (0.66)	$F_{(2,147)} = 1.033$ $p = .359$

Note: SDR = Science Dispute Reasons scales (Dieckmann and Johnson, 2019).
Participants answered the following question: "Studies on multivitamin supplementation often come to differing conclusions. Why do you think this is? Please indicate how often you think that the following statements are causes of scientific disagreement. - Scientists use different research methods." (This is an example for the process/competence construct.)
N = 150 (G: n = 45, E: n = 54, C: n = 51)

Table 15. Proportions of participants that indicated one of the three constructs of the SDR scale as the most likely reason for disagreement.

		Epistemological stance			Group			Explanation			
		A	M	E	G	E	C	1	2	3	4
Process/ competence	44%	35.1%	54.1%	42.3%	43.9%	46.7%	42.2%	45.3%	45.0%	43.9%	33.3%
Interests/ values	24%	24.3%	24.3%	25.0%	22.0%	26.7%	24.4%	21.9%	25.0%	29.3%	16.7%
Uncertainty/ complexity	32%	40.5%	21.6%	32.7%	34.1%	26.7%	33.3%	32.8%	30.0%	26.8%	50.0%
	Chi-Square = 3.670, *df* = 4, *p* = .453				Chi-square=0.772, *df*=4, *p* = .942			Chi-square=1.886, *df*=6, *p* = .930			

Note:
SDR = Science Dispute Reasons scales (Dieckmann and Johnson, 2019)
Proportions of participants within each of the three epistemological stances as identified in the writing task (Absolutism (A), Multiplicism (M), Evaluativism (E)), within each of the experimental conditions (Guided (G), Exposed (E), Control (C)) and for each category of the MDP measure explanation (1: No discussion ;2: Different expertise levels ;3: Variations in studies (methods, participant groups, outcomes, etc.) ;4: Knowledge may change over time/context) that indicated one of the three constructs of the SDR scale as the most likely reason for disagreement.
A variable was created based on the means for the three SDR scales, i.e., if an individual scored the highest on process/competence =1, interests/values=2, or uncertainty/complexity =3. Only participants with a highest score, i.e., not an equal score for two or three of the scales, were included. (*n* = 131)
Percentages may not total 100 due to rounding.

Table 16. Proportions of participants within each of the three epistemological stances and for each category of our MDP measure for conflict explanation.

Explanation	**Epistemological stance**		
	Absolutist	Multiplicist	Evaluativist
No discussion	40(85.1%)	25(61.0%)	12(21.1%)
Different expertise levels	4(8.5%)	9(22.0%)	8(14.0%)
Variations in studies (methods, participant groups, outcomes, etc.)	2(4.3%)	7(17.1%)	31(54.4%)
Knowledge may change over time/context	1(2.1%)	0	6(10.5%)

Note:
MDP = Multiple Document Processing
Chi-square = 55.594, *df* = 6, ***p* < .001** (*n* = 145)
Percentages may not total 100 due to rounding.

Differences in EBs within and between groups

BETWEEN GROUP COMPARISONS FOR MDP MEASURES

An independent samples Kruskal-Wallis test found no significant difference between the means of the groups (G: *M* = 3.38, *SD* = 1.24; E: *M* = 3.23, *SD* = 0.96; C: *M* = 3.37, *SD* = 0.99) for overall performance on the writing task (as sum score) ($H_{(2)}$ = 1.125, *p* = .570). Proportions of participants in each group for each category of the MDP measures are presented in **Table 17**. The epistemological stance the participants presented in their written recommendation was found significantly different between groups (Chi-square = 12.964, *df* = 4, *p* = .011). An overall

evaluativist stance was identified in 60.5% of the participants in the guided group, 30.8% in the exposed group and 30.0% in the control group.

Coverage and Argumentation did not quite reach significance (Coverage: Chi-square = 13.743, *df* = 8, *p* = .089; Argumentation: Chi-square = 17.411, *df* = 10, *p* = .066), nor did Recommendation (Ch-square = 5.795, *df* = 8, *p* = .670), Rationale (Chi-square = 7.292, *df* = 6, *p* = .295) or Explanation (Chi-square = 6.587, *df* = 6, *p* = .361).

Table 17. Proportions (%) of participants in each group for each category of the MDP measures.

	Guided	Exposed	Control
Epistemological stance	**Chi-square = 12.964, *df* = 4, *p* = .011**		
Absolutism	23.3%	40.4%	32.0%
Multiplicism	16.3%	28.8%	38.0%
Evaluativism	60.5%	30.8%	30.0%
Argumentation	Chi-square = 17.411, *df* = 10, *p* = .066		
One sided answer based on prior knowledge/ beliefs	15.6%	5.7%	6.1%
One sided answer without ref to sources	6.7%	0%	0%
One-sided answer with references to sources	11.1%	22.6%	22.4%
Two-sided/ nuanced answer without reference to sources	13.3%	5.7%	6.1%
Two-sided/ nuanced answer with reference to sources	31.1%	50.9%	44.9%
Two-sided/ nuanced answer with reference to sources and comparison (weighing up)	22.2%	15.1%	20.4%
Coverage	Chi-square = 13.743, *df* = 8, *p* = .089		
1 side	27.3%	13.5%	17.4%
2 sides but 1 side solely talked about in critique (shallow)	6.8%	19.2%	10.9%
2 sides both treated equally, no integration of conflict	6.8%	26.9%	19.6%
2 sides, conflict is highlighted but unresolved	31.8%	15.4%	26.1%
2 sides with nuanced weighing up	27.3%	25.0%	26.1%
Rationale	Chi-square = 7.292, *df* = 6, *p* = .295		
Prior knowledge	20.5%	5.6%	12.0%
Knowledge from authority	0	5.6%	4.0%
Corroboration	50.0%	61.1%	56.0%
Rules of inquiry	29.5%	27.8%	28.0%
Explanation	Chi-square = 6.587, *df* = 6, *p* = .361		
No discussion	46.7%	59.3%	51.0%
Different expertise levels	11.1%	14.8%	17.6%
Variations in studies (methods, participant groups, outcomes, etc.)	40.0%	22.2%	23.5%
Knowledge may change over time/context	2.2%	3.7%	7.8%
Recommendation	Chi-square = 5.795, *df* = 8, *p* = .670		
Take vit	22.7%	22.2%	16.0%
Don't take vit	29.5%	40.7%	36.0%
There's no way to know	2.3%	1.9%	4.0%
Everyone must make their own choice	25.0%	27.8%	24.0%
Seek help from authority	20.5%	7.4%	20.0%

Note:
MDP = Multiple Document Processing
Argumentation: "One sided answer based on external authoritative justification belief": none
Percentages may not total 100 due to rounding.

WITHIN GROUP COMPARISONS FOR ETA SCALES

All means are shown in **Figures 13&14.** Although the graphs show that within the guided group, absolutist beliefs decreased over time, paired t-tests did not find significant differences: Pre-Post:

$t_{(42)}$ = 1.262 (p = .214), d = 0.192 and Pre-FU: $t_{(25)}$ = 1.00 (p = .327), d = 0.196. In addition, although the D-score for the guided group increased over time, differences were not significant: Pre-Post: $t_{(42)}$ = -0.873 (p = .388), d = -0.133; Pre-FU: $t_{(25)}$ = -0.866 (p = .395), d = -0.170. Within the exposed group, the increase in multiplicism did not quite reach significance; Pre-Post: $t_{(47)}$ = -1.877 (p = .067), d = -0.271 and Pre-FU: $t_{(37)}$= -1.829 (p = 0.075), d = -0.297. Within the control group, a paired t-test showed a significant increase in multiplicism between pre and post: $t_{(48)}$ = -2.092 (**p = .042**), d = -0.299 (Multiplicism pre-FU: $t_{(33)}$ = -1.734 (p = .092), d = -0.297) and a significant increase in evaluativism Pre-FU: $t_{(33)}$ = -2.191 (**p = .036**), d = -0.376. No other significant changes were found. Proportions of participants within each group for whom absolutism and multiplicism decreased and evaluativism increased between pre and post measurement are presented in **Table 18**.

Table 18. Proportion of participants for whom absolutism decreased, multiplicism decreased and evaluativism increased between pre- and post-intervention measurement in each group.

	Absolutism decrease	Multiplicism decrease	Evaluativism increase
Guided	53.3%	36.4%	50.0%
Exposed	36.5%	31.4%	58.0%
Control	51.0%	36.7%	54.0%
	Chi-square = 3.320, *df* = 2, *p* = .190	Chi-square = 0.392, *df* = 2, *p* = .822	Chi-square = 0.604, *df* = 2, *p* = .739
Guided	55.6%	50.0%	48.1%
Exposed	46.3%	45.0%	59.0%
Control	44.1%	34.3%	69.4%
	Chi-square = 0.868, *df* = 2, *p* = .648	Chi-square = 1.709, *df* = 2, *p* = .426	Chi-square = 2.929, *df* = 2, *p* = .231

BETWEEN GROUP COMPARISONS FOR ETA SCALES

One way ANOVAs found no significant differences between the groups on any of the developmental stages at any of the measurement times; Multiplicism at post-intervention measurement: $F_{(2,95)}$ = 2.603 (p = .079); Absolutism at follow-up measurement: $F_{(2,95)}$ = 2.536 (p = .085); D-score at post-intervention: $F_{(2,95)}$ = 1.748 (p = .180); D-score at follow-up: $F_{(2,95)}$ = 1.016 (p = .085); all other Fs = <0.765 and ps = > 0.468. Also comparison of the mean changes over time did not show any significant differences between groups; Change in absolutism between pre and post was calculated with a Welch's ANOVA: $F_{(2,\ 54.259)}$ = 0.265 (p = .768); the others were calculated with one-way ANOVAs: Change in multiplicism between pre and post-intervention measurement: $F_{(2,95)}$ = 1.054 (p = .535); change in absolutism between pre and follow-up: $F_{(2,95)}$ = 1.718 (p = .185); change in D-score between pre and post: $F_{(2,95)}$ = 0.761 (p = .470); Change in D-score between pre and follow-up: $F_{(2,95)}$ = 0.635 (p = .532); all other Fs =< 0.387 and ps => 0.680. All means are shown in **Figure 14.**

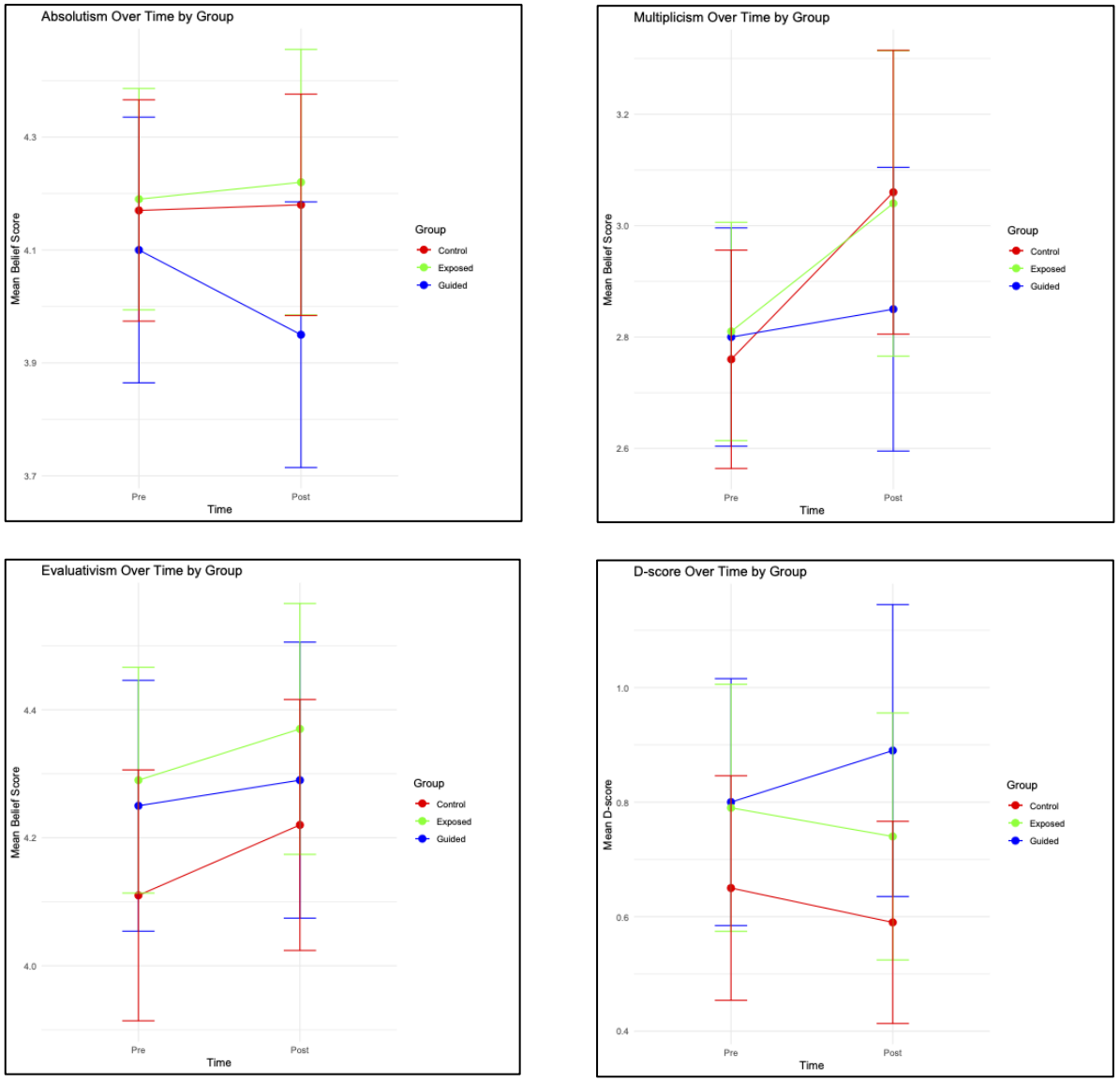
Given the limited sample size, analysis of pre and post measures only were conducted as well (with *n*=140). The means are displayed in **Figure 13**. The mean changes are presented in **Table 19.** However, with this larger sample size as well, no significant differences were found: Absolutism at post-intervention measurement: $F_{(2,137)} = 1.732$ ($p = .181$); Change in multiplicism: $F_{(2,137)} = 0.997$ ($p = .372$); all other *F*s = < 0.924 and *p*s = > 0.399.

Table 19. Mean changes in ETA scales and D-score for the three experimental groups

	Guided (*n*=43)	**Exposed (*n*=48)**	**Control (*n*=49)**
Change in absolutism pre-post	- 0.16 (0.81)	+ 0.03 (0.58)	+ 0.01 (0.69)
Change in multiplicism pre-post	+ 0.06 (0.62)	+ 0.23 (0.83)	+ 0.30 (1.00)
Change in evaluativism pre-post	+ 0.05 (0.64)	+ 0.07 (0.74)	+ 0.10 (0.70)
Change in D-score pre-post	+ 0.10 (0.73)	- 0.05 (0.67)	- 0.05 (0.78)
	Guided (*n*=26)	**Exposed (*n*=38)**	**Control (*n*=34)**
Change in absolutism pre-post	-0.04 (0.87)	+0.10 (0.54)	+0.09 (0.61)
Change in absolutism pre-follow-up	- 0.17 (0.89)	+ 0.04 (0.61)	+ 0.17 (0.71)
Change in multiplicism pre-post	+0.06 (0.52)	+0.31 (0.72)	+0.28 (0.72)
Change in multiplicism pre-follow-up	+ 0.22 (0.75)	+ 0.26 (0.89)	+ 0.27 (0.92)
Change in evaluativism pre-post	+0.15 (0.64)	+0.14 (0.59)	+0.15 (0.62)
Change in evaluativism pre-follow-up	+ 0.19 (0.81)	+0.09 (0.70)	+ 0.23 (0.61)
Change in D-score pre-post	+0.14 (0.74)	-0.07 (0.57)	-0.03 (0.74)
Change in D-score pre-follow-up	+ 0.17 (1.01)	- 0.06 (0.72)	+ 0.005 (0.71)

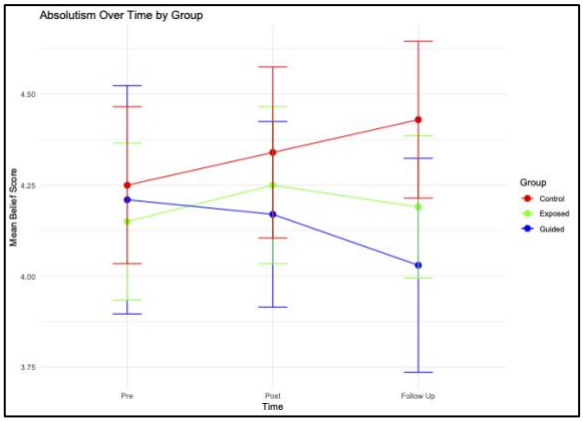
Note: ETA = Epistemic Thinking Assessment scales (Absolutism, Multiplicism, Evaluativism) (Barzilai and Weinstock, 2015). D-score = evaluativism -0.5*(absolutism + multiplicism) (Krettenauer, 2005).

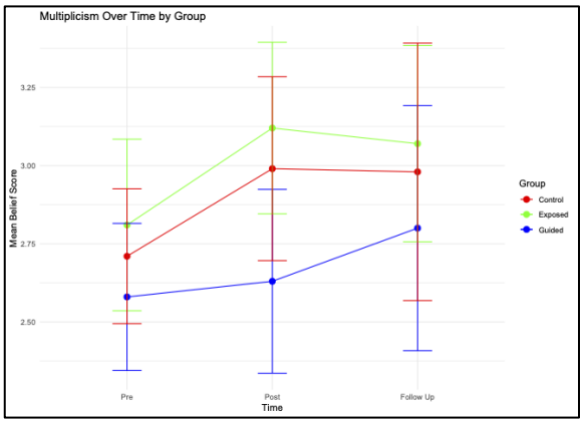
Figure 13. EBs over time (Pre – Post) per group.

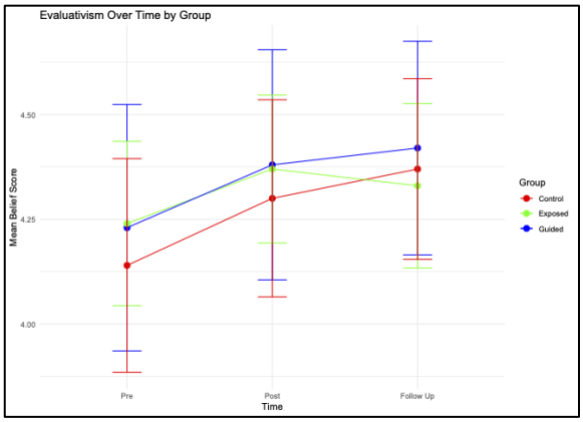


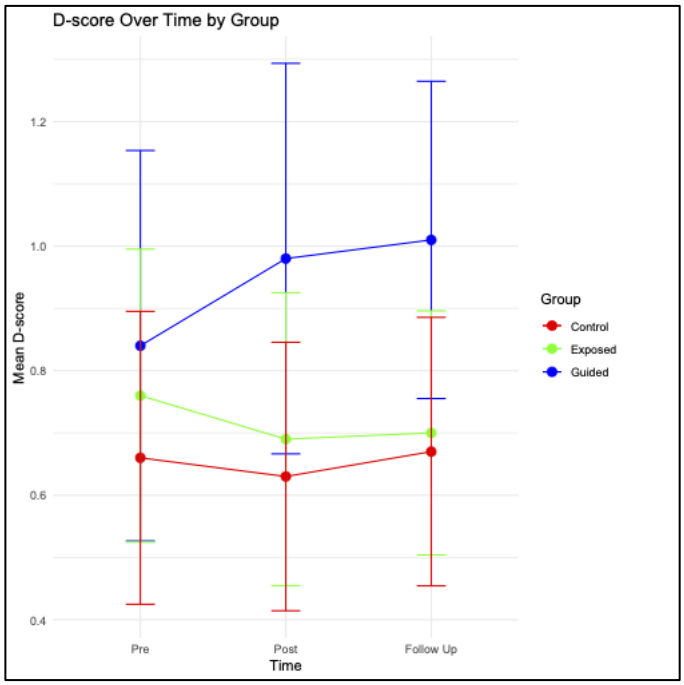
Note:
The graphs show the mean values for the Epistemic Thinking Assessment (ETA) scales (Absolutism, Multiplicism, Evaluativism) and the D-score (Evaluativism – 0.5*(Absolutism + Multiplicism)) Pre-intervention and Post-intervention measurements.
$N = 140$ (Guided group: $n = 43$; Exposed group: $n = 48$; Control group: $n = 49$)
The error bars present the 95% confidence interval defined as 1.96*Standard Error on either side of the mean.
For the development of the graphs ggplot2 in R was used.

Figure 14. EBs over time (Pre – Post – Follow-Up) per group.









Note:
The graphs show the mean values for the Epistemic Thinking Assessment (ETA) scales (Absolutism, Multiplicism, Evaluativism) and the D-score (Evaluativism – 0.5*(Absolutism + Multiplicism)) on the three measurements over time (Pre-intervention, Post-intervention and Follow-up).
$N = 98$ (Guided group: $n = 26$; Exposed group: $n = 38$; Control group: $n = 34$)
The error bars present the 95% confidence interval defined as 1.96*Standard Error on either side of the mean.
For the development of the graphs ggplot2 in R was used.

Information literacy

A total sample mean of $M = 5.36$ ($SD = 0.79$) was found for the self-efficacy in information literacy sum score. No significant difference between the groups ($F_{(2,104)} = 0.069$ $p = .933$) was found. However, a significant difference was found for the item "I feel I am capable of determining the authoritativeness, currency and reliability of information sources" (7 Likert) $F_{(2,104)} = 3.877$ $p = .024$). A post hoc test showed that the guided group ($M = 5.43$, $SD = 0.920$) and the control group ($M = 4.78$, $SD = 1.182$) were significantly different ($p = 0.05$). The group means are presented in **Table 20**.

Table 20. Between groups comparison of means for information literacy self-efficacy.

