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The Explaining Conflicting Scientific Claims (ECSC) Questionnaire: Measuring Laypersons' explanations for conflicts in science

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ABSTRACT

Making personally relevant decisions frequently confronts laypersons with contradictory science-based knowledge claims. Their subjective explanations of why scientists contradict each other on the same topic may influence how they evaluate claims and competing sources. Based on qualitative research, the *Explaining Conflicting Scientific Claims* (*ECSC*) questionnaire was developed to measure individuals' causal assumptions. Two studies report on its dimensionality, reliability, and validity. Factor analyses confirmed that scientific conflicts could be explained in terms of four stable dimensions: *Researchers' Motivation*, *Differences in Research Processes*, *Differences in Researchers' Competence*, and the *Thematic Complexity* of the research subject. The questionnaire's validity was confirmed by the way it sensitively tapped the effect of source information on laypersons' assumptions. Laypersons' explanations were shown to be influenced by beliefs about the nature of knowledge *and* beliefs about the social practice of science. The relevance of these causal assumptions is discussed and possible applications of the ECSC are sketched.

1. Introduction

Nowadays, anybody with the necessary skills and technical facilities can use search engines on the Internet to access information about science-based issues of personal interest. For example, it is easy to find information if you are interested in learning more about climate engineering, about the potential benefits and risks of preventive measures against cancer, or about the nature of matter. Unfortunately, however, most of this information is neither comprehensive nor unambiguous. Instead, you are likely to find contradicting knowledge claims about many scientific topics. Of course, you can reduce the likelihood of encountering contradictory information by confining your search to sources that can be assumed to be competent and unbiased. But even if you confine your focus to scientific information provided by "real" scientists, you will quickly realize that contradictions between different scientists are quite common (see also Bromme, Thomm & Wolf, 2013).

From an epistemological point of view, criticizing each other's knowledge claims is a regular and typical aspect of scientific progress in which scientists continuously put forward knowledge claims that either extend or contradict previous insights (Arbesman, 2012). Philosophers of science (e.g., Popper, 1959) give good reasons why such a process of continually producing refutations constitutes the heart of science. Yet, for a layperson looking up science-based information because she wants to cope with a real-life problem (e.g., deciding about a science-related political issue, deciding for or against a vaccination), merely understanding the general reasons for potential contradictions between scientists is often unsatisfactory. In her situation, the layperson has to consider and reach a final decision on the plausibility of competing knowledge claims. Causal explanatory assumptions allow people to make sense of and accept the conflicting information proposed by scientists. They may help laypersons to evaluate and decide on both the veracity of knowledge claims and the credibility of the experts making them. Particularly when dealing with conflicting science-based information put forward by different experts, laypersons usually lack the specific knowledge to make direct plausibility judgments based on their own understanding. Instead, they have to rely on the testimony of the experts and decide which expert they should finally believe (Bromme, Kienhues, & Porsch, 2010; Keil, 2010). Hence, beliefs about the concrete causes of such contradictions might be relevant, because different causes might imply different strategies for making such plausibility judgments. Such causal, explanatory assumptions held by laypersons are also relevant for research on the public understanding of science and especially on the use of the Internet for laypersons' science understanding (Allchin, 2011; Brossard & Scheufele, 2013).

2. Laypersons' explanations for scientific conflicts

Because conflicts are such a regular and typical aspect of the everyday work of scientists, prior research has examined individuals' understanding of the possibility of scientific conflicts, and/or it has used scientific conflicts to probe individuals' assumptions about the nature of science and scientific knowledge (e.g., Allchin, 2011; Chen et al., 2013; King &

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Kitchener, 1994; Lederman et al., 2013; Thoermer & Sodian, 2002). The investigation of such a *general* understanding has particularly been the focus of studies in developmental psychology (Bromme et al., 2013). In this tradition, both Kuhn (1991) and King and Kitchener (1994) have applied scenarios in which experts put forward contradicting knowledge claims to examine the different stages of cognitive development. Typically, participants, mostly school students and undergraduates, receive competing information put forward by different scientists and are prompted to reason about the controversy. Their responses are finally classified to express different, more or less advanced levels of epistemological stances (e.g., Smith & Wenk, 2006; Thoermer & Sodian, 2002).

Although assumptions about the possibility and origins of conflicts between researchers are understood as part of understanding science, little is known about the specific contents and characteristics of laypersons' explanations for scientific conflicts. To date, most insights regarding individuals' subjective assumptions about reasons for conflicting science-based claims have come from qualitative research. Kajanne and Pirttilä-Backman (1999) ran a large interview-based survey of laypersons' beliefs about the *causes* of contradictions between experts. They reported on their participants' explanations for *why experts may disagree* on a scientific topic, and classified different beliefs about the reasons for disagreement between experts. The authors differentiated between the explanations of experts' disagreement by defining three categories, namely, "general difficulties in obtaining scientific knowledge," "interest-related reasons," and "differences in the caliber and personal background of the expert" (Kajanne & Pirttilä-Backman, 1999, p. 307). Explanations in the first category refer predominantly to methodological aspects leading to the scientific conflict, whereas the second and third categories encompass beliefs about the person of the expert and the social practice of science as causal and influencing determinants of scientific controversies between experts.

