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Manuscript title: **Why do experts disagree? The development of a taxonomy**

Authors: Deroover K.[1*], Knight S.[1,4], Burke P.[3], Bucher T.[2]
Affiliations: [1]University of Technology Sydney, Transdisciplinary School, NSW, Australia;
[2]University of Newcastle, School of Environmental and Life Sciences, NSW, Australia;
[3] University of Technology Sydney, Business School, NSW, Australia
[4]University of Technology Sydney, Centre for Research on Education in a Digital Society (CREDS), NSW, Australia

*Corresponding author: Kristine Deroover: kristine.deroover@uts.edu.au

Ms Kristine Deroover is a PhD candidate at the Transdisciplinary School at University of Technology Sydney. Her current research aims to develop an understanding of the way people deal with conflicting information on health and nutrition, in order to support people in navigating health information for sustainable decision-making.
https://orcid.org/0000-0003-3879-4187

Dr Simon Knight 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 Knight researches how people learn to navigate uncertainty, disagreement, and evidence, and the mediating role of technology in that. His work has explored the use of data as a form of evidence, and design for learning towards epistemic and ethical reasoning.
https://orcid.org/0000-0003-4837-9446

Dr Paul Burke is Professor in Marketing and Deputy Director of the University of Technology Sydney Centre for Business Intelligence and Data Analytics (BIDA) at UTS:Business. He is an expert in applied and theoretical aspects of choice modelling, experimental design and consumer behaviour.
https://orcid.org/0000-0003-0978-0237

Dr Tamara Bucher is a Food and Consumer Behaviour academic and Head of discipline Food Science and Human Nutrition at The University of Newcastle. Dr Bucher researches nutrition education and environmental influences on food choice.
https://orcid.org/0000-0003-3244-5867

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 under investigated 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

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; Virlee et al., 2020). 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 (Bromme et al., 2015; Dieckmann and Johnson, 2019; Dieckmann et al., 2017; Johnson and Dieckmann, 2018; Thomm et al., 2017; Thomm and Bromme, 2016; Thomm et al., 2015; Kajanne and PirttilA-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, 1962; 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; 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.

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 1**. Further information on the expert sample and interview question outline can be found in **Table 1.** Ethics approval was obtained for this research project [details removed for anonymity in the review process], and all participants provided informed consent for their participation.

[Please insert FIGURE 1]
[Please insert TABLE 1]

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 2.** 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 2** to support the descriptions in the paragraphs below. Further details on the analysis underlining the taxonomy development can be found in **Appendix A** and **B**. A visual representation of the taxonomy is available [for review purposes, see Supplementary file 1, 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.

[Please insert FIGURE 2]
[Please insert Table 2]

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, 1962; 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 particular 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 in particular 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 our 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 actually 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 our 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., 2017).

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).

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 more or less adaptive, emerged from the interviews, along with determinants that may influence these coping strategies, as illustrated with quotes in **Table 3**:

(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.

[Please insert TABLE 3]

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., 2017; 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 multiplistic 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., 2017). More specifically, further investigation of the fine line of productive evaluatism 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.

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 a number of 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).

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.