	Guided (n=28)	Exposed (n=42)	Control (n=37)	
	M (*SD*)	*M* (*SD*)	*M* (*SD*)	
I feel I am capable of determining the authoritativeness, currency and reliability of information sources	5.43 (0.92)[a]	5.36 (1.06)[a,b]	4.78 (1.18)[b]	**$F_{(2,104)} = 3.877$, $p = 0.024$**
Information literacy SE sum score	5.40 (0.78)	5.35 (0.75)	5.33 (0.86)	$F_{(2,104)} = 0.069$, $p = 0.933$

Note: *M*= Mean (*SD*= Standard Deviation)
[a,b] Post hoc multiple comparisons were performed using Tukey-HSD test. Different superscript letters indicate significant differences ($p < 0.05$) between groups.

Information literacy was significantly and positively associated with all MDP measures (performance task: $r = 0.359$, $p < .001$), with absolutism (post: $r = 0.215$, $p = .044$; follow-up: $r = 0.466$, $p < .001$) and evaluativism at follow-up ($r = 0.283$, $p = .009$).

Intentions to adhere to healthy lifestyle behavioural recommendations.

Intentions concerning diet and PA were positively associated (at the premeasurement: $r = 0.390$, $p < .001$ and at FU: $r = 0.225$, $p = .020$). Intentions at pre and follow up measurement were positively associated; diet ($r = 0.527$, $p < .001$) and PA ($r = 0.687$, $p < .001$).

Although comparison of the mean changes over time did not show significant differences between the groups (Diet: $F_{(2,104)} = 0.834$ $p = .437$; PA: $F_{(2,104)} = 1.956$ $p = .147$), the results show changes in the opposite direction than initially hypothesised. The control group's mean intentions remained the same or even increased, whereas they decreased in the guided and exposed group. Significant differences between pre and follow-up assessment were found for diet-related intentions in the exposed group ($t_{(41)}$=2.050 $p = .047$) and for PA-related intentions in the guided group ($t_{(27)} = 2.540$ $p = .017$). Means are presented in **Table 21**. **Table 22** presents the proportion of participants in each group for whom intentions to adhere to diet and PA-related recommendations decreased between pre-intervention and follow-up assessment.

Table 21. Comparison of the means M(SD) within and between groups for the self-reported lifestyle behavioural intentions.

	Guided (*n*=28)	Exposed (*n*=42)	Control (*n*=37)	
Diet intention Pre	3.57 (1.10)	3.98 (1.00)	3.84 (1.17)	3.82 (1.09)
Diet intention FU	3.29 (1.08)	3.71 (0.97)	3.84 (1.04)	3.64 (1.04)
	$t_{(27)}$ = 1.315 p = .200	**$t_{(41)}$ = 2.050 p = .047**	$t_{(36)}$ = 0.000 p = 1.000	$t_{(106)}$ = 1.774 p = .079
Change in diet intention	- 0.29 (1.15)	-0.26 (0.83)	0.00 (1.15)	$F_{(2,104)}$ = 0.834 p = .437
PA intention Pre	3.82 (1.25)	4.24 (0.91)	4.14 (1.08)	4.09 (1.07)
PA intention FU	3.50 (1.32)	4.21 (0.90)	4.22 (0.85)	4.03 (1.05)
	$t_{(27)}$ = 2.540 p = .017	$t_{(41)}$ = 0.206 p = .838	$t_{(36)}$ = -0.488 p = .628	$t_{(106)}$ = 0.807 p = .421
Change in PA intention	-0.32 (0.67)	-0.02 (0.75)	+0.08 (1.01)	$F_{(2,104)}$ = 1.956 p = .147

Note:
Participants answered the question *Research has shown significant associations between lifestyle behaviours and health outcomes. Experts recommend engaging in regular physical activity and to eat a diet rich in fruit and vegetables. "How likely is it that you will have five or more servings of vegetables and two or more servings of fruit on most days in the next year?" and "How likely is it that you will exercise at least three times in most weeks in the next year?"* on a 5-point Likert scale (1: very unlikely – 5: very likely).
M= Mean (*SD*= Standard Deviation); Pre= pre-intervention measurement; FU= follow-up measurement; PA = physical activity

Table 22. Proportion of participants in each group for whom intentions to adhere to diet and PA-related recommendations decreased between Pre and Follow-up assessment.

	Diet intention decrease	PA intention decrease
Guided	32.1%	35.7%
Exposed	33.3%	19.0%
Control	29.7%	16.2%
	Chi-square = 0.120, *df* = 2, *p* = .942	Chi-square = 3.937, *df* = 2, *p* = .140

Note: PA= physical activity

To explore the potentially associated factors with a change in behavioural intentions, we conducted correlation analyses between the change variables for behavioural intentions and EBs. A significant positive correlation was found between change in diet-related intentions and the change in absolutism from pre-intervention to follow-up measurement (r = 0.152, p = .049). A significant negative correlation was found between change in diet-related intentions and the change in multiplicism from pre- to post- intervention measurement (r = -0.183, p = .019).

4.2.5. Discussion

Main findings of the present study

Part 1: Associations with task performance

RQ1: Do participants with more adequate EBs, present more adequate epistemic practices and overall perform better on a MDP task?

The EB measure based on the writing task (participants were assigned one of three developmental stages based on the epistemological stance they presented in their written recommendation) correlated well with the D-score at post-intervention measurement (evaluativism -0.5*(absolutism + multiplicism) as measured through the ETA scale). Furthermore, the sum score for the performance on the writing task (including the measures for epistemological stance, argumentation, coverage, rationale and explanation) was positively and significantly associated with the D-score. Particularly, coverage showed a strong correlation with the D-score.

Thus, these findings support the first hypothesis that participants with more adequate EBs performed better on the MDP task.

The observed signs of the associations between task performance and the ETA scales were positive for absolutism and evaluativism and negative for multiplicism. While the positive sign for absolutism is somewhat counterintuitive, this could be explained by the idea that both absolutism and evaluativism imply a person's positive evaluation of the scientific endeavour (Klopp and Stark, 2022a), which may explain their positive association with task performance. Furthermore, the profiles of absolutism and evaluativism are almost identical in the ETA scale, apart from the dimensions *Nature of knowledge* and *The role of multiple perspectives* (Barzilai and Weinstock, 2015; Klopp and Stark, 2022a).

RQ2: a) Do participants who spend more time on the MDP task, score higher on the task?

Our findings do not confirm this hypothesis; The time spent on the task was not significantly associated with the participants' performance on the writing task. There was a significant difference in task duration between the groups, more specifically, the control group on average spent longer on the task than the guided group. Possibly this could be explained by the idea that the guided group was already familiar with the concept of the task and the instructions. Alternatively, it is possible that because the control groups had not been exposed to as much information before starting the MDP task, they therefore still had a larger part of their attention span available for the task.

RQ2: b) Are participants' levels of familiarity and involvement with the topic associated with their EBs and task performance?

Except for an association between the perceived health impact of multivitamin supplementation and participants' *recommendation* in the MDP task, no further significant associations were found. Surprisingly, we did not find significant associations between topic familiarity and involvement and participants' EBs on the ETA scales with the corresponding topics, nor did we find significant associations between participants' familiarity and involvement with multivitamin supplementation and their performance on the MDP task (on multivitamin supplementation). This is surprising given

the well-known effects of prior knowledge and beliefs on information processing (Richter and Maier, 2017) and previous studies which have found that topic familiarity leads to higher levels of absolutism and views that knowledge is certain (Merk et al., 2018). However, in a recent experimental study with controversial historical topics, topic familiarity was found to affect source trustworthiness judgements and the coordination of evaluation strategies, however, did not affect meta-epistemic understanding of the legitimacy of the controversy, its nature nor its resolution (Barzilai et al., 2020).

RQ3: Are there significant associations between conflict explanations and EBs?

Overall, our findings partly support the hypotheses;

a) *Participants with more adequate epistemic beliefs are more likely to reason about/ address an explanation for the disagreement in their MDP writing task and are more likely to attribute expert disagreements to information- and complexity and uncertainty-related causes*

We found a significant association between the MDP measures *epistemological stance* and *explanation*. Out of the participants that presented a predominant evaluativist stance in their MDP task, more than three quarters addressed the disagreement in their response and tried to explain it, and more than half attributed the disagreement to variations in studies in relation to methods, study sample, studied outcomes, etc.

b) *Participants with more adequate EBs self-report complexity and uncertainty as more likely reasons for disagreement rather than competence or motivation.*

Our findings based on the SDR scale do not confirm this hypothesis. Instead, we found significant positive associations between *interests and values* and evaluativism. In addition, a positive significant correlation was found between *complexity and uncertainty* and absolutism. It should be noted these correlations were found with the ETA measures at the pre-intervention measurement (wine) and follow-up (coffee), whereas the SDR scales referred to the topic multivitamin supplementation (example question: "Studies on multivitamin supplementation often come to differing conclusions. Why do you think this is? Please indicate how often you think that the following statements are causes of scientific disagreement. - Scientists use different research methods."). No significant correlations were found with any of the ETA measures at the post-intervention measurement, i.e., with multivitamin supplementation as topic.

Surprisingly, i.e., not hypothesised, however, in accordance with the findings through the ETA scale, the biggest proportion (40.5%) of participants that presented an absolutism stance in their writing task reported *uncertainty and complexity* as the most likely reason for expert disagreement. Participants in

all three epistemological stances (as identified through the MDP task) reported *interests and values* as the least likely reason for disagreement. Within those with an evaluativist stance, the biggest proportion (43.7%) indicated *process and competence* as the most likely reason for disagreement.

While we hypothesised that evaluativism would be associated with indicating *uncertainty and complexity* as the most likely reason for disagreement, this finding is not entirely surprising. The SDR scale measures process- and competence-related reasons under one construct. Consequently, items such as "scientists vary in competence" and "scientists vary in their experience studying this issue" as well as "scientists use different research methods" and "techniques for analysing study data differ from study to study" are combined in this construct *process and competence*. This notion may explain our findings given that while the competence-related reasons are more expected to be prevalent in absolutism and perhaps less in evaluativism, the process-related reasons are in fact to be expected in evaluativism.

Attempts were made to use the SDR scale with 5 constructs (process, competence, values, interests and complexity & uncertainty) rather than 3, however, we were not able to find a good fitting solution. Future research may wish to further investigate the potential association between conflict explanations and EBs based on measures that allow distinction between informant-related explanations (such as competence) and information-related explanations (such as process), next to the complexity and uncertainty-related explanations (e.g., Thomm et al. (2017) using the scale developed in Thomm et al. (2015)).

RQ4: Are there significant associations between people's EBs, task performance and information literacy self-efficacy (SE)?

Significant positive associations between all MDP measures, absolutism (post) and evaluativism (post and FU) and self-reported information literacy SE support the hypothesis that more adequate beliefs, better MDP performance and higher information literacy SE are associated.

In conclusion, considering the existing literature, what has part 1 taught us about the relationship between EBs, beliefs about science disagreements and handling conflicting health information?

Beliefs about the nature of knowledge and knowing and beliefs about reasons for expert disagreements

Few have specifically investigated the relationship between EBs and conflict explanations or people's beliefs about the legitimacy and resolution of expert disagreements (Barzilai et al., 2020; Thomm et al., 2017) . However, the latter beliefs reflect people's metacognitive epistemic understanding of the nature of knowledge and knowing (Barzilai and Ka'adan, 2017; Barzilai et al., 2020; Barzilai and Zohar, 2014; Barzilai and Zohar, 2016; Thomm et al., 2017). In the present study, the Science Dispute

Reasons (SDR) scale developed by (Dieckmann and Johnson, 2019) was used. The scale measures three constructs; *process/competence* representing "disputing scientists include one group that is more competent than the other; *values/interests* representing "one or both groups' scientific work is influenced by values or self-interest"; and *uncertainty/complexity* representing "the topic is too complex and uncertain for scientists to (currently) converge on an answer". While Dieckmann and Johnson (2019); Johnson and Dieckmann (2018) did not investigate the relationship of the constructs with EB measures as was done in the present work, they did explore the relationship with scientific positivism (measured through items such as e.g., "science identifies objective truth about the universe"). Johnson and Dieckmann (2018) found that scientific positivism was positively associated with all reasons for scientific disputes. However, Dieckmann and Johnson (2019) found an association with competence reasons only and depending on the topic. The association between positivism, absolutism and attributing scientific disputes to competence-based reasons seems a plausible relationship given the idea that "scientists, if competent, would not be disagreeing about the truth". Others have found that absolutism is associated with information-related explanations (e.g., differences in the research process) rather than informant-related reasons (Thomm et al., 2017). Multiplicist beliefs were found to be associated with motivation-related explanations (Thomm et al., 2017). While the associated beliefs with absolutism and multiplicsm may differ, the literature consistently proposes an association between evaluativism and explaining expert disagreement through complexity and uncertainty. Nevertheless, even when significant, and plausible, associations were found their strength was weak to moderate (Thomm et al., 2017). Possible explanations are differences in the nature of the conflict as well as the idea that conflict explanations show one's understanding of a specific conflict, whereas EBs represent views regarding the epistemic status and nature of expert knowledge and the epistemic legitimacy of expert disagreement (Thomm et al., 2017). Thus, the present study did not find the expected associations, however, previous literature on this matter is limited and varied, and further research on these beliefs applied to specific conflict topics is warranted.

In addition, in the present study, adopting a mixed methods approach, qualitative measures based on the participants' performance on a MDP task were used. A specific measure *Explanation* was included in the assessment, including a code for the lack of an explanation in the scoring scheme. The main finding here is that most participants did not address the conflict by attributing it to a specific reason, i.e., they did not explain the conflict in their written response (Note that the task instructed them to write a recommendation (including a justification for that recommendation) for their friend based on the provided sources. Thus, there were no explicit prompts regarding detection, acknowledgement and explanation of the conflict.) Unfortunately, this means that little can be said about *how* they explain the perceived conflict. However, the interesting finding in the present study is the significant association between the participants' epistemological stance and their explanation for

the conflict, more specifically, *if* they explain the conflict; participants with a predominant evaluativist perspective were more likely to explain the conflict in their response.

Expert disagreement beliefs, EBs, and performance on a MDP task

What has part 1 taught us about the relationship between these three key aspects in the processing of conflicting health information?

A significant association was found between *Explanation* (our qualitative measurement of the reason for expert disagreement people indicated in their MDP written response) and overall task performance. In addition, significant associations were found between EBs, both as a qualitative measure (main epistemological perspective identified in the writing task) and as a quantitative measure (D-score based on the ETA scales), and overall task performance. Consequently, although we did not find significant associations with the quantitative measure for conflict explanations (measured through the SDR scale), we did find significant relationships between the qualitative measure for expert disagreement beliefs, the quantitative and qualitative measure for EBs and the participants' performance on a MDP task.

These findings also underscore the need for a mixed methods approach. Mixed methods research is particularly well-suited for exploring individuals' beliefs about knowledge and knowledge construction due to its inherent capacity to offer a comprehensive understanding of complex phenomena. By combining qualitative approaches, such as in-depth interviews or content analysis, with quantitative methods like surveys or structured observations, researchers can delve into the nuances of participants' beliefs while also capturing overarching trends and patterns. This dual approach enables a more holistic view of how individuals conceptualize knowledge and construct their understanding, allowing researchers to uncover both the intricacies of personal beliefs and the broader societal influences that shape them. As beliefs about knowledge often stem from a blend of subjective experiences and shared cultural contexts, mixed methods research stands as a powerful tool to unravel the intricate layers of this complex cognitive landscape (Davis et al., 2017; Mason, 2016).

Part 2. Exploring the effect of an educational intervention.

RQ1: Relative to other groups, do participants in the guided group present changes towards more adequate EBs?

No significant changes within the guided group were found for any of the belief measures. The exposed group as well, did not show any significant within-group changes. In the control group, however, we did find a significant increase in multiplicism as well as in evaluativism.

Analysis of change showed no significant differences between the groups on any of the measures.

However, when evaluating the trends, we found that despite the increased evaluativism trend in all three groups, due to the decrease in absolutism in the guided group (as compared to the increase in the other groups) combined with the slightly smaller increase in multiplicism in the guided group (as compared to the increase in the other groups), the resulting difference in D-score between the follow-up measure and the pre-intervention measure was positive for the guided group only. Given that we are particularly interested in the relative changes on all three developmental stages, the calculated D-score can help gaining such insight; Although comparisons of the D-score changes within and between groups were not significant, we did find an increase in D-score in the guided group over time, whereas in the exposed and control group the D-score decreased. This suggests a beneficial, although not significant, overall impact of the intervention.

Interestingly, the trends in the guided group, i.e., decreasing absolutism, increasing multiplicism and evaluativism, continued between the post-intervention and follow-up measurement and the four-week period did not seem to weaken the intervention effect.

The findings thus partly confirm the hypotheses: while we see trends that may suggest an overall beneficial change in beliefs in the guided group as compared to the other groups, we were not able to measure any significant effects over time or differences between the groups.

Exposure to multiple conflicting sources is expected to cause an increase in multiplicism (Kerwer and Rosman, 2018), as we see in all group trends. However, the intervention was hoped to mitigate this effect, resulting in a hypothesised status quo or even decrease in multiplicism in the guided group. Our findings do not show this, and instead an, although not significant, increase in multiplicism was found. While there is the possibility that the intervention has fostered the idea that science is only a collection of opinions and arbitrary per se thus resulted in the increase in multiplicism (Klopp and Stark, 2022b; Klopp and Stark, 2022a), it is perhaps more likely that merely the exposure to multiple conflicting sources may have affected multiplicism in all three groups in a similar manner. Similarly, confrontation with conflicting information, without any additional intervention, has been shown to increase evaluativism (Klopp and Stark, 2022a), which may explain this trend in all three groups and the significant increase on this scale in the control group.

Thus, despite the lack of significant changes, the findings suggest that the intervention (as the guided group received) had little impact on people's multiplicist and evaluativist beliefs, and these beliefs seem to have increased in all three groups, likely caused by the exposure to multiple conflicting sources. The findings also suggest that the intervention did have a positive, however non-significant, impact on participants' absolutist beliefs, i.e., the educational task based on the taxonomy of disagreements may have decreased their beliefs that only one account can be correct.

Overall, a decrease in both absolutism and multiplicism together with an increase in evaluativism may possibly not have been an appropriate goal for this study. The sample consisted of undergraduate marketing students. Previous research often studied psychology students, whose beliefs were not only assessed within their domain (psychology) but whom also had relatively high levels of prior knowledge in methodological and philosophy of science issues. From a developmental point of view, the decrease in absolutism and increase in multiplicism, may mean a positive change towards more "developed" EBs. We may cautiously suggest that these participants abandoned the belief that there is only one correct account of knowledge and have come to the belief that there are many possible accounts of knowledge, which may be equally correct (Barzilai and Weinstock, 2015). The desired decrease in multiplicism and increase in evaluativism is potentially only to be expected in a subsequent step. Some have even argued that a "one-in-all" effect (reducing absolutism and multiplicism while enhancing evaluativism) is simply not possible and interventions should only aim for a specific goal and be tailored specifically to that goal (Klopp and Stark, 2022a).

RQ2: Relative to other groups, participants in the guided group, score higher on the MDP task performance measures.

Our findings did not confirm the hypothesised better overall task performance, however, did show a significant difference between groups in terms of the epistemological stance participants presented in the task. Significantly more participants in the guided group presented an overall evaluativist stance in the MDP task as compared to the exposed and control group. Thus, while we could not measure a difference in EBs between groups when measured through the ETA scales (as discussed above in RQ1), our qualitative measurement of EBs based on the overall epistemological stance participants presented in their writing task response was significantly different between groups.

RQ3: Relative to other groups, participants in the guided group report complexity and uncertainty as more likely reasons for disagreement than competence or motivation.

A slightly higher proportion of participants in the guided group (34.1%) reported uncertainty and complexity as the most likely reason for disagreement than in the exposed (26.7%) and control (33.3%) group. (Note that within the guided group an even higher proportion (43.9%) reported process and competence as the most likely reason for disagreement.) However, comparisons of the mean values for the three different constructs of the SDR scale, did not find any significant differences between the groups.

In addition, while we found no association between experimental group and our MDP measure *Explanation*, the findings do provide some insights; In the guided group, more than half of the participants provided an explanation for perceived disagreement in their MDP writing task and a high proportion attributed the disagreement to variations in studies.

RQ4: Relative to other groups, participants in the guided group show higher levels of self-reported information literacy self-efficacy.

Our data did not show a significantly higher level of overall information literacy self-efficacy in the guided group. However, participants' self-reported capability to determine the authoritativeness, currency and reliability of information sources was significantly higher in the guided group than in the control group. Concerning the latter; it is reported here because it could be an interesting, and potentially promising, finding given the relevance of this specific item. However, it is appropriate to interpret this result in a context of multiple testing and a higher risk for type I error (Ranganathan et al., 2016).

RQ5: Are participants' intentions to engage in healthy lifestyle behaviours different after the intervention as compared to before? Are there differences between the experimental conditions?

The control group's mean intentions remained the same or even increased, whereas intentions decreased in the guided and exposed group. Although comparison of the mean changes did not show significant differences between the groups, the results showed changes in the opposite direction than initially hypothesised. A preliminary hypothesis would have been based on the idea that the exposure to conflicting health information may result in a decrease in intention to adhere to healthy lifestyle recommendations whereas for participants in the guided group the intentions would be less affected and remain the same. Thus: "In the guided group participants' intention to engage in healthy lifestyle behaviours does not decrease between Pre and Follow-up measurement, whereas in the other groups intentions decrease." A possible explanation is that the changes in behavioural intentions measured in the guided and exposed group are because they were exposed to more conflicting sources than the control group and the intervention component did not make a difference in that effect.