Inspired by Kajanne and Pirttilä-Backman (1999) results, we also carried out an interview study to analyze how laypersons reason about and resolve conflicting knowledge claims made by medical experts (Bromme et al., 2013). This not only confirmed the three main categories, but also expanded the distinct beliefs about reasons for scientific conflicts within different categories. Our findings also demonstrated that laypersons consider contextual information when reasoning on expert disagreement. Depending on whether it is *only practitioners* or *only scientists* who contradict each other on evidence for the same medical topic, participants preferred different reasons to explain the conflict.

These studies suggest that laypersons possess realistic and adaptive assumptions about why and how experts may arrive at conflicting science-based knowledge claims (Bromme et al., 2013). However, although qualitative research permits deep and invaluable insights into individuals' ideas, quantitative measures facilitate the exploration, systematic investigation, and description of relationships with further variables and processes. For example: It is interesting to scrutinize the impact of such subjective explanations on the *credibility evaluation* of conflicting science based claims and studying such research questions often requires large samples in order to control for further variables. Hence such a quantitative measure enables the study of diverse and larger samples and thereby enhances the reliability and validity of results (cf. Chen et al., 2013). Therefore, we developed a questionnaire allowing a standardized measurement of laypersons' explanations for scientific conflicts. We expected the instrument to complement prior qualitative research and to extend our insights into and knowledge about the role of subjective explanations when laypersons have to deal with conflicting scientific information.

3. Aims of the present studies

In the following, we present two studies: Study I depicts the development of the instrument and inspects its dimensionality with reference to prior research. We use an exploratory principal component analysis to identify four dimensions reflecting distinct kinds of *reasons* (in the following, the terms *reasons*, *causes*, and *explanations* will be used interchangeably) why scientists come up with conflicting scientific claims.

Study II examines the questionnaire's reliability and validity. To inspect the stability and consistency of its structure, we used data from another sample that had to deal with a different example of a controversial scientific issue. These data were subjected to a confirmatory factor analysis in order to test the dimension structure identified in Study I. Furthermore, we added critical source information about the scientists making the conflicting scientific knowledge claims. Such source information provides some hints regarding possible explanations for why the different scientists came up with opposing views. This enabled us to test whether the ECSC delivers a sensitive measure of individuals' contextually differentiated assumptions.

4. Study I: design and test of the ECSC

The major objective of Study I was to construct a questionnaire permitting a quantitative measurement of laypersons' subjective explanations for science conflicts. We took a concrete scenario of competing expert claims (e.g., Kajanne & Pirttilä-Backman, 1999; King & Kitchener, 1994) and combined its evaluation with answers to a standardized questionnaire presenting various reasons to explain the experts' disagreement. Based on previous qualitative findings, we expected to uncover different dimensions reflecting distinct explanation patterns.

4.1. Design of the ECSC

4.1.1. ECSC scenarios

The scenarios used by King and Kitchener (1994) cover topics taken from different science domains (e.g., history, chemistry) and present contradictory scientific findings put forward by different experts. In the same vein, we created a medical scenario consisting of a short introduction to the topic and the presentation of two conflicting claims by experts. The introduction named the topic, roughly summarized the contradiction, and presented the sources making the knowledge claims. In the present study, both sources were introduced as university scientists and labeled as *university professors*. Subsequently, the contradictory knowledge claims were presented as direct citations of the experts retrieved from Web sites. The scenario read as follows:

There is assumed to be a connection between various factors and the risk of developing arteriosclerosis—the buildup of plaques in the arteries. One of these risk factors—cholesterol—has received a lot of attention in the media. Several scientific studies have investigated the relation between the risk of developing arteriosclerosis and cholesterol levels in the body. The following statements come from the Web sites of two different teaching hospitals. Each was written by a different scientist working at that facility.
One university professor writes: "The results of the studies show that different factors are responsible for developing arteriosclerosis; however, the most important of these factors is cholesterol."
The other university professor writes: "The results of the study show that various factors influence the occurrence of arteriosclerosis; however, cholesterol plays an insignificant role in this."

The claims were presented in balanced order. After reading the scenario, participants answered the standardized questionnaire.

4.1.2. ECSC standardized questionnaire

The initial questionnaire consisted of 35 items. Each item depicted a different cause that might have led to the specific conflict between the scientists. Statements were based on original utterances about the assumed causes of conflict collected in the previous interview study (Bromme et al., 2013). Participants reported how far they considered each statement to be a relevant reason for the disagreement on a