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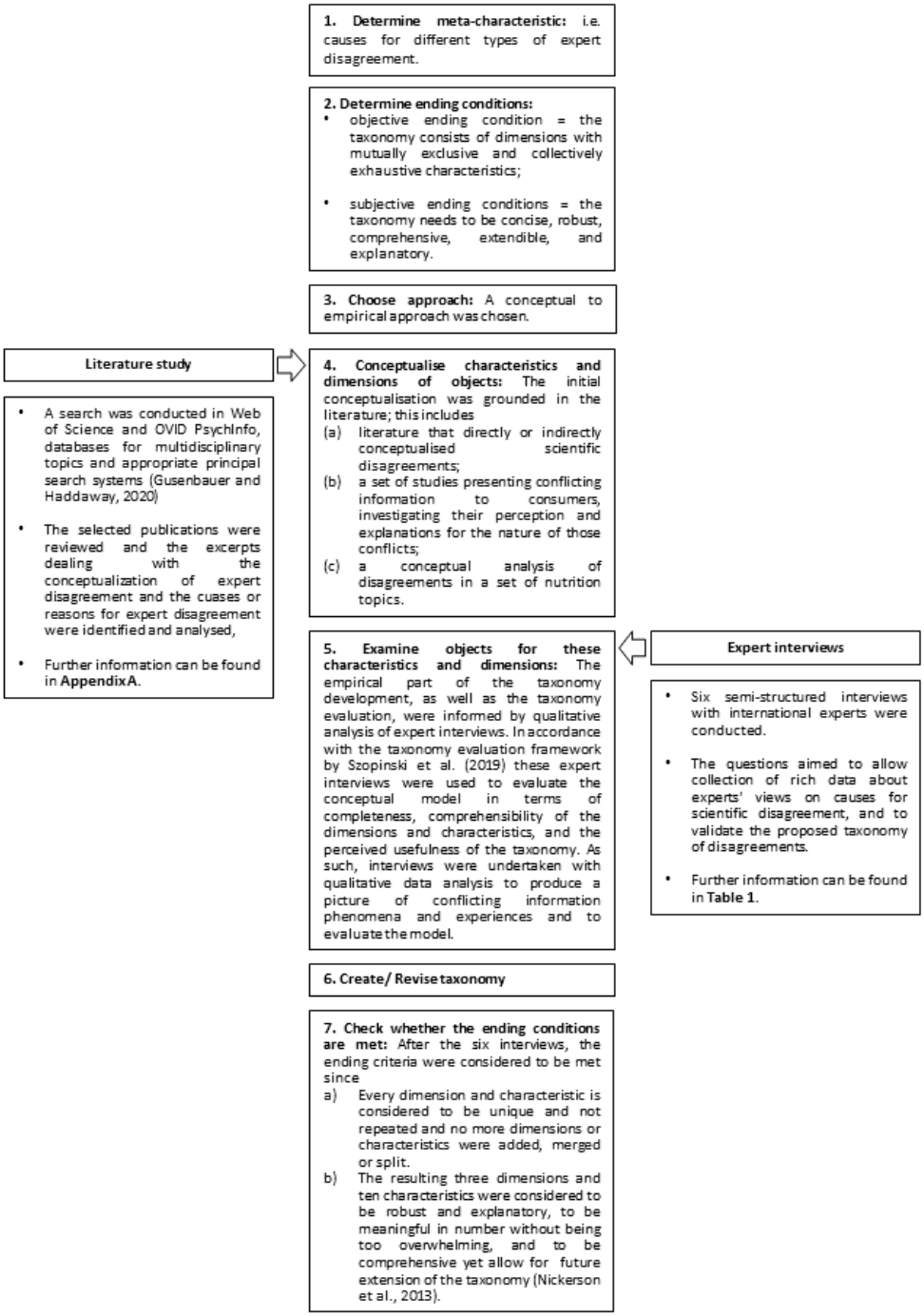

Figure 1. Methods for taxonomy development.

The taxonomy development method by Nickerson et al., (2013), which identifies seven steps, was used and includes an initial conceptualisation grounded in the literature and an empirical part based on expert interviews.

Table 1. 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).