In all groups less than half of the participants reported a decrease in behavioural intentions at follow-up as compared to the pre-intervention measurement. While only for a minority of participants behavioural intentions decreased between pre and follow-up, the means in the guided and exposed group significantly decreased for diet and physical activity respectively. This suggests that although only a minority of participants were negatively affected, for those participants the changes were relatively large. One could wonder if we can explain these differences with people's EBs. In the present study, no significant correlations were found between the changes in diet and PA intentions and participants' EBs. Another possible explanation is a potential association between one's changes in EBs and one's changes in behavioural intentions. In other words: "*Can we explain people's adverse reaction (in the form of a decreased level of healthy lifestyle behavioural intention) to exposure to conflicting sources based on the changes in EBs they experience due to that exposure?".*

We found a (weak) significant positive correlation between a change in absolutism and a change in diet-related intentions and a (stronger) significant negative correlation between a change in

multiplicism and the change in diet-related intentions. This may suggest that for those participants for whom multiplicist beliefs increased, this may have been associated with a decrease in diet-related intentions.

To the best of our knowledge no previous studies have investigated this link as such, however, we could cautiously suggest that the previously studied and observed association between exposure to conflicting health information and adverse outcomes through confusion and backlash (Lee et al., 2018; Nagler, 2014; Nagler et al., 2021; Vijaykumar et al., 2021b) could potentially be partly explained by inadequate EBs, more specifically increased levels of multiplicism, e.g., the belief that "science is just based on opinions".

Limitations

First, the different topics and scenarios presented in the ETA scales in the pre-, post- and follow-up measurement constitute a limitation. Wine was the topic of the pre-measurement scenario; multivitamin supplementation was the topic of the post-measurement scenario; and coffee was the topic of the follow-up measurement scenario. Thus, all three topics are situated within the same domain, i.e., health and nutrition. Furthermore, for all three topics similar levels of exposure to conflicting information have been found; In Nagler (2014) participants reported some or a lot of exposure to conflicting information about Wine: 52.9%; Vitamins: 55.7%; Coffee: 48.4%.

In the present study, as has been the case in previous research (Klopp and Stark, 2022b), it is implicitly assumed that all three measurements are parallel measures that allow comparison between them. However, it is possible that any measured changes were not due to the intervention or a change in beliefs but due to differences in beliefs related to different topics. Alternative approaches for future research include, always using the same scenario or randomly assigning the different topics. The former has the disadvantage of potential memory effects, but the latter has potential for future research, given sample size and other practical considerations allow such approach.

A second limitation concerns the low reliability for the CAEB scale. The scale has been used in relevant previous research, allowing for potential comparison of the findings and leading to inclusion of the scale in the present study (Rogers and Gould, 2015; Kienhues et al., 2008). However, only weak Cronbach's Alphas were calculated: Texture Pre: 0.67, Texture FU: 0.70; Variability pre: 0.50, Variability FU: 0.56. Because of the low internal consistency of Variability, we explored other possible solutions but could not find a better fitting solution. Therefore, the original theoretically proposed scale was used, however, we encourage caution and careful interpretation of this scale's results. Furthermore, the variability scale was excluded from further analysis due to this psychometric shortcoming. We note that previous use of the scale was varied; e.g., Kienhues et al. (2008) achieved a solution with acceptable internal consistency, however, a Cronbach's alpha (0.57 and 0.56) similar to ours was found by others (Bientzle et al., 2014).

Third, a potential priming effect may have been caused by the questions about the participants' familiarity and involvement with the topics. These questions may have caused participants to reflect about the topic and their knowledge, and may already have caused some doubts about those, which they would not have experienced if they had not been asked those questions.

Fourth, the design and online environment of this study may have impacted the stability or reliability of the results. However, measures were in place to reduce this potential issue; where subjects' answers were deemed highly implausible, they were excluded from the analysis. Nevertheless, motivation is generally lower in online studies and this should be considered in the interpretation of this study's findings (Jun et al., 2017).

Fifth, related to the above, the written recommendations were rather short. This limits the comparability with other studies where often essays are used. However, the shorter written responses suit our study, which aims to investigate lay people's handling of conflicting health information in a daily life context rather than within a scholarly context. Furthermore, the coding approach developed in this study seems to correlate relatively well with the measurement of EBs through scales. This suggests that this approach through their performance on a short written recommendation and justification based on a MDP task is a valid way to assess people's EBs and may be of interest in future research.

Sixth, likely due to the online study context as well as the demanding nature of the study, there was a high level of attrition. This was particularly present within the guided group, which was most likely caused by the high level of time and engagement with the materials that was required in this group. Although still acceptable, the smaller sample size for all three parts of the study, in addition to the unequal group sizes, limits power and both internal and external validity. We note that comparison of the post-intervention data for both sample sizes did not show any significant differences. Nevertheless, given the continuing trends we perceived between the post and follow-up measurements, it would be interesting for further research to investigate these longer-term trends in larger samples.

Implications and future research

Although, based on the ETA scales and the overall task performance, no significant intervention effects were found in the present study, the data did show promising trends. Furthermore, we did find a significantly higher proportion of participants who presented an overall evaluativist stance in the MDP task within the guided group as compared to the other groups. This is in accordance with other similar attempts with a conflict explanation intervention, and suggests that the intervention may have led to a better understanding, awareness and appreciation of the interpretive and constructive nature of science and expert's knowledge and the need to evaluate knowledge claims within and across sources (Barzilai et al., 2020).

Based on these preliminary findings and few earlier studies by others, we may still wish to suggest that proactively educating people about the possible causes for expert disagreement has the potential to pre-empt any adverse effects caused by exposure to conflicting information, e.g., inadequate source integration, or carry-over effects such as generalised misperceptions of science practice or reduced receptiveness to unrelated health messages and willingness to engage in the behaviours those message recommend. Therefore, we wish to encourage further research attempts investigating the effects of interventions that aim to foster the understanding and awareness of the existence, causes and normalcy of expert disagreement.

Furthermore, given the increasing importance of social media as a source of information, including health information, it may be interesting to further explore this approach in the social media context (Gierth and Bromme, 2020; Ngo et al., 2023).

In the present study, the intervention presented an overview of the potential causes for expert disagreement and explained these causes through examples in the health domain, thus the sensitisation presented general epistemological aspects of domain knowledge. So far, similar study designs all used this kind of approach (Klopp and Stark, 2022b; Klopp and Stark, 2022a; Barzilai et al., 2020). However, transfer and application of that knowledge to a specific topic at hand, may not be evident to all (Barzilai et al., 2020). Therefore, investigation of the effect of case- (and thus topic-) specific conflict explanations may be of interest in future research (Gierth and Bromme, 2020).

4.2.6. Conclusion

This study has made significant contributions to the existing body of research on conflicting health information, epistemological beliefs (EBs), and interventions for epistemic change. Through the collection of quantitative and rich qualitative data, we have gained a deeper understanding of how individuals perceive and justify their interpretations of conflicting health information, shedding light on the intricate cognitive processes involved.

Our findings support the hypothesized association between EBs and people's processing and integration of information from multiple sources, particularly in the context of conflicting health information. This study not only reaffirms the importance of these beliefs but also justifies the approach taken in this study and highlights the relevance of epistemic change interventions in helping individuals navigate the challenges posed by contradictory health information.

Furthermore, the introduction of a short-term text-based intervention design represents a valuable addition to the growing literature on such interventions for epistemic change. No significant intervention effect was measured in the quantitative data. However, the encouraging results from our guided group, which exhibited a more evaluativist stance in the MDP task, emphasize the potential of

this approach. Based on this finding we may cautiously suggest that the intervention may have led to a better understanding, awareness and appreciation of the interpretive and constructive nature of science and experts' knowledge and the need to evaluate knowledge claims within and across sources. However, much further research is warranted.

Overall, this study provides a strong rationale for future intervention efforts aimed at enhancing people's ability to handle conflicting health information. Proactively educating individuals about the sources of expert disagreement may serve as a pre-emptive measure to mitigate the potentially adverse effects of exposure to contradictory health information. These findings contribute to the advancement of both theoretical understanding and practical strategies for addressing a critical issue in contemporary health communication and information processing.

5. Discussion

5.1. Summary of the overall purpose of the thesis as a unified piece of work and a brief summary of each individual study

Conflicting information plays an essential role in the ongoing evolutionary progress of scientific inquiry. While scholars and healthcare experts acknowledge the inherently dynamic nature of research advancement, lay people are still often unaware of this concept (Carpenter et al., 2016; Chakravartty, 2022; Iles et al., 2022; Kennedy and Hefferon, 2019; Dieckmann et al., 2017b; Thomm et al., 2015). Consequently, the general population finds it challenging to navigate the influx of contradictory health-related information, often interpreting it as a display of expert inadequacy or generating unfavourable reactions (Carpenter and Han, 2020; Jensen and Hurley, 2012). These perceptions carry substantial and far-reaching repercussions. Exposure to inconsistent health information has been linked to confusion surrounding health directives and broader health-related research (Barnwell et al., 2022; Chang, 2013; Chang, 2015; Clark et al., 2019; Dixon and Clarke, 2013; Iles et al., 2022; Lee et al., 2018; Nagler et al., 2022; Nagler, 2014; Nagler et al., 2020; Nagler et al., 2019b; Ngo et al., 2023; Vijaykumar et al., 2021a). It also fosters scepticism towards scientists, impairs the capacity to gauge source credibility, and diminishes the willingness to adhere to public health recommendations, regardless of whether there is contention or consensus (Nagler et al., 2022; Chang, 2013; Chang, 2015; Jensen and Hurley, 2012).

Given the high prevalence of exposure to conflicting health information and the significance of its consequences, and in order to be able to improve the situation, there is a need to better understand how conflicting information affects people (Carpenter et al., 2016; Carpenter and Han, 2020). The present thesis aims to contribute to this goal. The primary aim was to better understand the concept, with the ultimate end goal to be able to better assist people with the handling of conflicting health information. Three studies were conducted in this work. The first study addressed the question "How do people handle conflicting health information?" through a review of the literature and the development of a critical interpretive synthesis. The second study investigated the causes for conflicting health information and addressed the question "What are possible reasons for expert disagreement?" and presents experts' conceptualisation of expert and scientific disagreement. In the third study, empirical quantitative and qualitative data were collected to gain insight into people's understanding of multiple conflicting sources of health information, and their justifications for that understanding and to explore the potential effect of an educational intervention.

The conceptualisation of *conflicting health information* in study 1, meant that the question "How do people handle conflicting health information?" transformed to "What factors influence the processing of conflicting health information? And how can they be classified?" and "Which factors can be

modified in order to support the handling of conflicting health information?". The synthesising argument presents a framework for the classification of the influencing factors based on their role in the communication: Who communicates what in what form and what context to whom in what situation using what strategies and to what effect. Potential interventions in education may be able to address and improve factors within the individual and potential interventions in communication may be able to address and improve factors within the source.

The conceptualisation of expert disagreement in study 2 led to the development of a taxonomy that answers the question "What are causes for expert disagreement?". The taxonomy describes ten possible causes for expert disagreement, which are classified in three groups: informant-, information-, and uncertainty-related causes. The study further suggests that knowledge about the range of causes for discerning information may help with an effective evaluation of, for example, health information and the developed taxonomy may inform and help both communication providers and receivers with the transfer of evidence-based information. To assist the use of the taxonomy for educational purposes a visual representation of the taxonomy was developed as an interactive slide.

The insights from studies 1 and 2 were combined and applied in study 3 and informed the design of empirical data collection on people's understanding of conflicting health information. In addition, the insights from the previous studies were used to develop and test an educational intervention aimed to improve people's handling of conflicting health information. The findings support the hypothesised associations between people's epistemic beliefs (EBs) and their ability to integrate conflicting health information. The intervention did not show significant effects on the quantitative measures, however, did show a significant difference between the experimental conditions in terms of the epistemological level of argumentation the participants presented in a writing task.

Figure 15 and **Table 25** present an overview of the key elements (Table 25) of the studies included in this thesis and how they link to each other (Figure 15) and may serve as an anchor and reference when reading through this discussion.

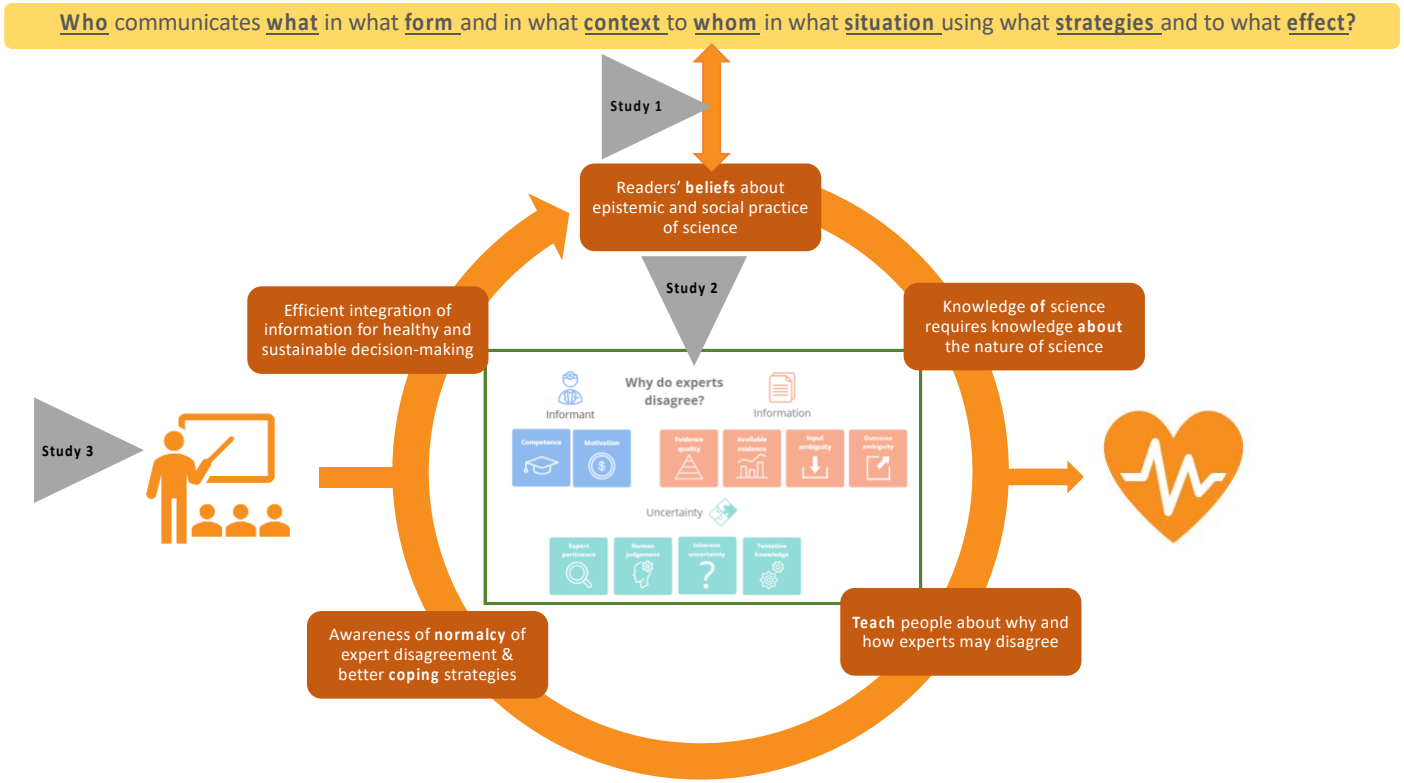


Figure 15. Visualisation of the present thesis, showing the three studies and how they are connected.

Table 23. Overview of the key elements in the three studies included in this thesis.

	Study 1	Study 2	Study 3	
Aim	To improve the understanding of the phenomenon "conflicting health information", a conceptual framework for the processing of conflicting health information is developed.	To conceptualise experts' views on expert disagreement, a taxonomy of disagreements is developed, which presents an overview of the range of possible causes for expert disagreements.	To gain further insight into people's handling of conflicting health information through collection of empirical data about participant's understanding of multiple conflicting sources of health information, and their justifications for that understanding. Part 1 aims to shed light on participants' *epistemic beliefs (EBs)* and beliefs about *reasons for disagreement* (conflict explanations) and how they associate with their performance on a multiple document processing (MDP) task.	Part 2 aims to provide information about the role of a multiple source processing task based on a taxonomy of disagreements as a novel intervention method.
Research question focus	"How do people handle conflicting health information?" • How can we conceptualise *conflicting health information*?" • Through which mechanisms does conflicting information affect people? • What steps/ stages are involved in the handling of conflicting health information? • What are the different pathways people may take when handling conflicting health information? • What strategies do people use to process conflicting health information? • What are the consequences/ outcomes of exposure to conflicting health information? • What factors influence the process? How can they be classified? • Which factors can be modified in order to support the handling of conflicting health information?	1) What are the causes for expert disagreement? 2) What are experts' perspectives on the use of a taxonomy of disagreement in supporting people with handling conflicting information?	1) Do participants with more adequate EBs perform better on a MDP task? 2) Are there significant associations between participants' task performance and a) their prior beliefs and involvement with the topic and b) the time they spend on the task? 3) Are there significant associations between conflict explanations and epistemological beliefs? 4) Are there significant associations between participants' epistemological beliefs, task performance and information literacy self-efficacy?	1) Are participants' EBs different after the intervention as compared to before? And are there differences between the experimental conditions? 2) Are there differences between the experimental conditions in terms of performance on the MDP task? 3) Are there differences between the experimental conditions in terms of the reasons for disagreement people indicate? 4) Are there differences between the experimental conditions in terms of self-reported information literacy self-efficacy? 5) Are participants' intentions to engage in healthy lifestyle behaviours different after the intervention as compared to before? And are there differences between the experimental conditions?

Design	Viewing the literature as the object of inquiry, a Critical Interpretative synthesis is conducted; • Synthesising quantitative and qualitative empirical evidence and theoretical work • Integrating concepts from multiple disciplines • Using both induction and interpretation to develop a synthesising argument	Taxonomy development based on (Nickerson et al., 2013): • a rigorous yet flexible method • an iterative approach • including a conceptual and an empirical part: 1) Initial conceptualisation grounded in literature 2) Semi-structured interviews with experts were conducted to examine and evaluate the conceptual model	• A mixed methods approach, including quantitative (i.e., psychometrically validated scales) and qualitative (i.e., MDP task performance measures based on content analysis) data • A 3 x 3 design was used with experimental condition (guided, exposed and control) as between-subjects factor and time (pre, post, and follow-up) as within-subjects factor	
Key findings	• The health literature lacks an overarching theoretical model. • MDP models and the role of EBs therein may provide a useful lens to fill in the above identified gap. • A useable model is presented that provides a structure for and overview of the factors that influence the processing of conflicting health information: *Who communicates what in what form and in what context to whom in what situation using what strategies and to what effect?*	• The resulting taxonomy presents 10 categories classed under three groups of causes: informant-related causes, information-related causes and causes based on the uncertainty of doing science in a real world. • The taxonomy may be a useful tool and has the potential to assist people with the handling of conflicting information.	• Participants with more adequate EBs presented more adequate epistemic practices and overall performed better on a MDP task. • Participants' multiplicism and information literacy could significantly explain their task performance. • In the MDP task, epistemological stance and explanation were significantly associated.	• Participants in the guided group were more likely to show an evaluativist stance in their MDP task. • For participants in the guided group absolutist beliefs decreased and multiplicism and evaluativism increased, however, our data did not show significant differences within or between groups. • There were no significant between-group differences for self-reported reasons for disagreement, information literacy, or behavioural intentions.
Limitations	• The paper explicitly acknowledges the authors' voices in this work and their influence on the selection, analysis and interpretation of the concept, the literature, and the findings. • A conceptualisation is always imperfect, incomplete and subject to regular updates and refinements over time. • Differing health topics/ conflict types may need different focuses, and theory-building within particular health topics/ conflict scenarios will be of interest in future research. • Increasingly health information is consumed via social media, which may come with a	• The small sample size and purposive sampling method have important limitations regarding representativeness and generalisability. • A best, correct, or finished taxonomy may be undefinable and should not be seen as the aim or target. • Need to acknowledge the direct and indirect influence of the researcher on the interview and in the qualitative data analysis.	• The online study design has important limitations, including participants' level of motivation to engage with the materials may have been lower, however, is unknown. In addition, due to the online study design and the relatively labour-intensive tasks and measures it includes, compromises were made, for example, we used short written responses rather than essays. • High level of attrition, especially in the guided group • Resulting small sample size • Future research may benefit from a study design in which the different scenarios for the ETA scale are randomly assigned in order to avoid any potential differences in EBs related to different topics.	

	particular set of features and additional challenges.		
Contributions	• Presents a first conceptual model for a better understanding of the mechanisms and constructs involved. • Provides a high level of transparency in the entire lifespan of this framework and its development. The findings, including specific information about the conceptual contributions of different parts of the literature, and the various epistemic iterations that occurred in the process of developing this framework, aim to inform researchers and encourage future scholarly work on further refinements.	• Presents an original overview (i.e., taxonomy) that provides a structure or framework that is usable for researchers and practitioners. • Provides the description of a taxonomy development method in the conceptualisation of expert disagreement. • Contributes a visual representation of the taxonomy is available as an interactive slide. • Proposes the use of this taxonomy as a tool in education practice.	• Contributes empirical evidence to the literature on conflicting health information, including rich qualitative data on people's understanding of conflicting health information and their justification for that understanding. • Contributes empirical evidence to the literature on MDP and supports the hypothesised association between EBs and MDP. • It shows the above relationship in the context of conflicting health information. • The study adds empirical mixed methods data to the relatively small but growing body of literature on short-term text-based interventions for epistemic change. • The study presents a study and intervention design for such short-term text-based interventions for epistemic change, which could assist future intervention efforts.
Implications	• There are modifiable determinants within the source and the individual that could be addressed by health communicators and health educators respectively. • People need to embrace conflict/disagreement, and to be able to do so they need a more accurate understanding of the role scientists play in the construction of knowledge. • The presented framework may inform further research and communication about *conflicting health information*.	• Providing a theoretical base for further research and communication around expert disagreement, this taxonomy aims to be extendible, and to provide a tool to raise awareness, spark discussion and encourage further research. • Knowledge about the range of causes for discerning information may help both communication senders and receivers with the transfer of evidence-based information.	• The empirical evidence for the association between participants' handling of conflicting health information and their EBs supports the idea of using interventions targeting epistemic change in our efforts to help people with the handling of conflicting health information. • The study found that a significantly higher proportion of participants in the guided group presented an overall evaluativist stance in the MDP task as compared to other groups. This suggests that the intervention may have led to a better understanding, awareness and appreciation of the interpretive and constructive nature of science and experts' knowledge and the need to evaluate knowledge claims within and across sources. • Based on these preliminary findings, we may still wish to suggest that proactively educating people about the possible causes for expert disagreement has the potential to pre-empt any adverse side effects caused by exposure to conflicting health information.

5.2. Introduction to the discussion

As a synthesis of this work's contribution to knowledge, this discussion presents overarching themes that emerged through integration across the included studies and considers how this knowledge may influence and inform future research and practice. While the studies conducted in this thesis include discussions with reflections about the findings, contributions to the existing literature, limitations, and implications, this part of the thesis aims to provide an integrated discussion which demonstrates how the different parts are closely connected and work together. To do so, it aims to analyse and interpret the work through a high level of abstraction.

In the development and structuring of this integrated discussion, two frameworks (in addition to others as discussed throughout) were used, which provided guidance and lenses through which the overarching themes and contributions are identified and discussed. First, the work by Lewis et al. (2021) provides a more general guideline for the creation of an integrated discussion and outlines a set of sections to be included. In addition, the broad scope and explorative intent of this work benefited from a transdisciplinary approach; allowing and creating space for an iterative and evolving methodology, integrating diverse knowledge types, and generating insights that transcend disciplinary boundaries. Such research context differs from other research is several ways and influences the planning, designing, reporting and evaluation of the work. Therefore, the framework by Mitchell et al. (2015) was applied to this work in order to evaluate its contribution as a transdisciplinary enquiry. Both frameworks were integrated and adapted to form an outline for this integrated discussion that aims to specifically suit the present work (see **Figure 16)**.

1. Summary of the overall purpose of the thesis as a unified piece of work and a brief summary of each individual study
2. Opening paragraph introducing the information to be presented in the chapter
3. General discussion
    a. Aims and designs: how do they reflect the philosophical perspectives?
    b. Answering the research questions: key themes, finding, implications and stakeholders
        - Key themes: What has been done?
        - Key findings and implications: What has been found and why does it matter?
        - Key stakeholders: Who is this for?
    c. Strengths and limitations
4. Contributions
    a. Impact as a transdisciplinary enquiry
        - An improvement in the situation or field of inquiry
        - The generation of relevant stocks and flows of knowledge
        - Mutual and transformational learning
    b. Contribution to practice
        - Practical use of the taxonomy as an educational tool
    c. Theoretical contributions
        - A conceptual framework for a better understanding of conflicting health information
        - A taxonomy of disagreements as a reference providing an overview and terminology for future research and communication about expert disagreements
    d. Methodological contributions

- Conceptualisation methods
- MDP task intervention development method

5. Extending the impact of this research beyond the life of the current project
    - Decision aids
6. Other future research and practice recommendations
7. Conclusions overall

Figure 16. Elements of the integrated discussion

5.3. General discussion

5.3.1. Aims and designs across the included studies: how do they reflect the philosophical perspectives?

Study 1 endeavours to improve the understanding of "conflicting health information" by developing a conceptual framework for its processing. Aiming for a holistic view, the study acknowledges the complexity of this phenomenon and the need for a reflective, inclusive and iterative approach. The study employs a Critical Interpretative Synthesis (Depraetere et al., 2020; Dixon-Woods et al., 2006), treating the literature as the object of inquiry. By synthesizing quantitative and qualitative empirical evidence, theoretical work, and integrating concepts from multiple disciplines, it embraces a pragmatic epistemological stance. This comprehensive approach aspires to allow researchers to draw actionable insights and contribute to addressing the real-world challenges of conflicting health information.

Study 2 aims to develop a taxonomy of disagreements and explores potential causes for expert disagreements. The study utilizes a rigorous method for systematically developing taxonomies (Nickerson et al., 2013), reflecting its commitment to a disciplined inquiry. At the same time, the iterative approach, integrating both conceptual and empirical elements, highlights the pragmatic emphasis on drawing from various sources of knowledge. Through semi-structured interviews with experts, the study incorporates real-world perspectives, enriching the taxonomy's applicability and relevance.

Study 3 seeks to gain knowledge about participants' understanding of conflicting health information and their justifications. The study adopts a mixed methods approach, combining quantitative and qualitative data, in line with pragmatism's emphasis on multiple perspectives. Given the nature of the research questions in this study, i.e., to measure potential associations and a potential intervention effect, this study includes some positivist elements as well, as for example reflected in the randomisation, the assessment of quantitative measures in a longitudinal design, and the inferential statistical analyses.

Thus, the three research studies presented here exemplify the adoption of a pragmatic epistemological stance and demonstrate the value of integrating diverse approaches to address real-world challenges effectively.

5.3.2. Answering the research questions across (key themes) and within (key findings and implications) the included studies

Key themes: What has been done?

In the modern-day knowledge society, people must navigate an enormous amount of information based on often competing scientific knowledge claims in order to make decisions about their health, including everyday decisions, for example, about what to eat. To be able to use this information for effective and sustainable decision-making, they need to be able to critically evaluate the conflict to assess the competing knowledge claims. The present thesis presents three studies that investigated the phenomenon *conflicting health information* and two central constructs in the processing of conflicting health information: epistemic beliefs and beliefs about reasons for expert and scientific disagreement. In other words, the work included in this thesis investigated and integrated people's *beliefs about knowledge (What is knowledge?) and knowing (What is it to know something?)* and their *beliefs about science practice and knowledge construction (What is the role of scientists in constructing knowledge?) and causes for disagreement (Why do experts disagree?)* in their processing of conflicting health information.

The present work's contribution to research is 1) it broadens our conceptual understanding of 1a) how people process conflicting health information (Study 1) and 1b) how experts conceptualise expert disagreement (Study 2) and 1c) how we can assist people in their handling of conflicting information (Study 1 and 2) and 2) it provides a deeper insight in the relationship between different manifestations of people's understanding of conflicting health information; i.e., their epistemic beliefs, their beliefs about reasons for disagreement and their ability to integrate and evaluate the information (Study 3).

Key findings and implications: What has been found and why does it matter?

The aim of study 1 was to improve the understanding of "conflicting health information" by developing a conceptual framework for its processing. The study found that the health literature lacked an overarching theoretical model for understanding conflicting health information. This finding underscores the need for a structured and comprehensive framework that can shed light on the complexities of processing conflicting health information. The conducted research suggests that Multiple Document Processing (MDP) models and the role of epistemic beliefs therein could serve as a useful lens to fill the identified gap. These models provide a basis for understanding how individuals process information from multiple sources and how their epistemic beliefs influence their cognitive

processes (Bråten et al., 2011; Stadtler and Bromme, 2014). The study presents a useable conceptual framework that provides an overview of the factors influencing the processing of conflicting health information. This framework serves as a valuable contribution to the field, providing a structured way to understand and study the phenomenon. The implications of the study's findings are significant for various stakeholders in the realm of health communication and education. Firstly, the study proposes a theoretical framework that can guide further research and communication about conflicting health information. This framework can serve as a basis for developing interventions and strategies to address issues related to health information conflicts. Second, the study highlights the modifiable determinants within the sources of information and the individual. Health communicators can address these determinants to enhance the quality and clarity of health information, while health educators can work on improving individuals' cognitive approaches to information processing. Another important implication is the need for people to embrace conflict and disagreement, recognizing that such tensions are inherent in the scientific process. The study suggests that a more accurate understanding of the role of scientists in constructing knowledge can lead to more adaptive epistemic beliefs and better strategies for handling and processing information.

Overall, study 1 contributes valuable insights to the field of conflicting health information processing. By providing a structured conceptual framework and highlighting the potential implications for health communication and education, the findings pave the way for more informed decision-making and effective communication in the domain of health information. Moreover, recognizing the importance of adaptive beliefs about the epistemic and social practice of science may lead to more constructive and rational approaches to information evaluation, ultimately promoting better health outcomes.

The objective of study 2 was to create a comprehensive classification of disagreements among experts, encompassing various potential causes. The study yielded a taxonomy comprising ten distinct categories, grouped into three main sets of causes: those related to the individuals who are providing information, factors tied to the information itself, and causes rooted in the inherent uncertainty of real-world scientific endeavours. To facilitate understanding, an interactive slide featuring a visual representation of the taxonomy was generated.

The implications of this taxonomy are two-fold. Firstly, it serves as a foundational framework for future research and communication concerning expert disagreements. Designed to be extensible, the taxonomy aims to stimulate awareness, stimulate discussions, and encourage continued exploration in this area. Secondly, the insights gained into the spectrum of causes for varying information interpretations offer potential benefits in appraising information effectively, especially in domains like health information. Consequently, the developed taxonomy stands to aid both disseminators and consumers of evidence-based information, improving the transfer of knowledge in health and science communication and media communication contexts. Furthermore, the taxonomy can be used in

differing health and science education efforts promoting such literacies (as further discussed on p 172 and 179).

The collection of empirical data from lay people in study 3 aimed to provide increased insight in the way people process conflicting health information sources. The findings supported the hypothesised associations between an individual's epistemic beliefs and their ability to integrate information from multiple conflicting sources. Furthermore, an experiment was conducted where participants in the interventional condition (guided group) received an educational intervention in which they were provided with information on causes for expert disagreement in addition to being guided through a series of reflection-promoting tasks. Significantly more participants within the guided group showed a pre-dominant evaluativist epistemological stance when asked to write a recommendation for a friend based on a set of conflicting information sources. However, the results did not show significant differences between the groups on beliefs when measured through scales.

The findings support the need for mixed methods approaches when measuring complex variables like people's beliefs about knowledge and knowledge production. Furthermore, they underscore the need for further research on this matter with consideration for study design characteristics such as the sample size and the specific measures used. In addition, the characteristics of the intervention design may inform future intervention development (as further discussed on p179).

Key stakeholders: Who is this for?

This thesis is a contribution to various stakeholders, encompassing both the research community and practitioners in various fields, such as (but not limited to) health communication, public understanding of science, multiple document processing, epistemic cognition and the evaluation of epistemic beliefs and epistemic change. The significance of this work extends to researchers and practitioners alike, offering valuable insights and tools to enhance their respective works.

For researchers, it provides a comprehensive overview, a guiding framework, and a structured approach to understanding and studying conflicting health information. Concrete examples of how the framework can support intervention design are described on p 179 and how the taxonomy can support research on the presentation and communication of expert disagreement on p 183. The thesis introduces language and terminology that serves as a foundation for future conceptual and empirical work. It stimulates awareness, discussions, and encourages continued exploration in the dynamic landscape of health information. The research has also exemplified use of emerging knowledge synthesis methods, as applied in the development of multiple document processing task design, and presentation of complex ideas, providing a model for future adoption.

For health promotion practitioners as well, the developed framework may become a basis for developing interventions and strategies. Health and science communicators can address the

modifiable determinants within the source to enhance information quality and clarity. Health educators can improve individuals' cognitive approaches to information processing. The taxonomy of expert disagreements' insights benefit both information disseminators and consumers, aiding in the transfer of evidence-based information. Furthermore, the taxonomy serves as a tool in health and science education practice (as discussed on p 172) but could also be used in other educational contexts, it may, for example, support teachers in developing information synthesis tasks. The study and intervention design for short-term interventions for epistemic change presented here (and further discussed on p179) may serve as a valuable resource for those involved in designing and implementing interventions to bring about changes in knowledge and understanding.

In summary, this thesis bridges the gap between research and practice, providing a foundational framework for understanding and addressing conflicting health information and offering practical tools for intervention and education. It is poised to inspire further research, discussions, and advancements in the fields of health and science communication and education.

5.3.3. Strengths and Limitations

In addition to the discussion of strengths and limitations of the different studies in the respective papers and chapters, in this section, I aim to reflect about the strengths and limitations of the thesis as a unified body of work. More specifically, this part aims to discuss the "paths not taken" and the benefits and challenges of the ones we did take. In addition, section 5.6. discusses a selection of other potential paths for future research and practice.

When zooming out and viewing the project from sufficient distance, a first limitation that may need to be considered is related to the construct "knowledge" and its role in behaviour. The present work investigates information and information processing, however, with the aim to improve health decision-making, health behaviours and ultimately health outcomes. Therefore, one needs to be mindful of the limited role of knowledge in predicting and explaining behaviour. Knowledge is only one, and arguably rather distant, determinant of behaviour (De Vries, 2017). For example, environmental aspects such as availability (e.g., Is there a fast-food restaurant around the corner or a healthy café?) and accessibility (e.g., What is the cheapest and easiest - most convenient - option?) are more influential drivers of behaviour in health-nutrition decision making (Kremers, 2010). However, while being mindful of this limitation, knowledge remains a crucial pre-requisite for behaviour and behavioural change, particularly given the frequency with which people must handle multiple conflicting health information sources to make everyday life decisions about health behaviours (e.g., what to eat and drink).

Second, the thesis focuses on the processing of multiple conflicting sources of information which one may encounter, for example, in an online search. However, several other communication and information processing contexts exist. For example, one may read something and then hear something else in person. Such face-to-face information exchange may have specific influences on how that information is provided, processed and evaluated (Imhof et al., 2014; Greenacre et al., 2012). Also, increasingly social media are used for information exchange, which comes with its own specific set of features and additional challenges (Imran et al., 2015; Ngo et al., 2023; Meijer et al., 2023). However, one may argue that the concepts and ideas of the present work are relevant in the analysis of conflicting health information consumed through social media as well and the specific features the social media context adds are mostly related to credibility aspects. In terms of the processing of conflicting information in documents, another possible way this may present is through single document conflict, for example, when a source (e.g., a guideline) is updated over time (e.g., a health recommendation is changed based on new evidence). The latter is an interesting situation with potentially considerable public health impact, and thus a relevant research avenue (Lyons et al., 2020).

Third, a significant focus of the work included in this thesis is conceptual in nature and does not directly address empirical investigation of a particular conflicting health topic. The processing of conflicting information is case-specific and investigating a specific topic and context may be instrumental for the development of targeted effective interventions. Here again, while certainly there is a need for investigation of specific conflicting health information scenarios, the overarching and holistic perspective with the aim to develop an improved conceptual understanding of the phenomenon "conflicting health information" is a pre-requisite for further future investigation of specific scenarios. That is, the work described in this thesis lays foundations for investigation of exposure to specific conflict. The thesis presents one such intervention, and although this provides only a single example (in part due to resourcing and recruitment challenges described in Chapter 4), it nevertheless provides a model, and evidence, regarding this work.

Fourth, future efforts similar to study 3 in this thesis, may wish to pre-register the study design, hypotheses and analysis plan. Such open science approach is desirable for transparency-related reasons (Van't Veer and Giner-Sorolla, 2016; Nosek et al., 2015), and may also make the analysis afterwards more time and effort efficient. Nevertheless, while we wish to advocate for such approach in future efforts, we also note that given the explorative nature of this research and, for example, the iterative development of the coding approach for the MDP task performance measures, not being restricted by a pre-determined fixed analysis approach may have been the right choice for this project.

Fifth, when interpreting the results of study 3, it is important to consider that the sample comprised marketing students in Sydney. Their education, which integrates elements from various disciplines

and emphasises social sciences, may shape their beliefs and understanding of knowledge and conflicting information in unique ways. This specialised background could influence their responses and potentially limit the generalisability of the findings to broader population.

Furthermore, a sixth consideration may question the measures taken in study 3. While we believe that the study design and measures are based on careful investigation of the literature and their selection is justified (as discussed in the respective chapter), we are mindful of other paths that could have been taken and could be taken in future research efforts. Instead of, or in addition to, our data collection through a written recommendation, rich data could be obtained using data collection methods based on eye tracking and think aloud recordings. Furthermore, to improve the effectiveness of interventional efforts (for example aiming at epistemic change), social interaction and sustained support may be needed. Focus groups or motivational interviewing may provide potential ways to collect qualitative data which allow and support such interaction.

Related to the above point, a seventh consideration could wonder about other aspects that may affect the effectiveness of such intervention. For example, "Is there a minimum threshold of "openness"/ adaptiveness needed for epistemic change to be able to happen? And, if so, is this an individual factor or a situational factor?". If the latter, we have said before that we cannot have much influence on people's situation when they are exposed to (conflicting) information. However, what could we perhaps do about the situation they are in when exposed to an intervention? The online at home data collection in study 3, while a real-world context and situation as well as a low-cost research context, is not ideal and instead an in-person approach may be required. Future research may wish to carefully consider the way the interventional information is provided and digested. In study 3, participants were presented with the information in a 1-way and passive manner. However, science communication, and perhaps especially this kind of information, benefits of and may require a more active, dynamic and interactive two-way type of information sharing. Dialogue with both experts and non-experts about the taxonomy of disagreements may need to be an essential part of the intervention to create an optimal situation for possible epistemic change in a favourable direction and to avoid any adverse effects of informing them about possible causes for expert disagreement like increased anti-science beliefs. This consideration is also further discussed in part 5.4.4., p179.

Lastly, we wish to emphasize the need to be mindful and cautious of any over-generalisation of the conclusions drawn from study 3. Therefore, it is important to recognise that while we believe that both our taxonomy of disagreements and the MDP task approach may be transferable to topics beyond health and nutrition, it is crucial to interpret the findings of this thesis – particularly those from study 3 - within the context of its specific design, assumptions and limitations. The thesis aims to acknowledge and accommodate the fluidity of the defined and perceived meaning of the concepts "expert" and "expertise" and generally uses "expert" to refer to a person who is (perceived as) very

knowledgeable in a particular area. However, in study 3, the term expert becomes more (or less) fluid, and, for example, no clear distinction is made between experts and scientists, as evidenced using the Science Dispute Reasons scale. Furthermore, the findings should be considered considering the particular expertise (e.g., health and nutrition) and the specific study population (e.g., marketing students). Consequently, our conclusions are based on health experts and the context of nutrition and health promotion, and caution should be exercised when generalising these findings to all experts, scientists, and other disciplines, fields and contexts. At best, we may propose educational efforts to increase the likelihood of individuals to evaluate information effectively and adopt an evaluativist stance in a specific and appropriate health (nutrition) promotion context. Finally, the interpretation of study 3's findings has been heavily focused on the evaluation of expected outcomes, which may oversimplify the complexities of epistemic beliefs. To address this, it essential to reflect on how our own assumptions have influenced the work, acknowledging the specific limitations this focus introduces. This discussion also serves as a reminder of the intricate processes through which epistemic beliefs are formed, altered, and applied in real-world contexts. Future research should consider interpreting and reporting the findings of study 3 not only as an evaluation of an educational task intervention but also as an exploration of its associations with epistemic beliefs. Adopting a more open approach would involve paying closer attention to instances where no significant changes occurred over time or between groups, as well as recognizing outcomes that may deviate from initial expectations (e.g., presenting changes in differing directions).

In sum, there are many different alternative paths that could have been taken in this thesis, and in the above paragraphs, I have aimed to list some important ones to consider in the interpretation of the wider context of the present work. However, when returning to our starting point "How do people handle conflicting health information?", the crucial idea is that the fundamental work in this area was missing. Therefore, the present thesis aims to contribute to this foundational understanding by presenting conceptual and explorative enquiries and findings that assist with better understanding the phenomenon "conflicting health information".

The strengths of the individual studies included are discussed in the corresponding chapters. In addition, two overarching features of the thesis can be identified. (1) *Presenting complex ideas*: Throughout the thesis, the ideas and concepts are presented in several creative ways, often including written elaborations as well as structured visual abstractions. For example, the interactive slide visualising the taxonomy of disagreements presents the ten causes for expert disagreement in one overview (visually easy to digest through the use of pictograms), with each category being elaborated upon through the utilization of the Frayer model (Frayer et al., 1969) (see **Appendix 1**). This model encompasses the definition, distinguishing characteristics, illustrative examples, and counterexamples ("non-examples") for each category. This methodology serves as a versatile means to precisely delineate and visually represent items, simultaneously facilitating the distinction between the various

categories. An additional illustration can be found in **Figure 8**, which showcases various types of perceived conflict. Employing jigsaw puzzle pieces to abstractly represent "the perception of conflicting information" and present it in a visually comprehensible format represents an innovative approach for conveying a complex phenomenon. In addition, the application and adaptation of the model of communication to present and structure the determinants that influence the processing of conflicting health information based on their role in the communication provides another example of a creative way to approach and present a complex idea. As such, throughout this thesis, several innovative and creative illustrations are presented which can be viewed as examples of ways to create boundaries and get ideas across in transdisciplinary research. (2) *A modular approach*: Each of the thesis's key points can serve as a foundation to guide future endeavours. In essence, the work conducted here can be seen as a collection of fundamental aspects or building blocks upon which future endeavours, whether in research or practical applications, can be constructed. Given the foundational nature of this work, its transparent development and creation process, as well as the conceptual insights it has yielded and the structured approach to presentation and reporting, this current work can be regarded as modular. It forms a set of modules that not only provide a structured framework for other, perhaps less conceptual inquiries but also accommodate the addition of new modules in the future.

A last point in this discussion of the strengths and limitations of the paths that were (not) taken in this research is linked to the challenges and benefits of a PhD project in a transdisciplinary setting. Navigating the contextual challenges of a research project, particularly in the context of a PhD where time and resources are often limited, can be a daunting endeavour, especially for those who are just beginning their research journey. Transdisciplinary (TD) research, by its very nature, demands a significant allocation of time to explore the uncharted path in the middle, describing it comprehensively, and documenting the search process. Furthermore, the unique nature of the research topic and the chosen approaches may pose difficulties in finding suitable publication venues, adding another layer of complexity. Beyond these logistical challenges, transdisciplinary research brings inherent issues, such as differing assumptions and epistemological positions among research partners, which can lead to tensions during the conceptualisation phase. For example, Pineo et al. (2021) described that these challenges may extend to “longer project duration, difficulty publishing in high impact journals or as a single author, challenges obtaining adequate research funding for larger and longer projects, falling between funding body remits, problems communicating within and beyond the team, researcher vulnerability to adverse psychological impacts, and avoiding social pressures to implement research with a single focus (Lynch, 2006; Lang et al., 2012; Davies et al., 2015; Hébert et al., 2016; Black et al., 2019)”. However, regardless of the challenges that can come along with it, the transdisciplinary approach used in the present project has greatly benefited both the work (as described throughout this thesis) and the researchers’ growth (Abrams, 2006; Pineo et al., 2021).