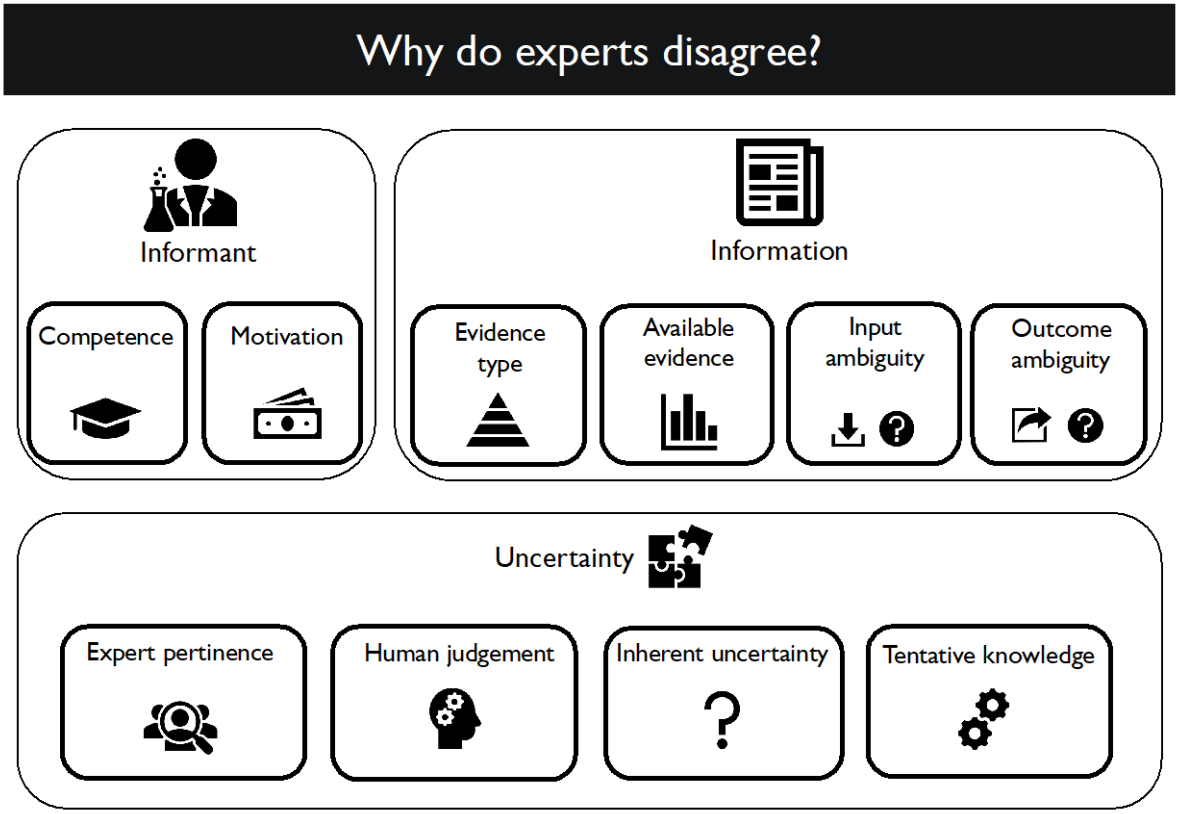

Figure 2. Causes for expert disagreement: ten categories are classed into three groups; Informant-, Information-, and Uncertainty-related causes

Table 2. Quotes and examples from the expert interviews and literature study 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*	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*

	example, whether or not that is something you do to reach a long-term goal." [E3]	*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] "*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]	Expert disagreements may arise when experts use different problem definitions caused by fact-value confusion (Elliott, 2019*; Parkkinen et al., 2017*). *"[…] 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.

Table 3. 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.

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

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., Bucher T. (2022) Why do experts disagree? The development of a taxonomy. *Public Understanding of Science*. xxx

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

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

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

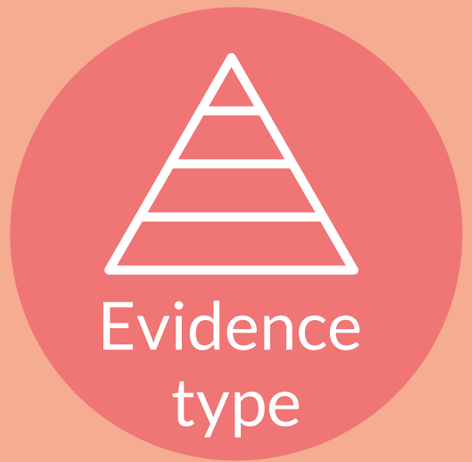
Different levels of strength, quality and rigour of scientific evidence.

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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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.

Available evidence

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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Definition

Ambiguity about the relevance of the input variable

Characteristics

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

Input ambiguity

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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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.

Outcome ambiguity

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 specific question.

Characteristics

Expert pertinence is particularly relevant for complex topics where several fields 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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Definition

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

Characteristics

-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.

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

Human judgement

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. field, 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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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.

Tentative knowledge

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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