5.4. Contributions

5.4.1. Impact as a transdisciplinary (TD) inquiry

Although many definitions exist, transdisciplinary research is generally seen as the most integrative form of cross-disciplinary research and typically involves integrating and transcending multiple disciplines to warrant the development and application of novel conceptual and methodological approaches that synthesize and extend discipline-specific perspectives, theories, methods, and translational strategies to yield innovative solutions to particular scientific and societal problems (Choi and Anita, 2008; Choi and Pak, 2006b; Choi and Pak, 2007; Lynch, 2006; Stokols et al., 2013). Increasingly, people view the need for the integration of many actors from different sectors to co-produce knowledge and policy to solve complex global health challenges in order to improve the health of the public in the 21st century (De Leeuw, 2017; de Leeuw, 2022; Kickbusch and Gleicher, 2012; Pineo et al., 2021). *Conflicting health information* is a complex real-world problem and the present work aimed to contribute to the solving of this problem by developing new knowledge, through integration of different knowledge and stakeholder types and with the aim to inform research and practice innovations. Consequently, the studies included in this work describe approaches that reflect transcending, transgressing and transforming (Klein, 2010; Klein, 2017; Pohl et al., 2021; Klein, 2008). Both the conceptualisation of conflicting health information (in study 1) and of expert disagreement (study 2) are transcending in the sense that they aim for a unity and reorganising of the structure of knowledge leading to new overarching syntheses. In addition, the included studies transgress disciplinary, theoretical and methodological boundaries and interrogate different structures of knowledge with the aim of transforming them (Klein, 2010; Klein, 2017; Klein, 2008).

While acknowledging that there is no one right way to do transdisciplinary research, increasingly, scholars aim to conceptualise the process and evaluation of transdisciplinary research (Mitchell et al., 2015; Pohl et al., 2021; Willetts and Mitchell, 2009). Many of those come from environmental issues and focus on the purpose of sustainable development, however, planetary health and public health are interrelated in many ways and their insights are transferable and translatable to a wider view on sustainable development, i.e., addressing health challenges in a sustainable manner (Corral-Verdugo et al., 2021). Furthermore, few have specifically focused on describing the TD approaches in public health and, whilst recognising its challenges, model and describe the great potential of TD as a vehicle for investigating and improving health and its wider determinants (Abrams, 2006; Pineo et al., 2021).

Throughout this discussion, the above-mentioned publications are used to evaluate the present work. To further reflect about the impact of this work as a transdisciplinary inquiry, the framework by (Mitchell et al., 2015; Willetts and Mitchell, 2009) and the identified outcome spaces therein provide

a useful lens. A visual of the framework is presented in **Figure 17**. Their conceptual map shows the three outcome spaces: situation (the field of inquiry), knowledge, and learning. It further indicates that a project is subject to a field of vision of the three spaces, which are embedded in a wider and uncertain context. The field of vision is limited to the experiences, knowledge and worldviews of the research team. In this thesis, explicit attention to this field of vision was provided in the introduction to allow interpretation of the research. In addition to being subject to a field of vision, a project is also bound in resources such as finances, time and space. The introduction also allows interpretation of these aspects.

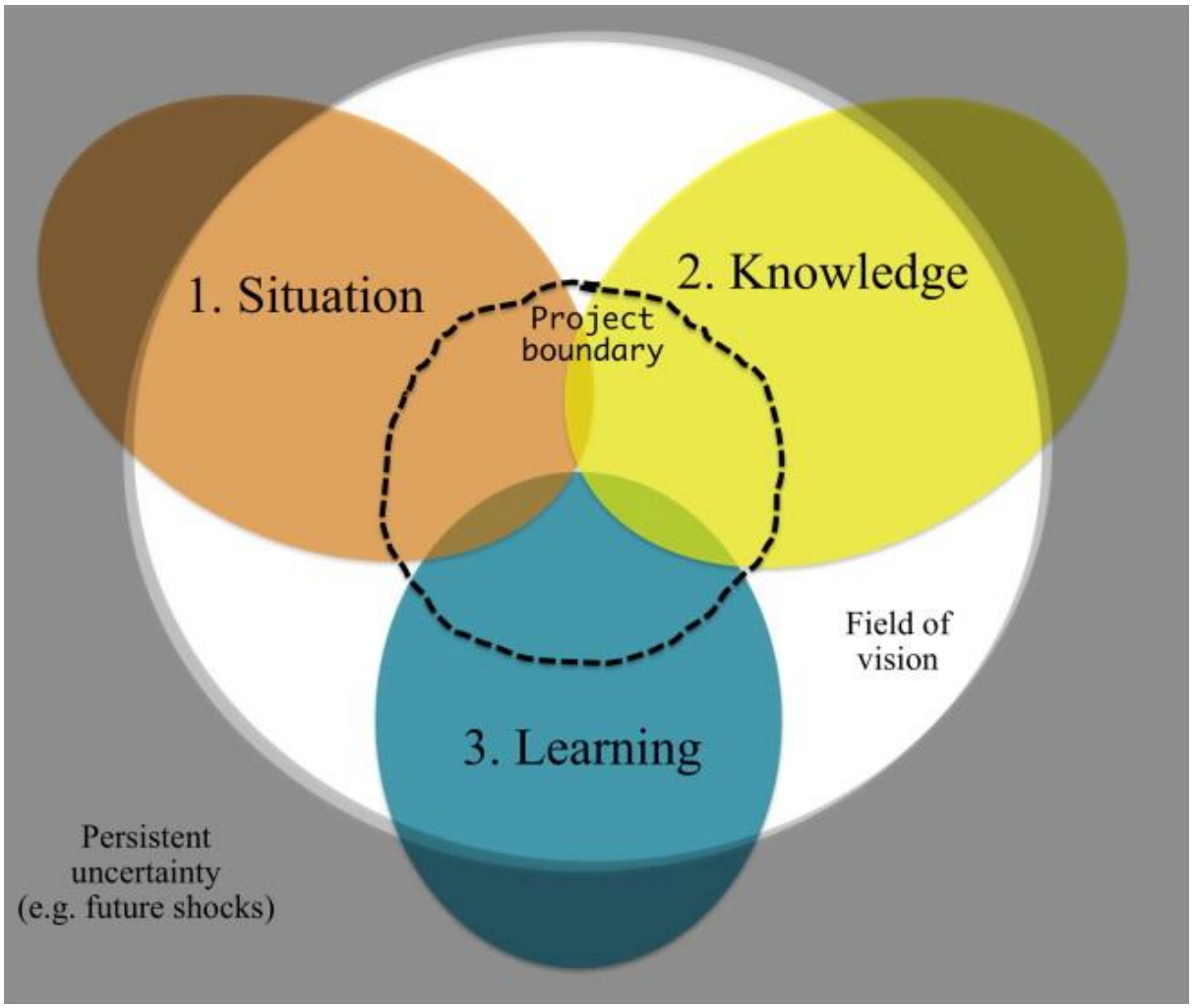


Figure 17. The conceptual map for TD research by Mitchell et al. (2015)

Note: The conceptual map for TD research by Mitchell et al. (2015) presents three outcome spaces; (1) an improvement in the situation or field of inquiry, (2) the generation of relevant stocks and flows of knowledge, and (3) Mutual and transformational learning. [The original article was published under a creative commons cc-by-nc-nd license.]

In the following, the research project's contribution to three outcome spaces (Mitchell et al., 2015) is described and evaluated: (1) *an improvement in the situation or field of inquiry*; The development,

creation and dissemination of the taxonomy of disagreements as a new tool (providing structure and terminology for future research as well as a reference and practical tool for educational purposes) addresses this first outcome space. Attempts were made to improve dissemination of the work beyond academia to a wider audience, for example, through a publication in The Conversation, however, the latter was unsuccessful thus far. Continued dissemination efforts and uptake of the tool, e.g., as evidenced in other's work, will further increase the impact. In addition to the taxonomy as a tool, the present work has contributed conceptual, however, also practical insights that are in a good condition and place to improve the field. The overarching synthesising argument of the CIS review aims to reorganise the structure of knowledge around conflicting health information and to provide a useable and structured way to model the factors involved in the processing of conflicting health information and is expected to benefit future research efforts whether that be conceptual work that further builds on the existing framework or empirical work that is informed by this framework. In addition, the work aims to translate the findings to practical implications, i.e., action points for science and health communicators as well as educators;

(2) *the generation of relevant stocks and flows of knowledge*: This work has contributed to the flow of knowledge through presentation of the work at invited talks and national and international conferences (see p7). Presenting and discussing the work early on and throughout the PhD trajectory, and both internally and externally, allowed for richer feedback, frequent feedback loops, and multiple iterations and adaptations of the work, which is believed to have improved its contribution. Furthermore, at the time of this writing, one paper (based on study 2) has been published and one paper based on the work presented in study 1 has been prepared for review. The other work is being prepared for publication and further dissemination efforts of all the work involved are intended to inform and encourage further research efforts.;

(3) *Mutual and transformational learning*: In this work, the processes valued and triggered learning for researchers and for those engaged in the projects; Firstly, the diverse disciplinary, cultural, and professional perspectives of those involved in this project enabled, facilitated, encouraged and enriched the mutual learning. Through this experience, old perspectives were triggered and questioned, new perspectives and orientations surfaced, and new strategies and tools were identified, taken in and applied. For example, rather than a rigid systematic literature review approach (as was described in the research proposal), the critical interpretive synthesis (Depraetere et al., 2020; Dixon-Woods et al., 2006) provided just the right amount of flexibility in terms of crossing disciplinary and methodological boundaries while at the same time providing a structure for a rigorous knowledge synthesis method. Secondly, the interviews with a variety of experts from differing fields as part of the development of the taxonomy allowed for exchanges of perspectives and encouraged deeply reflective practice on the part of all parties involved. Thirdly, the participants in the third study were a sample of business and marketing students who enrolled to this study through the university's

behavioural lab. Such participation in research provides them with valuable experience with consumer behaviour research in a broader sense, in this case the consumption of health information and subsequent decision-making. Furthermore, all participants were debriefed at the end of the study, were informed about the study purpose and were presented with the information on causes for expert disagreements.

In addition, the process of knowledge production that led to these research outcomes achieved the four aims for transdisciplinary work that Pohl and Hadorn (2008) and Pohl et al. (2017) described; Grasp the *complexity* of the issue at stake; Take into account practitioners' and researchers' *diverse perceptions*; Link *abstract and case specific* knowledge; and Develop descriptive, normative and transformative *knowledge for sustainable development. These aspects are at the core of the approaches in the present work and the included studies as described in earlier parts of the discussion, in the respective papers and as presented in* ***Table 26****. For example, by approaching the concept of conflicting health information from a holistic point of view, the Critical Interpretive Synthesis conducted to develop an overarching model of the concept aims to grasp the complexity inherent to a phenomenon like conflicting health information. The rich data collected through the interviews with a range of experts from differing fields as a part of the taxonomy development shows how diverse stakeholder perceptions were considered. In addition, in the development of the taxonomy, conceptual descriptions as well as specific cases of expert disagreement were analysed to come to an integrated understanding.*

5.4.2. Contribution to health and science education practice

Practical use of the taxonomy as an educational tool

People are frequently exposed to conflict in nutrition choices and find it hard to reconcile that conflict, which has the potential to undermine the success of healthy eating campaigns and interventions.

In addition, people tend to focus on financial interests of experts (e.g., informant-related causes, ‘sugar lobby’) while neglecting information-related causes (e.g., different outcome variables, heart vs cancer risks) and uncertainty-related causes (e.g., model uncertainty, or risk tolerance).

Our rigorously grounded ‘taxonomy of disagreements’ is a tool that can help people understand expert disagreement and make evidence-informed decisions. A visual representation of the taxonomy is available as an interactive slide. There, each category is further explained using the Frayer model (Frayer et al., 1969), describing the definition, characteristics, examples, and nonexamples. This approach provides a flexible method to both define and illustrate items, while also supporting differentiation between the different categories.

The **Figure 18** shows (an example of) how the taxonomy could be presented as an educational tool. The interactive slide can be accessed through the QR code in this document, however, would be embedded in the webpage. In this thesis, a pdf of the full taxonomy can also be found in **Appendix 1.**

10 reasons for expert disagreement

Why understanding expert disagreement matters for decision-making.

From choosing your groceries and health treatments, to making political choices, we're exposed to conflicting information. But how do we learn to navigate this conflict when sometimes even the experts seem to disagree?

You might think that the conflict is about incompetence, or financial interests, and we know that can reduce overall trust in experts. Experts, however, view the nature of science as uncertain and contested, and focus on those aspects when explaining conflict.

We walk you through 10 possible causes for expert disagreement, providing you with knowledge about science practices and better awareness of the normalcy of expert disagreement. Such knowledge and awareness will make you better equipped to handle conflicting information.

Deroover K., Knight S., Burke P.F., Bucher T. (2023) Why do experts disagree? The development of a taxonomy. *Public Understanding of Science*, 32(2), 224-246. https://doi.org/10.1177_09636625221110029

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Figure 18. The taxonomy of disagreements as an educational tool.

5.4.3. Theoretical contributions

Despite the growing research interest in the topic "conflicting health information" over time, very little conceptual work exists. Carpenter et al. (2016) and Carpenter and Han (2020) described a typology of types of conflict and pointed out the difference between informational and decisional conflict. Important foundational empirical work was conducted by Nagler's research group (Nagler, 2014; Nagler et al., 2020; Nagler et al., 2022; Nagler et al., 2019b) and others (Chang, 2015; Zimbres et al., 2021; Li et al., 2020; Wu and Ahn, 2010). A growing body of empirical sources exists and were further analysed in our literature study to identify key work on the processing of conflicting health information. In that process, it was noted that almost all empirical studies mentioned a theory, model, or framework that they used to design their study. Particularly interesting is that many studies used different models, examples include dual processing models (such as the elaboration likelihood model (Petty et al., 1986)), the uncertainty management theory (Brashers, 2001), and the health belief model (Rosenstock, 1974), however, many more others are being used. As such, these conceptual models reflect the assumptions (research questions and hypotheses) of the researchers and have the goal to serve as a structure to build a study that answers a specific research question. None of these models is necessarily more or less "correct", but all are simplified abstractions that serve a specific purpose, i.e., answering a specific research question. This observation suggests a need for a more general framework to conceptualise the phenomenon *conflicting health information*. In a similar fashion, others have identified the need for a conceptualisation of uncertainty in health care and aimed to address that gap through the development of an overarching orienting framework (Han et al., 2019), while recognizing the need for such work on the concept of conflicting health information (Carpenter et al., 2016; Han et al., 2019) and restating the research need in 2020 (Carpenter and Han, 2020). Our literature study confirms this gap in the literature and demand for a more holistic view, an integrated framework, that aims to develop a better understanding of the overall concept of "conflicting health information" to assist both research and practice. By providing a conceptual framework this work aims to make a theoretical contribution to the field. In particular, the contribution is three-fold: 1) an enriching of the theoretical understanding through integration of the literature on multiple document processing in the health communication literature (transgressing), and 2) through combination and integration of different knowledge domains, the provision of an overarching framework that aims to be open and aims to provide a useable modelling of the factors involved, spanning across the antecedents, over the processing mechanisms to the outcomes of exposure to conflicting health information (transcending); 3) by emphasising the role of and shifting the focus towards people's knowledge and beliefs regarding epistemology and expert disagreement (transforming).

Furthermore, while some recent research efforts were aimed at measuring lay people's explanations for expert disagreements (Thomm and Bromme, 2016; Dieckmann et al., 2017b; Johnson and

Dieckmann, 2018; Gottschling et al., 2020) and at the development of such measures (Dieckmann and Johnson, 2019; Thomm et al., 2015), a model of experts' conceptualisations of expert disagreement, and the range of variations within, was lacking (Mumpower and Stewart, 1996). Consequently, the development of the taxonomy of disagreements (in study 2) presents a theoretical contribution to the existing knowledge base and may inform and assist further research and communication around expert disagreement.

5.4.4. Methodological contribution

Conceptualisation methods

In study 1 and 2, both conceptualisations aimed to apply open, dynamic, iterative approaches to the development of open and flexible models of the concepts which allow further additions and refinements. Regardless of this "open" perspective on both the process and the outcome, both models were developed using rigorous and structured methodological knowledge synthesis guiding principles. The conceptual framework for conflicting health information (study 1) emerged from a critical interpretative synthesis based on the methods as described by Dixon-Woods et al. (2006) and the reporting practices as described by Depraetere et al. (2020). The paper presents an example of how such knowledge synthesis methods can be used in the development of integrated knowledge and aims to show their suitability for such purpose. In a following section, I elaborate further on the selection of a vehicle for knowledge synthesis with the purpose of developing an overarching holistic view on a complex phenomenon through integration of differing perspectives, allowing the emerging of new insights.

The taxonomy in study 2 was developed using the taxonomy development approach by Nickerson et al. (2013). This approach to taxonomy development was originally developed for application in the information systems (IS) field (Nickerson et al., 2013). By outlining seven steps, it provides guidance for those aiming to develop a concise, robust, comprehensive, extendible, and explanatory taxonomy. Five of the steps may need several cycles or iterations based on an evaluation of a set of previously determined ending conditions. The approach by Nickerson et al. (2013) is characterised by the combining of a conceptual and an empirical part, the order in which they appear in the process can be chosen specific to the situation. In the development of the taxonomy of disagreements, a conceptual-to-empirical approach was used, and the empirical part (the expert interviews) functioned as a validation of the taxonomy draft that was created based on the conceptual part (grounded in the literature). In a way, our conceptual part already included an empirical part given that we analysed specific cases of expert disagreement in a set of health and nutrition topics in all kinds of literature to evaluate whether they corresponded to the characteristics that were identified in the conceptual

literature to arrive at an initial version of the taxonomy. With each iteration, new dimensions may be added or eliminated, and iterations are added until the ending conditions are met. Upon completion of the method, the resulting taxonomy gets evaluated for its' usefulness. In a way, this stage is still ongoing as the ultimate evaluation of usefulness may be based on whether others use it. However, in order to estimate the potential use of the taxonomy, the expert interviews (next to their contribution to the development) were also used to query this variety of experts with different angles of interest in science communication about the potential use of the taxonomy (Nickerson et al., 2013). A last note on the taxonomy development method concerns both its' terminology and approach; We use the term "taxonomy" to refer to the resulting artefact of the above-described approach. However, this artefact (the end product) is a hybrid of a typology and a taxonomy and could also be called a classification or framework or another term. The method described by Nickerson et al. (2013) is a hybrid of methods used for the creation of typologies (conceptual) and taxonomies (empirical) and reflects a pragmatic approach for the creation of an artefact that combines elements of both ideal and constructed types. Such hybrid and flexible method is expected to result in taxonomies that are likely to be more broadly useful than those coming from more restricted approaches (Nickerson et al., 2013).

In both works (study 1 and 2), a high level of transparency in the entire lifespan of the framework development is provided. The papers provide detailed information about the empirical contributions, the conceptual contributions of different parts of the literature, and the various epistemic iterations that occurred in the framework development process. As these works detail the generation, iteration and development of the present versions of the frameworks, they also provide information on what paths and ideas have not been taken and are potentially worth considering in future scholarly work (Greene, 2022).

The selection and application of a vehicle for knowledge synthesis for the development of an integrated understanding

In the development of the framework in study 1, we reviewed relevant literature from various fields. We started with an open research question "How do people handle conflicting health information?". To be able to help people process conflicting information when making important health decisions, we need to understand through which mechanisms conflicting information affects people and the strategies typically used to process it. The development of such understanding requires an integration and interpretation of information from different disciplines, fields and topics: The specific information from different fields that is relevant for the present study can differ in nature, for example, literature on information processing may describe processing mechanisms that would also be relevant in the scenario of multiple conflicting information sources or literature on the public understanding of science may identify determinants that influence the way people engage with claims that are relevant to the way they process conflicting health information. However, the parts of information of relevance

for study 1 have differing characteristics and cannot easily be found by a same set of well-defined and pre-defined inclusion criteria. Furthermore, rather than adjudicating, i.e., producing *settled science* and eliminating error , the aim here is to use a more holistic view in order to get a better understanding of a phenomenon and promote new insights and the emergence of new kinds of research (Cronin and George, 2023; Turner et al., 2017). Therefore, rather than applying an aggregative highly systematic review methodology, study 1 aimed to be a synthesis of empirical (qualitative and quantitative) and theoretical work and integrates concepts from multiple disciplines.

Knowledge-synthesis vehicles include theories, meta-analyses, and different types of reviews, and each vehicle can perform a variety of "*sensegiving*" functions (Huff, 2008; Cronin and George, 2023). In a scoping review of the methodological features of review types, Straus et al. (2016) identified two main groups: 1) does the review allow integration of both quantitative and qualitative research, and 2) whether or not the review is conducted for establishing a theory or phenomenon. They identified four types of review that can do both: the critical interpretive synthesis (CIS), the integrative review (IR), the realist review (RR), and the narrative synthesis (NS) (Straus et al., 2016). The RR, focusing on testing whether a theory can applied under various circumstances, and the NS which focuses on how, why, and for whom an intervention works, do not fit our study intention and purpose well. The present study (study 1) aligns with the aims of the integrative review in the sense that it aims to synthesise theories and evidence by integrating different "*conversations"* (Huff, 2008) which may be rooted in different paradigms, allowing the development of new insights that may not have emerged from one of the included disciplines or fields ("*communities of practice*" (Brown and Duguid, 1991), and contributing to the development of a better understanding of a phenomenon (Cronin and George, 2023). However, the CIS also specifically acknowledges the relevance of adjacent literatures, and, given that the present study aims to theorise the evidence through synthesis that involves both induction and interpretation, viewing the literature as an object of inquiry, the CIS review fitted our study best (Dixon-Woods et al., 2006).

In contrast with other review types, that limit their critical orientation to the exclusion or inclusion of papers in their analyses, the critique in a CIS is a key part of the synthesis, is conducted rather than appraised, and informs the sampling and selection of material (Dixon-Woods et al., 2006). The voice of the author as well as the need for flexibility in CIS are explicitly acknowledged, fuel the development of emerging theoretical framework, and guide the search of all types of evidence (Dixon-Woods et al., 2006; Schick-Makaroff et al., 2016). Based on the methodology for a critical interpretive synthesis discussed in Dixon-Woods et al. (2006) and Depraetere et al. (2020), we used a broad searching strategy with flexible inclusion criteria and open to both quantitative and qualitative research, based on discussion of the topic within our multidisciplinary team, exploratory searches in scientific databases and search engines, and reference screening and chaining. In addition, we discussed laypeople's handling of conflicting information with external experts. In congruence with

the CIS approach, searches were documented, while also drawing creatively on literatures that do not fit precise search criteria (Dixon-Woods et al., 2006). The development of a conceptual framework starts with analysis of the literature sources and identification of relevant concepts, including the identification of recurring themes. This involves an iterative process where themes and concepts are constantly compared and analysed within their context to identify relationships among them with the aim to develop a synthesis argument (Depraetere et al., 2020; Dixon-Woods et al., 2006). When reporting the findings, the CIS first reports on the key themes and concepts identified in the selected literature sources and adopts a critical and reflexive approach to the literature and its relevance to the development of an understanding of how conflicting health information is processed. Then, the aim is to integrate the evidence from across the reviewed studies into a coherent theoretical framework with a network of constructs and showing the relationships between them (Dixon-Woods et al., 2006). Consequently, the final part of the findings of the CIS presents a synthesising argument with the function to provide more insightful, formalised, and generalisable ways of understanding the phenomenon (Dixon-Woods et al., 2006).

In sum, in study 1, the used approach was characterised by a) methodological and reporting practices which emphasise and explicitly acknowledge the authors' interpretation of and inferences made based on what is not explicit in existing research, and b) the aim to create a transcending, transgressing and transforming model. For the latter, I could use Daan Van Knippenberg's words again: the paper describes a framework that is grounded in the literature, however, aims to provide *a blueprint* (i.e., a through interpretation developed integrated, overarching yet useable framework) *for houses that could be built* (e.g., further testing and refining of the model and its applicability in research and practice) *rather than just reporting on houses that already exist* (a pure literature review) (Elsbach and van Knippenberg, 2020; Cronin and George, 2023).

Multiple Document Processing (MDP) task intervention development method

Study 3 shows how the findings of study 1 and 2 can be applied and used to inform intervention development and evaluation: i.e., how an educational intervention may be designed. **Figure 19** presents a visual overview of the intervention development and study design characteristics in study 3, applying the findings and resulting models from study 1 and 2.

Figure 19. Visual presentation of the intervention and study design characteristics of study 3 within the findings of study 1 and 2.

Who communicates **what** in **what form** and in **what context**	to **whom**	in **what situation**	using **what strategies**	and to **what effect?**
	• Age, gender, education level • Familiarity with reading scientific literature • Topic familiarity • Beliefs about topics' health impact • Connotative aspects of epistemic beliefs • Epistemic thinking assessment • Epistemic level of argumentation • Science Dispute Reasons • Information literacy self-efficacy	• Time spent on the integration task	• *Rationale* in task: assessment of first-hand and second-hand evaluation as well as cross-corroboration • *Coverage* in task: assessment of conflict ignorance as well as information avoidance • *Explanation* in task: assesses conflict explanation	• Cognitive: level of integration (*argumentation*) as well as overall performance in task • Decision-making: *recommendation* in task • Behavioural: intention to engage in healthy lifestyle behaviours

Components	**Materials**	**Mechanisms**
Cognitive conflict	**Set of conflicting sources** The sources present different perspectives on wine consumption and health and include scientific peer-reviewed articles, non-peer reviewed articles and blog posts. Three of the sources have a more positive view on wine and health, three have a negative perspective on the health impact of wine and one aims to provide a balanced two-sided view on the issue. Several types and causes for disagreement are presented in this set of sources; they show informational versus decisional conflict, and present examples of inherent uncertainty, outcome ambiguity, input ambiguity and different levels of scientific evidence.	⟺ Epistemic doubt
Metacognitive reflection	**Taxonomy of expert disagreements**  *"Why do experts sometimes disagree? Some think that consensus is an essential requirement for expertise. They consequently propose that when experts disagree this means that at least one of them is not an actual expert or may be influenced by personal interests. However, disagreement is a normal aspect of science, and next to these expert-related causes, there are many other reasons why experts may disagree or why you may think they disagree. Please use the figure below to familiarise yourself with the different types of conflict and causes for expert disagreement. Please click on the boxes for more information."*	⟺ Epistemic sensitisation
Active learning	**Guided tasks** ○ Writing task: *"Imagine that a friend has asked you for your views on the health impact of wine. She is an educated (has an undergraduate degree) professional of about 35 years old but does not work in health or nutrition. Imagine you've searched the internet and found these resources. Based on these sources, what perspective would you give your friend?"* Key elements: Encourage consideration of all sources (including elaboration and time spent on engagement with the materials), however, open and indirect question formulation so that the level of source credibility evaluation, conflict detection and explanation, and cross-corroboration remains variable. ○ Ranking task: participants were instructed to click and drop the sources in two boxes "recommended sources to read" and "not recommended sources". ○ Conflict explanation task: "*In the following exercise you will be shown some examples of conflicts that are present in the set of resources on the health impact of wine. Please match the examples with their corresponding cause of disagreements by selecting it form the drop-down menu."*	⟺ Resolution strategies

Note: The top part of the figure presents the determinants within the individual that were measured in study 3, classified in the model developed in study 1 "Who communicates what in what form and in what context to whom in what situation using what strategies and to what effect". The bottom part (in the orange frame) presents the intervention design, i.e., its components, materials and mechanisms.
The order of the above information does not correspond with the order in which the information, tasks and measures appeared in the study intervention.

Within the framework "who communicates what in what form and in what context to whom in what situation using what strategies and to what effect?", the first four categories are situated within the source. In study 3, the participants were provided with the same set of sources, thus these factors (i.e., source, content and form and presentation of the information, as well as the context of exposure) were held constant. Future work may wish to investigate the influence of differing variations of these factors. Also, the present work has focused on multiple conflicting sources. However, conflict within one source and how it compares to conflict between sources is of interest in future research. This is particularly relevant in a context where, for example, a policy document includes the changes that were made over time to its guidelines (Iles et al., 2022).

In **Figure 19**, intervention components, materials and mechanisms are presented. A set of conflicting sources on the health impact of wine consumption was provided to the participants. Qualtrics showed a small image of the front page of the source and the title, both the image and title included hyperlinks to the full source. Participants were presented with the sources and the instruction of the multiple document processing (MDP) writing task at the same time. The MDP task involved an open question, i.e., to write a recommendation for a friend based on the provided sources, as well as a justification for that recommendation. It is expected that this question would encourage participants to at least consider each source's claim. The level up to which the participant considers the sources' credibility and the reasons they mention, is variable. Furthermore, this indirect integrative question is expected to encourage the participants to integrate perspectives across texts. However, due to its indirect nature, the level to which one engages in integration would give an indication of their need for justification by multiple sources, as compared to a more direct question that would, for example, ask the participant to describe the different views. In addition, a ranking task was used to encourage reflection about the usefulness of the different sources. The sources were selected to present a mixture of voices, i.e., positive and negative, including one source with a balanced perspective, and with the purpose of presenting a variety of source characteristics and conflict and disagreement types. Consequently, when participants were provided with the interactive slide presenting the taxonomy of expert disagreements, they were prompted to reflect about the information provided in the taxonomy by applying that knowledge, i.e., identifying the type of conflict and disagreement present between two sources.

Key components in educational intervention aimed at developing more adaptive and adequate epistemic beliefs and more effective handling of conflicting information in order to support sustainable decision-making may include; *Cognitive conflict*: presenting individuals with conflicting information or alternative perspectives can create cognitive dissonance and prompt them to re-evaluate their existing beliefs. Exposure to diverse viewpoints, contradictory evidence, or challenging scenarios can stimulate critical thinking and initiate the process of epistemic change (Bråten et al., 2014b; Ferguson et al., 2012; Lunn Brownlee et al., 2017).; *Metacognitive reflection*: Encouraging

individuals to reflect on their own thinking processes, assumptions, and epistemic beliefs is crucial for inducing epistemic change (Kerwer and Rosman, 2018; Kienhues et al., 2016; Lunn Brownlee et al., 2017; Pieschl et al., 2021). Metacognition involves being aware of and monitoring one's own cognitive processes, including beliefs about knowledge acquisition, evaluation, and application. Reflective practices, such as journaling, self-assessment, and guided questioning, can help individuals become aware of their epistemic beliefs and critically examine them.; *Active learning*: Engaging individuals in active learning experiences that involve problem-solving, inquiry-based activities, and real-world applications can promote deeper understanding and reflection. Active learning approaches, such as discussions, debates, case studies, and hands-on activities, encourage individuals to question assumptions, consider multiple viewpoints, and construct their own knowledge (Knight and Littleton, 2017). It may also have an important link with an internal locus of control and better perceived self-efficacy.

Active learning may be associated with another possible component, which was not included in study 3, however, may be of interest in future intervention development; *Social interaction*: Providing opportunities for individuals to engage in meaningful discussions and collaborative activities with peers and experts can foster epistemic change (Knight and Mercer, 2017). Social interaction allows for the exchange of ideas, challenging of assumptions, and negotiation of meaning (Knight and Littleton, 2015). Interacting with others who hold different perspectives and epistemic beliefs can broaden individuals' understanding and stimulate reconsideration of their own beliefs (Knight and Littleton, 2017). In addition, it should be noted that another key component may be the need for ongoing efforts. *Sustained support*: Epistemic change is a gradual and ongoing process. Providing sustained support, such as ongoing guidance, feedback, and opportunities for practice, is important for individuals to solidify and integrate their evolving epistemic beliefs. Continuous engagement in activities that reinforce critical thinking, evidence evaluation, and information literacy can help individuals apply their changing beliefs in practical contexts.

The last four categories of determinants (“to whom in what situation using what strategies and to what effect?”) are situated within the individual. In study 3, several measures were included that are expected to provide a better understanding of one’s handling of conflicting information based on these determinants identified in study 1. **Figure 19** presents an overview of the measured variables in study 3 within the structure of study 1’s framework. This also shows that no measure of any situational determinants was included, except for an indirect indication of the participants’ reading goals through the recorded time they spent on the task. Given that the situation the individual finds themselves in when handling information is not something that can be modified through education or communication, investigation of these measures is less of interest from the interventional point of view. However, future research may wish to include other measures for people’s reading goals and the level of time, effort, and motivation to engage with the information they have available and are

willing and able to use. In addition, people's coherence expectations as well as measures for conflict and uncertainty aversion could be included to further investigate the role of these situational determinants in people's handling of conflicting information.

5.5. Extending the impact of this research beyond the life of the current project

This thesis aimed to make a step towards a better understanding of people's handling of conflicting health information and how people may be assisted with such information processing in a context of multiple conflicting scientific knowledge claims. While there are several other types of perceived conflicting information (e.g., mis- and disinformation) which need attention, conflicting information due to expert-expert disagreement requires significant future work in research and practice, for example, in health communication and education (Williams et al., 2023). Further research on the concept of expert-expert or scientific disagreements will be essential in a world that is expected to continue to be increasingly information-driven and in which autonomic and shared decision-making are increasingly required (as opposed to being told what to do by an authoritative in the form of a simple one-sided advice).

In the following, I briefly illustrate the relevance of the work in this thesis to such practical context, through outlining ongoing work that investigates how expert conflict is presented and addressed in decision aids.

Use of the taxonomy in the analysis of decision aids

One way people are being assisted with decision-making around health topics is by providing them with decision aids. Patient decision aids (PDAs) are tools designed to assist patients in making informed and personalised decisions about their healthcare options, particularly when facing difficult choices or treatment decisions. These tools are intended to support shared decision-making between patients and healthcare professionals by providing evidence-based information, presenting potential benefits and risks of different options, and facilitating a patient's understanding of their own values and preferences (Arab-Zozani et al., 2020; Will, 2013; Witteman et al., 2021). First, I wish to note that, both the term and the concept are still mostly focused on "*patients"* and "*treatments"*, however, such decision aids can be, and are, also used in public health promotion and thus can function in "*prevention"* for the "*public*" as well. However, it is good to note as well that PDAs are typically developed with the intention to prepare a person for decision-making and to aid the shared decision-making between a patient and a healthcare professional rather than to assist a person with making a decisions by themselves. Patient decision aids have been shown to improve patients' knowledge about their options, increase their satisfaction with the decision-making process, and potentially lead to choices that better align with their values (Witteman et al., 2021). They are particularly valuable for

complex or preference-sensitive decisions, such as choosing between different treatment approaches, undergoing screening tests, or considering surgery. In such decision-making around complex health issues, it is more likely that there are differing perspectives between health experts on what is the best option.

Presenting expert disagreement within patient decision aids (PDAs) is a challenging yet important aspect of providing balanced and comprehensive information to patients. Expert disagreement can arise when different healthcare professionals or medical organisations have varying opinions or recommendations about the best course of action for a particular medical condition or treatment. Including this type of information in PDAs allows patients to understand the range of perspectives and make more informed decisions based on their own values and preferences. The key is to provide patients with a nuanced understanding of uncertainty and disagreement, while empowering them to engage in thoughtful discussions with their healthcare providers. Decision aids should emphasize that the goal is to make the most informed choice based on the available information, patient values, and individual circumstances, even in situations where uncertainty or disagreement exists.

To warrant quality of PDAs, they are ideally created and evaluated based on a set of criteria specified in the International Patient Decision Aid Standards (IPDAS) (Witteman et al., 2021). The IPDAS checklist sets out criteria related to the content, the development process and the effectiveness (Witteman et al., 2021). The checklist shows that there is already some focus on the communication of uncertainty and the provision of science literacy related information. The content-related criteria include the provision of probabilities of outcomes and evaluates the presentation of those, including whether the PDA describes uncertainty around those probabilities (Witteman et al., 2021). The development process evaluation includes elements such as whether the information is provided in a balanced manner, and transparency-related aspects (e.g., author information and conflict of interest disclosure) as well as information related to the scientific evidence (Witteman et al., 2021). The latter includes “report steps to find, evaluate, summarise evidence” and “describe the quality of scientific evidence (including a lack of evidence)” (Witteman et al., 2021).

While the IPDAS include some criteria related to the provision of information about uncertainty and the handling of scientific literature, no guidelines exist on how to represent expert disagreement, nor do we know up to what extent disagreements are made explicit in PDAs and how this is done. Furthermore, although included in the checklist, it is not well known up to what extent the uncertainty and science literacy related aspects are present in PDAs today (Bansback et al., 2017; Bonner et al., 2021; Witteman et al., 2021). To be able to potentially develop a better understanding of how PDAs could, and if they should, include more effective information on expert disagreements, a more in-depth analysis of the content of PDAs is required. Therefore, we are analysing publicly available PDAs with the aim to investigate a) What types of disagreement and uncertainty are covered in PDAs

today? and b) How are disagreement and uncertainty addressed? Or in other words, what kind of supportive strategies are used to assist people with any disagreement and/or uncertainty?

In this analysis, to be able to investigate the types of disagreement that are present in the PDAs, there is a need for an abstraction of the concept "expert disagreement" and a definition/ explanation, terminology and classification for differing disagreement types. The taxonomy developed in study 2 aims to do exactly that: i.e., to present an overview of types of disagreement by providing a name/term, an explanation and an example for different types of disagreement (we identified 10 types), in a structured manner (classified under 3 categories). Thus, the taxonomy promotes a better awareness and understanding of the distinction between different types and assists with identification of those different types of disagreement when they are present in the PDA. To the best of our knowledge, using the taxonomy of disagreements in this way to assist with content analysis, illustrates how it adds a useful tool to the field as there was nothing of that nature before. In a similar manner, one could use the taxonomy as a reference for the conceptualisation of expert disagreement in different research contexts. Furthermore, due to the open and modular abstraction and presentation of the taxonomy, if future analysis of disagreement contexts would identify additional categories, they could still be added to the present taxonomy. As such, future work may benefit from the present taxonomy, and may be beneficial to the taxonomy, making it a dynamic useful tool for research and practice around expert disagreement.

5.6. Future research and practice recommendations

The thesis offers a promising framework for future research and practice in addressing expert disagreement and conflicting health information. The breadth and transdisciplinary nature of this work leads to many and varied areas for future research. Each of the key points outlined in the thesis can be leveraged to guide future endeavours. More specifically, the conducted work can be viewed as a set of core aspects or modules on which future work (whether that be based in research or in practice) can build.

In particular, the present work proposes the importance of people's epistemic beliefs in the handling of conflicting health information and study 3 explores potential intervention targeted to the individual (the information receiver) with the aim to promote epistemic change through a better understanding of the nature of science. We propose further efforts based on this idea (i.e., promoting adaptive epistemic beliefs) and I have suggested potential alternative and additional intervention design aspects in previous sections in this discussion. However, the phenomenon conflicting health information is a complex issue and may benefit a multi-faceted solution with interventions looking at the issue from different angles and providing assist on different fronts.

Due to the foundational nature of the work, the high level of transparency in its development and creation, and the resulting conceptual findings and structured manner of presenting and reporting these, the present work can be viewed as modular, i.e., a set of modules that provide structure for other (less conceptual) enquiries but that also allows for other modules to be added.

In the following, a list of other potential future research and practice recommendations is described. I view these different paths as complementary approaches, which can all "attack" the issue at the same time, but which focus on different facets (different determinants within the information and within the individual as listed in study 1). None of them may provide a sufficient solution to the issue by themselves, however, together they may create a sufficiently improved situation. The metaphor of the layers of Swiss cheese comes to mind here (Larouzee and Le Coze, 2020; Reason, 1990). This metaphor is well known in risk management, and was, for example, often used in the communication around the rules and restrictions that were used during the Covid 19 pandemic (Haghani et al., 2023); each of the different approaches (e.g., mask use, limiting social contacts, vaccination, etc.) has flaws (i.e., there are holes in each cheese layer), however, when stacked on top of each other, there may be sufficient overlap and the one layer may cover the hole in the other layer. Similarly, none of the proposed recommendations here may provide a sufficient solution to the issue by themselves, however, together they may create a situation where the information and the individual are in better shape for effective and efficient communication and information processing and more sustainable decision-making.

Potential additional modules/ paths that may be of interest in future work around health information processing include: (a) Reducing exposure to poor information by limiting its availability. *Future Research*: While limiting exposure to poor information suffers challenges including feasibility (how do we reduce exposure), conceptual (how do we understand poor information, particularly considering conflict between 'high quality' sources), and in terms of evidence (reduction in exposure may not change beliefs/behaviour), future research can delve deeper into understanding the implications of this stance. It can explore the ethical and practical challenges associated with censorship or content restriction, as well as the unintended consequences that may arise from such actions. *Practice Recommendation*: Rather than limiting information, the focus should be on equipping individuals with critical thinking skills to discern between reliable and unreliable sources. Promoting media literacy and fact-checking initiatives can empower individuals to make informed decisions (Yakub et al., 2020). In the social media environment, however, certain restrictive measures in order to reduce the exposure to poor information may be beneficial and feasible (Schneider and Rizoiu, 2023). On social media, the spread of information, and perhaps in particular false information, can spread at an incredibly high speed. Intervening in the algorithmic spread of false information may be able to reduce exposure to false information and potential consequent harm (Schneider and Rizoiu, 2023).

(b) Reducing exposure to poor information by increasing the availability and accessibility of good quality information (Eysenbach, 2020). *Future research* should investigate innovative ways to improve the availability and accessibility of credible information. This might involve studying the impact of open-access initiatives, evaluating the effectiveness of public information campaigns, and exploring emerging technologies like blockchain for data verification (Nosek et al., 2015). It may also involve investigation of the conduct, presentation and impact of fact-checking initiatives (Walter et al., 2020). Fact-checking is an important tool in the present media landscape and may provide guidance for public discourse and support evidence-based decision-making (Walter et al., 2020). However, fact-checking faces challenges as well. Not only can the perceived objectivity of the fact-checker be unclear to the public, but other challenges are also associated with this approach (Shin and Thorson, 2017). More specifically, it has been found that misinformation can continue to influence people even when they understand and remember the correction (Ecker et al., 2020). The phenomenon where corrected misinformation continues to influence people's memory and reasoning even if the correction is understood and remembered is termed the *continued influence effect of misinformation* (Johnson and Seifert, 1994; Ecker et al., 2020). Whether such repetition of poor information should be avoided or not and how refutation texts should be designed for optimal effect may still need much further investigation (Ecker et al., 2020). *Practice Recommendation*: Governments, educational institutions, industry and media can collaborate to create centralised hubs or platforms where high-quality information is readily accessible (Meijer et al., 2023). Promoting transparency in information sources can also enhance credibility.

(c) Improving credibility assessment capacity. *Future research* can focus on developing and testing tools and frameworks for assessing credibility effectively. This could include the development of credibility assessment algorithms and studying the psychological factors that influence individuals' perceptions of credibility. *Practice Recommendation*: Educational institutions could integrate (more) media literacy and critical thinking courses into their curricula (Chiang et al., 2022; Lee and Ramazan, 2021; Yakub et al., 2020). Fact-checking organisations can play a crucial role in providing accessible resources for credibility assessment (Walter et al., 2020).

(d) Improving science literacy (Eysenbach, 2020). *Future research* can explore the long-term impact of improved science literacy on decision-making and public discourse. It can also investigate the most effective pedagogical methods and interventions for enhancing science literacy at various educational levels. This includes further investigation of efforts to improve people’s ability to distinguish between different types of disagreement. *Practice Recommendation*: Schools and universities should prioritize education that emphasizes critical thinking, scientific methodology, and the importance of evidence-based decision-making (Knight and Mercer, 2017; He et al., 2021; Sharon and Baram-Tsabari, 2020). The taxonomy of disagreements (developed in Chapter 2) may assist with developing such educational interventions (as also discussed in 5.4.4. on p 179) (Deroover et al., 2023). Scientific

institutions can engage in science communication efforts to bridge the gap between experts and the public.

(e) Improving awareness of cognitive processes. *Future Research* can continue to advance our understanding of cognitive biases and their effects in different contexts. It can explore interventions and strategies to mitigate the impact of these biases, drawing from behavioural economics, psychology, and cognitive science. A better understanding and awareness of, for example, confirmation bias and motivated reasoning may assist with more effective reasoning or may help us better understand what reasoning is. As Mercier and Sperber (2011) argue, our reasoning and the kind of cognitive biases that have received popular attention (Kahneman, 2017) may not reflect flaws. Instead, reasoning can be viewed as an adaptive process of justification for decisions, with 'biases' reflecting otherwise adaptive features of this process (Mercier and Sperber, 2011). *Practice Recommendation*: Regardless of how one views the function of reasoning, public awareness campaigns and educational programs could inform individuals about cognitive biases and make them better able to exert some control over their own biases (Kahneman, 2017; Mercier and Sperber, 2011) and about the cognitive processes that happen when being exposed to conflicting information (as discussed in Chapter 2). These initiatives can provide practical tools for recognising and managing biases in everyday decision-making.

(f) In all these recommendations, artificial intelligence (AI) could, and likely will, play a significant role. For example, AI could be play a role in credibility assessment (c) (Chiang et al., 2022; Przybyła and Soto, 2021) and could be a useful tool in science education (d) (Cooper, 2023). There are, however, several distinctive challenges related to generative artificial intelligence (Dwivedi et al., 2023). For example, in a context of expert disagreement, when asked to summarise three expert positions on something, GenAI may produce an output where differences between experts are emphasised, and the information may be presented as more conflicting than it is or the differences between the experts and the nuances may get lost in the output because of the separation between source and content. Consequently, a better understanding and awareness of such challenges will be essential for effective and efficient use of GenAI. In general, the potential, merits and challenges of the use of generative artificial intelligence still need extensive investigation and regulation (Claudi L. Bockting, 2023). The development of evidence-based guidelines for GenAI may be crucial for science and public trust (Claudi L. Bockting, 2023).

5.7. Conclusions

The rapid advancement of technology, particularly the internet, has granted us unprecedented access to a vast array of information. While this access empowers individuals to self-educate and make

informed decisions, it also exposes us to conflicting and contradictory viewpoints. Consequently, the ability to assess and evaluate conflicting information has become a prerequisite for meaningful participation in society. Conflicting information can arise not only from the presence of false information but also from genuine expert conflict. Disagreements among experts are a natural part of scientific progress and discourse, yet this fact may not be fully grasped by the public. This perception of science as absolute and unwavering can hinder our appreciation of the inherent uncertainty, disagreement, and tentativeness within the scientific community. Such appreciation is essential for critical evaluation of scientific claims. The challenge of handling conflicting information is especially intriguing in the context of health due to its direct impact on people's well-being. The ability to navigate and interpret scientific contradictions is vital for promoting well-informed choices and building a healthier, more informed society.

This thesis comprises three interconnected studies that aim to unravel the complexities of how people process and respond to conflicting health information. These studies aim to grasp the complexity of the problem and involve an integration and interpretation of diverse knowledge types and perspectives to develop a comprehensive understanding of this issue.

The work conducted in this thesis makes methodological contributions to the field of inquiry, which may inform further efforts within the *conflicting health information* space or inspire similar (transdisciplinary) endeavours aiming for a better conceptual understanding of a wicked complex issue.

Working towards an improvement of the situation, this research contributes to both theory and practice, highlighting the significance of individuals' epistemic beliefs and their perspectives on how knowledge is constructed. This work informs strategies for improving health communication and enhancing information literacy in the context of conflicting health information, ultimately promoting more informed and effective health decision-making.

This research represents the foundational work, and it is hoped that future endeavours will build upon it, further advancing our understanding and handling of the complex phenomenon of conflicting health information.

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Appendix 1. Taxonomy interactive slide (print)

Why do experts disagree?

This is a visual presentation of our taxonomy of disagreements as described in our published article; please use the following citation when using the figure:
Deroover, K., Knight, S., Burke, P. F., & Bucher, T. (2023). Why do experts disagree? The development of a taxonomy. *Public Understanding of Science*, *32*(2), 224-246. https://doi.org/10.1177_09636625221110029

What

Conceptualising expert disagreement is a crucial step in supporting lay understanding of such disagreement to mitigate against rejection of expert information and reduce confusion. While many elements discussed here are individually recognised in both the literature, and the expert interviews, the purpose of the taxonomy is to bring these dimensions of disagreement together to provide a shared conceptualisation. This taxonomy aims to contribute to the conceptualisation of disagreement and to facilitate an awareness of the differences therein. Please note that we wish to acknowledge that a best, correct or finished taxonomy may be undefinable and should not be seen as the aim. Instead, this taxonomy aims to be extendible, and to provide a tool to raise awareness, spark discussion, and encourage further research.

Why

The primary use of the present taxonomy is to provide a theoretical base for further research and communication around expert disagreement. Additionally, knowledge about the range of causes for discerning information may help with an effective evaluation of, e.g. health, information, and the developed taxonomy may inform and help both communicators and readers with the transfer of evidence-based information.

How

This work aims to provide an overview of the possible causes for expert disagreement with the use of such overview as an educational tool in mind. It identifies ten types of disagreement classified under three dimensions; informant-, information-, and uncertainty-related causes for disagreement. We used a Frayer model-inspired structure to explain the different categories of the taxonomy (Frayer et al., 1969). As such, for every category, we provide a definition, characteristics, example(s) and non-example(s). This approach provides a flexible method to both define and illustrate items, while also supporting differentiation between the different categories.

› to the taxonomy

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Why do experts disagree?

Informant

- Competence
- Motivation

Information

- Evidence type
- Available evidence
- Input ambiguity
- Outcome ambiguity

Uncertainty

- Expert pertinence
- Human judgement
- Inherent uncertainty
- Tentative knowledge

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Competence

Definition

Different levels of competence based on educational/ professional background, experience and scientific expertise.

Characteristics

- One's competence may influence the methods or research process used to answer a research question.

Different methods may be able to avoid biases to a greater or lesser extent.

- An expert's level of competence may also be influenced by one's ability to invest time and effort .

Example(s)

"*Besides the unreliability that may be intrinsic to a complex, ambiguous task such as forensic evaluation, research has identified multiple extrinsic sources of expert disagreement. One such source is limited training and certification for forensic evaluators. While specialised training programs and board certifcations have become far more commonplace than in the early days of the field in 70s and 80s, the training and certification of typical clinicians conducting forensic evaluations today remains variable and often poor (De Matteo et al., 2009).*" (Guarnera et al., 2017)

Non-example(s)

Experts must make judgements all along the scientific process, which may be equally "correct". They decide on research design and methods (*Evidence Type)* and make judgements about the problem definition and integration of information (*Human judgement on problem structure*).

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Definition

Material, financial or status-related interests may influence experts.

Characteristics

-Personal interests may result in selective reporting of findings or may affect the expert's willingness to admit uncertainty about reported findings.

-Funding environments and political factors may influence research topics and outputs.

Example(s)

Weaver and Miller (2017) described how scientists routinely have to navigate bias in clinical nutrition research, both that of others and their own; "*Important examples of the former include the biases of reviewers of grant applications and manuscripts, as well as public and professional perceptions. External assumptions of bias can be particularly acute when the research is funded by industry, which has become a growing issue as federal funding declines and industry funding is sought to fill the void and maintain research programs. Examples of individual bias include the desire for respect and recognition among peers, the academic imperative to "publish or perish", [...] and financial conflicts of interest.*"

Non-example(s)

Experts (or the business/ organisation the experts are associated with) may be influenced by their perspectives, including their worldviews, values, and beliefs about social, ethical, cultural, religious or political aspects (*Perspective*). Such beliefs or preconceived ideas about the topic may, intentionally or unintentionally, cause a tendency to confirm one's prior beliefs or hypotheses.

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Perspective

Definition

Experts (or the business/ organisation the experts are associated with) may be influenced by their perspectives, including their worldviews, values, and beliefs about social, ethical, cultural, religious or political aspects.

Characteristics

Beliefs or preconceived ideas about the topic may, intentionally or unintentionally, cause a tendency to confirm one's prior beliefs or hypotheses.

Example(s)

-In clinical nutrition research: "*[…] Scientists may be subject to bias based on a personal history of supporting a specific position, personal passions, ideologies or philosophies, religious or ethical orientations, nationality, ethnicity. […]*' (Weaver & Miller, 2017)

- "*Selective observation is a critical problem in social science research as often inquiry into an issue is driven by professional interest in a particular phenomenon. [...] Once you have concluded that a particular pattern exists and developed a general understanding of why, then you will be tempted to pay attention to future events and situations that correspond with the pattern. You will most likely ignore those that don't correspond*" (Robb, 2020)

Non-example(s)

Perspective could be an informant-related cause or an uncertainty-related cause, depending on the informant's level of competence and the nature of their motivation. If competence and motivation are constant between scientists, they may still come to differing conclusions based on having made differing judgements along the scientific process. This category is further described in "*human judgement*".

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Definition

Different levels of strength, quality and rigour of scientific evidence.

Characteristics

- Different weights should be given to evidence that is based on a study that describes a single case versus a study that combines the findings of multiple studies and includes an indication of the quality of those studies.

- Correlation does not necessarily imply causation.

- There is a need to evaluate evidence based on the knowledge of different research designs and their relative ability to answer the research questions.

Example(s)

- *"[...] Nutritional epidemiology is plagued by measurement error, reverse causality, selection bias, weak effects, analytical flexibilty, and unmeasured or residual confounders. [...] Randomized diet intervention trials, on the other hand, often do not actually study the effects of different diets, but rather investigate the effects of differing diet advice.[...] Domiciled feeding studies can provide important mechanistic insights, however, their artificial environment may limit generalizability and application to free-living populations [...]"* (Hall, 2020)

Non-example(s)

- Several types of study designs and evidence are required to come to new knowledge. As such, the choice for different types of studies can be correct, however, may come to different conclusions. This is, however, not about choosing a design that does not suit the research question (*competence*) or fake evidence (*interest*).

- With time, new better research designs may be discovered (*tentative knowledge*)

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Available evidence

Definition

The unavailability or inaccessibility of information to the expert at a particular time.

Characteristics

-Evidence includes both the theory and data.

-Academic papers are not always published in open-access databases.

-Accessibility may be temporarily enabled due to a delay in the dissemination of new data.

-In the case of business-generated data, there may even be interests or incentives to withhold information from others.

Example(s)

"*Conventionally, public health professionals seek evidence from the published literature. However, in the case of tobacco, much research was done by the industry with the explicit intention that it not be published.*"
(Rosen et al., 2010)

Non-example(s)

There is a distinction between the availability of data and human judgement about the use of data. If judgement about the screening, selection, integration and interpretation of data is the cause for expert disagreement, this would be a matter of disagreement based on human judgement about the research process *(Human judgement)*.

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Input ambiguity

Definition

Ambiguity about the relevance of the input variable

Characteristics

we need to define clearly what 'x' is in claims like: 'x' causes 'y'

Example(s)

"*[…] Most studies show that a lack of vitamin D increases the risk of osteoporosis and the likelihood of hip and other non-spinal fractures. […] Some studies include only women, others both men and women; some include only frail, elderly, or institutionalized subjects, others physically active people; some use vitamin D alone, others a combination of D and varying doses of calcium; and some administer 400 international units (IU) of vitamin D a day, others up to 800 IU a day)[…]*" Vitamin D and your health: Breaking old rules, raising new hopes, May 17, 2019.

Non-example(s)

-This is not about the probability of information being correct, instead here disagreement arises based on doubt about the relevance of the input variable

- When there is ambiguity about the relvance of the dependent variable, or outcome variable, that is an example of "*Outcome Ambiguity*"

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Outcome ambiguity

Definition

Ambiguity about the relevance of the outcome variable

Characteristics

-there is a need to define clearly what 'y' is in claims like: 'x' causes 'y'

- Often concepts like health or wellbeing are ultimately the outcome variable of interest, however, such variables are hard to define and may depend on personal and contextual differences. As such, experts may define the same construct differently.

Example(s)

"[…] A professor of nutrition and epidemiology questions the conclusion that the cons of drinking always outweigh the pros. While there's "no question" that heavy drinking is harmful, he says that plenty of data supports links between moderate drinking and lower total mortality and a decreased risk of heart disease – which, he says, are far more relevant concerns for most Americans than something like tuberculosis, which the Lancet paper identifies as a leading alcohol-related disease worldwide. Tuberculosis is very rare in the U.S.[…]' A new study says any amount of drinking is bad for you. Here's what experts say. August 24, 2018.

Non-example(s)

-This is not about the probability of information being correct, instead here disagreement arises based on doubt about the relevance of the outcome variable.

- When there is ambiguity about the relvance of the independent variable, or input variable, that is an example of "*Input Ambiguity*".

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Definition

Uncertainty about the relevance of that expert to answer a speci c question.

Characteristics

Expert pertinence is particularly relevant for complex topics where several elds are involved, which may have different ways to look at a certain topic.

Expert pertinence

Example(s)

"*What dieticians think is important differs from what nutrition scientists think is important. Dieticians and nutrition scientists can vary a lot; a dietician will care a lot more about how you measured something and what the error is of your measurement methods or devices. I think nutrition scientists are happy for devices to have a bit more error.*" (Deroover et al., 2022)

"*When I compare basic and applied research, I see that basic research wants to show an effect and it does not matter how big or small that effect is. In applied research, however, it is only interesting if it concerns a large effect that can make an impact in real life.*" (Deroover et a'., 2022)

Non-example(s)

When an expert is incompetent, or influenced by personal interests or perpectives, those causes are respectively "*Competence*", "*Motivation by Interest*" or "*Motivation by perspective*".

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Human judgement

Definition

Experts have to make judgements about the way a) the problem is de ned and b) the information is integrated

Characteristics

-Differences in the way the problem is seen by different experts may lead to differing problem de nitions, research methodology, interpretation of the ndings and formulation of conclusions.

-Different ways in which an expert organises and integrates information can also be a cause for disagreement.

- Theory choice can be based on pursuit-worthiness (Lichtenstein, 2021)

Example(s)

"*[. . .] Most studies show that a lack of vitamin D increases the risk of osteoporosis and the likelihood of hip and other non-spinal fractures. But there is considerable disagreement about how much supplements reduce the risk of fractures. [. . .].*" Vitamin D and your health: Breaking old rules, raising new hopes, May 17, 2019.

Non-example(s)

-Judgement may be influenced by *competence*, personal *interests* or *perpectives*.

-The experts' background, e.g. eld, may influence their judgements along the research process. One expert may be more or less pertinent to answer a question, which could result in disagreement caused by "*Expert Pertinence*".

However, when competence, bias and pertinence are constant, experts may still make different judgements on the problem structure.

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Definition

Uncertainty due to the randomness of the world.

Characteristics

the probability associated with future outcomes

?

Inherent uncertainty

Example(s)

-"*[…] Perhaps the reason so many studies come up with so many different conclusions is that every person is different to a degree, especially in the way they metabolize substances. […]*" ZME Science. (2019) Is coffee good or bad? A critical view on the science behind it.

-" *There is always another finding that could disapprove your findings, especially in human sciences, you're never 100% sure.*" (Deroover et al., 2022)

Non-example(s)

-It distinguishes itself from epistemic uncertainty, which refers to the type of uncertainty that is about how much one actually knows about something. Where inherent uncertainty refers to the future, epistemic uncertainty is about the certainty we have about present issues and represents the recognition of the limitations of our knowledge. Epistemic uncertainty refers to knowledge about phenomena that is currently incomplete but theoretically attainable.

- Experts may differ in their willingness and ability to admit uncertainty. Differences in willingness to admit uncertainty are based on motivational aspects and therefore classify under that category in this taxonomy.

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Tentative knowledge

Definition

As experts a) work in dynamic situations with evolving conditions and constraints, and b) keep building upon existing knowledge, they keep revising and updating ideas, theories, and concepts.

Characteristics

-the dynamic nature of knowledge

↳ the "facts" of today may tomorrow be obsolete and regarded as the flaws of yesterday

-Social (need for policies) and financial (lack of funding) factors may hasten the process to come to solutions quickly and pressure scientists not to engage in debates or express uncertainty.

Example(s)

-"[...] Conflicting information about the effects of coffee abound. Until not too long ago, the WHO classified coffee as "possibly" carcinogenic, but later reversed the statement stating that evidence for the association between coffee and cancer is inadequate. [...]" ZME Science. (2019) Is coffee good or bad? A critical view on the science behind it. Available at: https://www.zmescience.com/science/coffee-good-or-bad-04232/.

-"The knowledge we have is created, constructed, and therefore always evolving." (Deroover et al., 2022)

Non-example(s)

- This is not about being uncertain about an outcome (*inherent uncertainty*) but instead about acknowledging knowledge based on the evidence available at a certain point in time and at the same time being aware that this knowledge may be revised in the future.

-This is not disagreement due to experts' differing judgements on the problem definition and integration of information (*Human judgement*)

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Frayer DA, Fredrick WC and Klausmeier HJ (1969) A schema for testing the level of concept mastery. Wisconsin Univ. Research & Development Center for Cognitive Learning

Guarnera, L. A., Murrie, D. C., & Boccaccini, M. T. (2017). Why do forensic experts disagree? Sources of unreliability and bias in forensic psychology evaluations. Translational Issues in Psychological Science, 3(2), 143.

Hall, K. D. (2020). Challenges of human nutrition research. Science, 367(6484), 1298-1300.;

Harvard Health Publishing. (2019) Vitamin D and your health: breaking old rules, raising new hopes. Available at: https://www.health.harvard.edu/staying- healthy/vitamin-d-and-your-health-breaking-old-rules-raising-new-hopes.;

Lichtenstein, E. I. (2021). (Mis) Understanding scientific disagreement: Success versus pursuit-worthiness in theory choice. Studies in History and Philosophy of Science Part A, 85, 166-175.

Robb, A. (2020). Methodological challenges in social science: Making sense of polarized and competing research claims. Family Court Review, 58(2), 308-321.

Rosen, L., Rosenberg, E., McKee, M., Gan-Noy, S., Levin, D., Mayshar, E., ... & Lev, B. (2010). A framework for developing an evidence-based, comprehensive tobacco control program. Health Research Policy and Systems, 8(1), 1-13.

Time. (2018) A New Study Says Any Amount of Drinking Is Bad for You. Here's What Experts Say. Available at: https://time.com/5376552/how-much-alcohol- to-drink-study/

Weaver, C. M., & Miller, J. W. (2017). Challenges in conducting clinical nutrition research. Nutrition reviews, 75(7), 491-499.; ZME Science. (2019) Is coffee good or bad? A critical view on the science behind it. Available at: https://www.zmescience.com/science/coffee-good-or-bad-04232/.

ZME Science. (2019) Is coffee good or bad? A critical view on the science behind it. Available at: https://www.zmescience.com/science/coffee-good-or-bad- 04232/.

Appendix 2. Intervention for the guided group in study 3 (extract from Qualtrics)

Welcome

Thank you once again for your interest and welcome to part 2 of this study!

If you have concerns about the research that you think we can help you with, please feel free to contact us on paul.burke@uts.edu.au or simon.knight@uts.edu.au or kristine.m.deroover@student.uts.edu.au.

If you would like to talk to someone who is not connected with the research, you may contact the Research Ethics Officer on 02 9514 9772 or Research.ethics@uts.edu.au and quote this number ETH20- 5078.

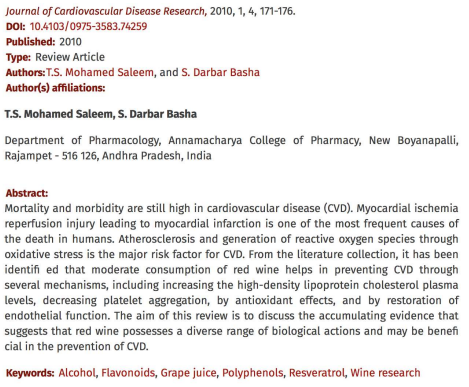
Guided group

We will now guide you through a series of tasks based on a set of sources. When you click on the picture or the title of each source, it takes you to the full source (your browser will open them in a different window).

A friend has asked you for your views on the health impact of wine. She's an educated (has an undergraduate degree) professional of about 35 years old, but does not work in health or nutrition. Imagine you've searched the internet, and found these resources. Based on these sources, what perspective would you give your friend?

Sources:

7 Smart Reasons You Should Drink Red Wine Every Night



Red Wine: A Drink to Your Heart

Alcohol use: a systematic analysis for the Global Burden of Disease Study

A New Study Says Any Amount of Drinking is Bad for You. Here's what Experts Say.

Alcohol: Balancing Risks and Benefits

Association between alcohol and cardiovascular disease: Mendelian randomisation analysis

Why I Stopped Drinking Wine: I love wine, too, but I've decided it's just not worth it

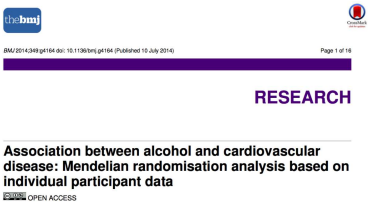
Based on these sources, what perspective would you give your friend? [Minimum 500 characters (or about 80 words) - Maximum 3000 characters (or about 500 words)]

Please justify and explain your recommendation. [Minimum 500 characters (or about 80 words) - Maximum 3000 characters (or about 500 words)]

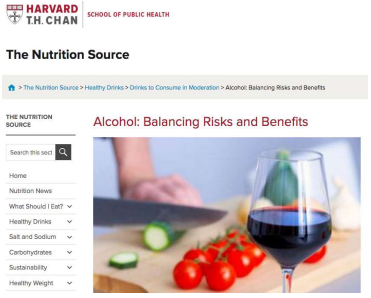
You can make two piles of source(s) using the tool below; those you would recommend she reads, and those you don't think she should spend time reading. She'll read the ones you recommend from the top, so you should put the most important ones first and the least important ones last.

Items

BMJ - Association between alcohol and cardiovascular disease



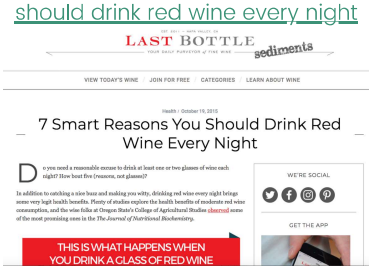
Harvard - Alcohol: Balancing risks and benefits



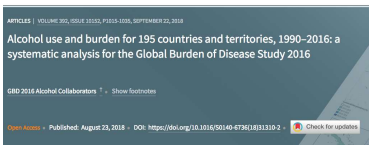
Recommended	Not recommended

Psychology Today - Why I stopped drinking wine

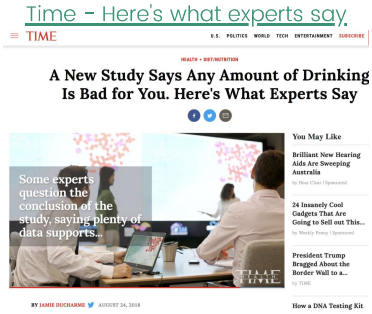
Last Bottle - 7 smart reasons you should drink red wine every night



The Lancet - Alcohol use is a global burden



Time - Here's what experts say



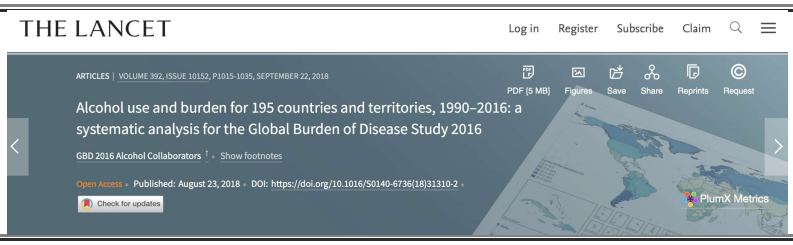
Journal of cardiovascular disease research - Red wine: a drink to your heart

Please explain how you evaluated whether or not your friend should read each of the sources. [Minimum 500 characters (or about 80 words), maximum 3000 characters (or about 500 words)]

The resources from the previous task have differing views on the health impact of wine. Why do experts sometimes disagree? Some think that consensus is an essential requirement for expertise. They consequently propose that when experts disagree this means that at least one of them is not an actual expert or may be influenced by personal interests. However, disagreement is a normal aspect of science, and next to these expert-related causes, there are many other reasons why experts may disagree or why you may think they disagree.

Please use the figure below to familiarise yourself with the different types of conflict and causes for expert disagreement. Please click on the boxes for more information.

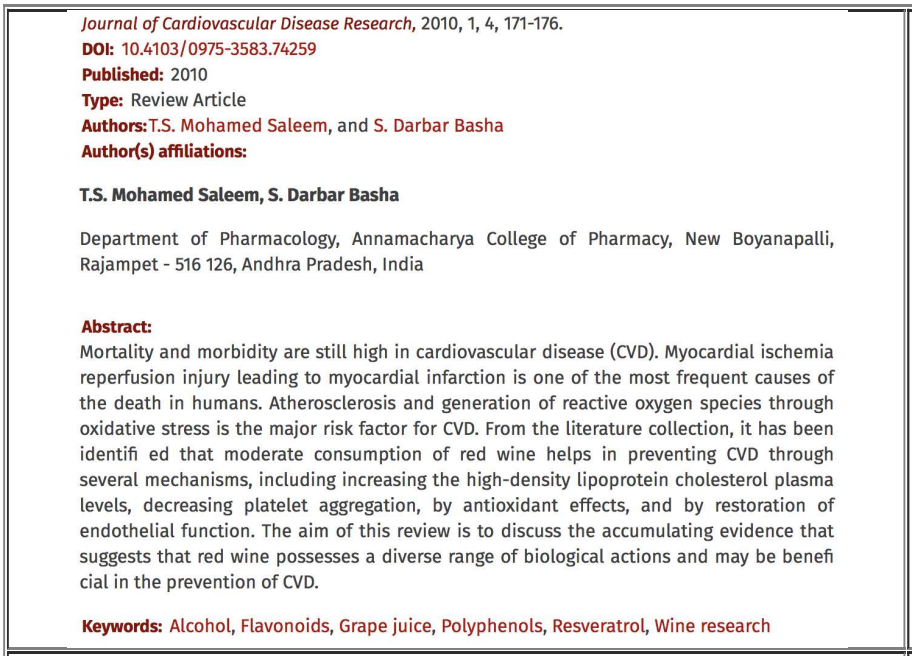
In the following exercise you will be shown some examples of conflicts that are present in the set of resources on the health impact of wine. Please match the examples with their corresponding cause of disagreement by selecting it from the drop-down menu.

	AND	
The article in the Lancet concludes that no amount of alcohol is good for your health based on the association between alcohol consumption and tuberculosis, road injuries, self-harm, and cancer.		The reaction article in T the leading alcohol-rel article in the Lancet, is Western countries and make general conclusi world.

Please select the cause for this disagreement:

	AND	
The blog on the Last Bottle Wines website lists reasons in favour of wine consumption.		The article published in (BMJ) advises to reduc

Please select what may be the cause for disagreement between these sources:



Journal of Cardiovascular Disease Research, 2010, 1, 4, 171-176.
DOI: 10.4103/0975-3583.74259
Published: 2010
Type: Review Article
Authors: T.S. Mohamed Saleem, and S. Darbar Basha
Author(s) affiliations:

T.S. Mohamed Saleem, S. Darbar Basha

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Abstract:
Mortality and morbidity are still high in cardiovascular disease (CVD). Myocardial ischemia reperfusion injury leading to myocardial infarction is one of the most frequent causes of the death in humans. Atherosclerosis and generation of reactive oxygen species through oxidative stress is the major risk factor for CVD. From the literature collection, it has been identifi ed that moderate consumption of red wine helps in preventing CVD through several mechanisms, including increasing the high-density lipoprotein cholesterol plasma levels, decreasing platelet aggregation, by antioxidant effects, and by restoration of endothelial function. The aim of this review is to discuss the accumulating evidence that suggests that red wine possesses a diverse range of biological actions and may be benefi cial in the prevention of CVD.

Keywords: Alcohol, Flavonoids, Grape juice, Polyphenols, Resveratrol, Wine research

AND

thebmj Research

Research

Association between alcohol analysis based on individual

BMJ 2014 ; 349 doi: https://doi.org/
Cite this as: *BMJ* 2014;349:g4164

The review on wine and cardiovascular health.		The review on alcoho

Please select the appropriate cause for the disagreement between these sources:

Please feel free to share any comments. Perhaps you can think of an additional cause for expert disagreement?

Imagine now that another friend has asked you for your views on the use of multivitamins. She, as well, is an educated (has an undergraduate degree) professional of about 35 years old, but does not work in health or nutrition. Imagine you've searched the internet, and found these resources. Based on

Appendix 3. Scenarios for the ETA scales

The following questions are based on your reading of the below extracts!

The following are two brief accounts of the health impact of wine consumption. These accounts are based on two published papers.

Extract from a review from 2010 by Dr Saleem "Red wine: A drink to your heart":

Mortality and morbidity are still high in cardiovascular disease (CVD). Myocardial ischemia reperfusion injury leading to myocardial infarction is one of the most frequent causes of the death in humans. Atherosclerosis and generation of reactive oxygen species through oxidative stress is the major risk factor for CVD. From the literature collection, it has been identified that moderate consumption of red wine helps in preventing CVD through several mechanisms, including increasing the high-density lipoprotein cholesterol plasma levels, decreasing platelet aggregation, by antioxidant effects, and by restoration of endothelial function. The aim of this review is to discuss the accumulating evidence that suggests that red wine possesses a diverse range of biological actions and may be beneficial in the prevention of CVD. CONCLUSION: CVDs are now a current major problem in causing mortality in both Western and developing countries. Oxidative stress associated with atherosclerosis and endothelium-dependent vascular inflammation plays a major role in the development of CVD. Red wine contains antioxidative components like resveratrol, proanthocyanidine, quarcetin, etc. and these active components exert protective functions like free radical scavenging effects, decreasing the oxidative stress and reducing the inflammatory atherosclerotic lesion in both animals and humans, which is evident in this review. **From these findings, it has been concluded that red wine as a diet supplement might be beneficial for cardiovascular risk factors.**

(Saleem, T. M., & Basha, S. D. (2010). Red wine: A drink to your heart. Journal of cardiovascular disease research, 1(4), 171-176.)

Extract from a review from 2014 by Dr Holmes "Association between alcohol and cardiovascular disease: Mendelian randomisation analysis based on individual participant data":

OBJECTIVE: To use the rs1229984 variant in the alcohol dehydrogenase 1B gene (ADH1B) as an instrument to investigate the causal role of alcohol in cardiovascular disease.
DESIGN: Mendelian randomisation meta-analysis of 56 epidemiological studies.
PARTICIPANTS: 261 991 individuals of European descent, including 20 259 coronary heart disease cases and 10 164 stroke events. Data were available on ADH1B rs1229984 variant, alcohol phenotypes, and cardiovascular biomarkers.
MAIN OUTCOME MEASURES: Odds ratio for coronary heart disease and stroke associated with the ADH1B variant in all individuals and by categories of alcohol consumption.
RESULTS: Carriers of the A-allele of ADH1B rs1229984 consumed 17.2% fewer units of alcohol per week (95% confidence interval 15.6% to 18.9%), had a lower prevalence of binge drinking (odds ratio 0.78 (95% CI 0.73 to 0.84)), and had higher abstention (odds ratio 1.27 (1.21 to 1.34)) than non-carriers. Rs1229984 A-allele carriers had lower systolic blood pressure (−0.88 (−1.19 to −0.56) mm Hg), interleukin-6 levels (−5.2% (−7.8 to −2.4%)), waist circumference (−0.3 (−0.6 to −0.1) cm), and body mass index (−0.17 (−0.24 to −0.10) kg/m2). Rs1229984 A-allele carriers had lower odds of coronary heart disease (odds ratio 0.90 (0.84 to 0.96)). The protective association of the ADH1B rs1229984 A-allele variant remained the same across all categories of alcohol consumption (P=0.83 for heterogeneity). Although no association of rs1229984 was identified with the combined subtypes of stroke, carriers of the A-allele had lower odds of ischaemic stroke (odds ratio 0.83 (0.72 to 0.95)).
CONCLUSIONS: Individuals with a genetic variant associated with non-drinking and lower alcohol consumption had a more favourable cardiovascular profile and a reduced risk of coronary heart disease than those without the genetic variant. **This suggests that reduction of alcohol consumption, even for light to moderate drinkers, is beneficial for cardiovascular health.**

(Holmes, M. V., Dale, C. E., Zuccolo, L., Silverwood, R. J., Guo, Y., Ye, Z., . . . Wong, A. (2014). Association between alcohol and cardiovascular disease: Mendelian randomisation analysis based on individual participant data. British Medical Journal, 349, g4164.)

The following are two brief accounts of the health impact of multivitamin supplementation. These accounts are based on two published papers.

Extract from a review from 2014 by Dr Angelo "Efficacy of Multivitamin/ mineral Supplementation to Reduce Chronic Disease Risk: A Critical Review of the Evidence from Observational Studies and Randomized Controlled Trials":

We reviewed recent scientific evidence regarding the effects of multivitamin/mineral (MVM) supplements on risk of chronic diseases, including cancer, cardiovascular disease, and age-related eye diseases. Data from randomized controlled trials (RCTs) and observational, prospective cohort studies were examined. The majority of scientific studies investigating the use of MVM supplements in chronic disease risk reduction reported no significant effect. However, the largest and longest RCT of MVM supplements conducted to date, the Physicians' Health Study II (PHS II), found a modest and significant reduction in total and epithelial cancer incidence in male physicians, consistent with the Supplementation en Vitamines et Mineraux Antioxydants (SU.VI.MAX) trial. In addition, PHS II found a modest and significant reduction in the incidence of nuclear cataract, in agreement with several other RCTs and observational, prospective cohort studies. The effects of MVM use on other subtypes of cataract and age-related macular degeneration remain unclear. Neither RCTs nor prospective cohort studies are without their limitations. The placebo-controlled trial design of RCTs may be inadequate for nutrient interventions, and residual confounding, measurement error, and the possibility of reverse causality are inherent to any observational study. **National surveys show that micronutrient inadequacies are widespread in the US and that dietary supplements, of which MVMs are the most common type, help fulfill micronutrient requirements in adults and children.**

(Giana Angelo, Victoria J. Drake & Balz Frei (2015) Efficacy of Multivitamin/ mineral Supplementation to Reduce Chronic Disease Risk: A Critical Review of the Evidence from Observational Studies and Randomized Controlled Trials, Critical Reviews in Food Science and Nutrition, 55:14, 1968-1991, DOI: 10.1080/10408398.2014.912199)

Extract from a review from 2018 by Dr Haslam "Multivitamins do not reduce cardiovascular disease and mortality and should not be taken for this purpose: How do we know that?":

The prevalence of multivitamin/mineral supplement use is high in the United States and other developed countries. Most studies have demonstrated a net neutral effect of multivitamin/mineral supplements in cardiovascular health, but several studies have suggested possible benefit in certain cardiovascular outcomes. In this systematic meta-analysis of 18 prospective cohort studies and randomized controlled trials, there was no benefit of multivitamin/mineral supplements on cardiovascular disease prevention in the general population. **The study supports present guidelines that recommend against the routine use of multivitamin/ mineral supplements to promote cardiovascular health.**

(Haslam, A., & Prasad, V. (2018). Multivitamins do not reduce cardiovascular disease and mortality and should not be taken for this purpose: How do we know that?. Circ Cardiovasc Qual Outcomes. 2018;11:e004886. DOI: 10.1161/CIRCOUTCOMES.118.004886)

The following are two brief accounts of the health impact of coffee consumption. These accounts are based on two published papers.

Extract from a review from 2014 by Dr Lee "Coffee or tea consumption and the risk of rheumatoid arthritis: a meta-analysis":

The aim of this study was to analyze published results for an association between coffee or tea intake and the development of rheumatoid arthritis (RA). We investigated the evidence for a relationship between coffee or tea consumption and the development of RA by performing a meta-analysis of the published results. Five studies (three cohort and two case–control studies) including 134,901 participants (1,279 cases of RA and 133,622 non-cases) were considered in the meta-analysis. Meta-analysis of the cohort studies revealed a trend of an association between total coffee intake and RA incidence (relative risk [RR] of the highest versus the lowest group = 4.148, 95 % confidence interval [CI] = 0.792–21.73, p = 0.092). Meta-analysis of case–control studies showed a significant association between total coffee intake and RA incidence (RR = 1.201, 95 % CI = 1.058–1.361, p = 0.005). Combining the data of the cohort and case–control studies showed a significant association between total coffee intake and RA incidence (RR = 2.426, 95 % CI = 1.060–5.554, p = 0.036). Meta-analysis stratified by seropositivity indicated a significant association between coffee consumption and seropositive RA risk (RR = 1.329, 95 % CI = 1.162–1.522, p=3.5×10−5), but not seronegative RA risk (RR=1.093, 95 % CI = 0.884–1.350, p = 0.411). No association was found between tea intake and RA incidence (RR = 0.880, 95 % CI = 0.624–1.239, p = 0.463). **This meta-analysis of 134,901 participants (most of the participants were controls) suggests that high coffee consumption is associated with an elevated risk of RA development**. The association between coffee and RA was found in seropositive RA, but not in seronegative RA.

(Lee, Y. H., Bae, S. C., & Song, G. G. (2014). Coffee or tea consumption and the risk of rheumatoid arthritis: a meta-analysis. Clinical rheumatology, 33(11), 1575-1583.)

Extract from a review from 2013 by Dr Allan "Coffee: advice for our vice?":

Does drinking coffee affect mortality or other health outcomes in the general population? Some studies suggest coffee is associated with reduced rates of some cancers, others find no association. Most studies find coffee is associated with fewer CV events, including stroke; others find no association. Coffee intake is also associated with a reduced risk of diabetes and depression. Decaffeinated coffee seems to confer similar benefits. Coffee in pregnancy (particularly ≥4 cups/d) increases risk of fetal loss. Coffee consumption is associated with no change or a small reduction in mortality in cohort studies. **The evidence is not strong enough to recommend that non-drinkers start consuming coffee, but coffee drinkers can be reassured that it does not appear to result in excess harm (except in pregnancy).**

(Allan GM, Korownyk C, Mannarino M. Coffee: advice for our vice?. Canadian Family Physician. 2013;59(3):269.)

Appendix 4: Factor analyses for scales used in study 3

Science Dispute Reasons (SDR) scale factor analysis:

		Process-Competence	Interests-Values	Uncertainty-Complexity
Process	**1.** Scientists use different measuring tools.	0.731		
	2. Scientists use different research methods.	0.738		
	3. Techniques for analyzing study data differ from study to study.	0.665		
Competence	**4.** Scientists vary in competence.	0.669		
	5. Scientists have different credentials for this research.	0.655		
	6. Scientists vary in their experience studying the issue.	0.661		
Interests	7. Scientists conform to what their close colleagues want.		0.551	
	8. Scientists are influenced by the chance for money and promotion.		0.713	
	9. Scientists want recognition and a good reputation.		0.625	
Values	10. Scientists tend to reach conclusions that fit their personal values.		0.652	
	11. Scientists' views on science are affected by their political beliefs.		0.707	
	12. Scientists reach conclusions shaped by what they want to believe.		0.726	
Uncertainty-Complexity	13. The topic is so complex scientists may not realize they're grasping only part of it.			0.597
	14. The topic is too unpredictable.			0.601
	15. The topic is too complex to get clear results.			0.825
	16. Reaching general conclusions on the topic is hard.			0.491
	17. There is too much uncertainty in this area for definite answers			0.508
Cronbach's Alpha:		*0.792*	*0.754*	*0.623*

Note:

Scale and factor analysis used and conducted as per: Dieckmann NF, Johnson BB (2019) Why do scientists disagree? Explaining and improving measures of the perceived causes of scientific disputes. PLoS ONE 14(2): e0211269. https://doi.org/10.1371/journal.pone.0211269

Epistemic Thinking Assessment (ETA) scale factor analysis:

Dimension	Answer	Abs	Multi	Evalu
1. Is there an answer to the question of what happened in/to this topic?	Eventually there will be one right answer.	0.614		
2. Can there be certainty about this topic?	Eventually one could know for certain.	0.647		
3. Is it possible to find out the truth about this topic?	With further investigation we would find out that there is one truth about this topic.	0.682		
4. Is there truth about this topic?	There is truth. If it is not known it is important to find it out.	0.597		
5. What should the knowledge about this topic be based on?	Only on the facts.	0.729		
6. What should the knowledge about this topic include?	Only detailed data about the topic.	0.660		
7. What should be the source of knowledge of those who study this topic?	The source of knowledge should be only in evidence that can be gathered.	0.649		
8. Does the answer to this topic depend on perspectives?	No. One should think about this topic without being influenced by personal perspectives.	0.413		
9. How should one evaluate explanations about this topic?	The most important thing is to check if the explanation reports exact data and not opinions.	0.637		
10. What is the best way to judge different accounts about this topic?	The best way is to check if the account is based only on the facts.	0.656		
11. What would a reliable explanation be regarding this topic?	A reliable explanation is one that includes detailed information without opinions mixed in.	0.513		
1. Is there an answer to the question of what happened in/to this topic?	In principle, it is impossible to know the right answer.			
2. Can there be certainty about this topic?	One could never know for certain because it is impossible to find out what happened.		0.554	
3. Is it possible to find out the truth about this topic?	With further investigation we would find out that truth is in the eyes of the beholder.		0.653	
4. Is there truth about this topic?	There is no single truth and therefore there is no point in seeking the truth.		0.639	
5. What should the knowledge about this topic be based on?	Mainly on personal points of view.		0.753	
6. What should the knowledge about this topic include?	Mainly people's opinions about the topic.		0.748	
7. What should be the source of knowledge of those who study this topic?	The source of knowledge should be mainly in peoples' opinions and ideas.		0.790	
8. Does the answer to this topic depend on perspectives?	Yes. The answer to the question depends on personal perspectives.		0.671	
9. How should one evaluate explanations about this topic?	The most important thing is to check if the explanation matches the reader's view of the topic.		0.756	
10. What is the best way to judge different accounts about this topic?	The best way is to check which account is most reasonable according to the reader's worldview.		0.784	
11. What would a reliable explanation be regarding this topic?	A reliable explanation is one that makes sense according to the reader's personal knowledge.		0.759	
1. Is there an answer to the question of what happened in/to this topic?	There may be multiple right answers but they are not equally right.			0.576
2. Can there be certainty about this topic?	There is never full certainty, but it is possible to improve the degree of certainty.			0.628
3. Is it possible to find out the truth about this topic?	With further investigation we would find out that there is more than one truth but that there are different degrees of truth.			0.776
4. Is there truth about this topic?	Truth can have many interpretations but some interpretations are better than others.			0.618
5. What should the knowledge about this topic be based on?	Mainly on interpretations of data.			0.598
6. What should the knowledge about this topic include?	Mainly theories that explain the topic.			0.576
7. What should be the source of knowledge of those who study this topic?	The source of knowledge should be mainly in how people interpret the evidence that was gathered.			0.610
8. Does the answer to this topic depend on perspectives?	Yes. But by considering multiple perspectives one can form a balanced position.			0.723
9. How should one evaluate explanations about this topic?	The most important thing is to check if the explanation helps improve understanding of what is known about the topic.			0.736
10. What is the best way to judge different accounts about this topic?	The best way is to check which interpretation best explains the available data.			0.688
11. What would a reliable explanation be regarding this topic?	A reliable explanation is one that is based on a theory that explains the phenomena.			0.617
	Cronbach's Alpha:	*0.835*	*0.886*	*0.826*

Note:

ETA scale with the coffee scenario at follow-up measurement in study 3

Scale and factor analysis used and conducted as per: Barzilai, S., & Weinstock, M. (2015). Measuring epistemic thinking within and across topics: A scenario-based approach. *Contemporary Educational Psychology, 42,* 141–158. https://doi.org/10.1016/j.cedpsych.2015.06.006