

**DEPICTED EPISTEMOLOGICAL DIMENSIONS IN SCIENCE COVERAGE:
HOW SCIENCE TELEVISION PROGRAMS REPRESENT KNOWLEDGE
OF MOLECULAR MEDICINE.**

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Abstract

Viewers of science television programs need sophisticated epistemological beliefs to better understand the represented scientific knowledge of molecular medicine. Although some research studies measured the different epistemological dimensions of such beliefs of pupils, teachers and adults, no study ever addressed actual media content as representing epistemological dimensions. Furthermore, journalists apply typical depiction styles that are defined here as media frames. The question remains if these frames interact with depicted epistemological dimensions. This is why this paper investigates frames and the coverage of epistemological dimensions in a full sample of German science television programs of the years 2008 and 2009 on molecular medicine ($n = 204$); which is a suitable domain for this research as it is an important new scientific field and at the same time hard to understand by the average recipients. Results of a content analysis identified three frames of molecular medicine that represent typical depiction styles of science journalists. According to the depicted epistemological dimensions of coverage about molecular medicine first insights into the certainty, simplicity, sources and justification of knowledge are presented. Epistemological dimensions significantly interact with the frames of molecular medicine. Findings indicate which journalistic depiction style is presumably able to promote sophisticated epistemological beliefs of recipients the best.

Key words: science communication, media frames, epistemological dimensions, science television programs, molecular medicine

1 SCIENCE REPORTING

Issues related to health and medicine are the highest covered scientific issues by the German mass media, with science coverage increasing in the last decades (Elmer, Badenschier & Wormer 2008).³⁰ Mass media are the most important and sometimes even the only source the general public uses to get informed about issues related to health and medicine, with television (TV) coverage stated as the most frequently used media channel for this kind of information (Wormer 2011).

Thereby, perceptions and knowledge of the mass media audience increasingly depend on the journalistic depiction of medical information stressing specific aspects of an issue while neglecting others. In line with Entman (1993) this process can be referred to as *framing*. The framing approach is often applied by researchers to identify typical journalistic depiction styles of issues (Matthes & Kohring 2008) and

³⁰ For the predominance of medical issues, Wormer (2011) reasons three factors: (1) the high output produced by medical research, (2) the fact that medical issues meet many criteria of the classical theory of news values, (3) the economic aspect as medical issues are perceived to be very important for recipients, leading to higher news media publication rates in times of economic pressure.

to measure effects of these frames on the audience (Guenther et al. 2013). For instance, related to health issues it has been tested if gain- or loss-frames produce higher effects on prevention and detection behaviors of recipients (O’Keefe & Jensen 2008). Studies investigating effects of the media show that recipients are affected by different journalistic depiction styles: Especially medical representations in the media seem to be powerful in affecting medical behavior. Media coverage can be crucial, for instance, increasing participants’ use of complementary and alternative medicine (Bonevski, Wilson & Henry 2008), of vaccination against Human Papilloma Virus (HPV, Hopfer 2012), of breast cancer screenings (Chapman et al. 2005), or decreasing their use of hormone therapy (Haas et al. 2007). Hence, media coverage is perceived to strongly influence public opinion and understanding of medical issues (Wormer 2011). Therefore, media information should be perceived, understood and learned by recipients.

Learning and comprehension are influenced by the epistemological beliefs that individuals gained (Hofer 2001). Epistemological beliefs are an individual’s cognition about the nature of knowledge and knowing (Conley et al. 2004; Kienhues, Bromme & Stahl 2008; Wegner, Weber & Fischer 2012), including epistemological assumptions regarding science and scientific evidence (Hofer & Pintrich 2002). According to Pintrich and Hofer (1997) these beliefs can be distinguished on the basis of four contiguous, empirically supported dimensions. The nature of represented knowledge in science coverage can presumably vary in their depicted epistemological dimensions. Southerland, Sinatra and Matthews (2001) already noted some years ago that epistemological questions underlie many of the controversial issues fundamental to research and practice in science teaching and learning. Although research on epistemological beliefs and their dimensions has expanded and intensified over the past three decades, there are still issues that need to be further developed (Bendixen & Rule 2004). Until now, research on the depiction of epistemological dimensions, especially in science coverage, is widely absent. Since mass media are the main source of medical information for the public, their representation of knowledge and epistemological dimensions should be essentially influential on recipients’ perceptions.

Thereby, information of molecular medicine takes up a leading position as this issue can be seen as *evidence sensitive*, due to the major role of evidence-based medicine in this field (Ruhrmann et al. 2013). For recipients, the topic is hard to understand because of its complexity and abstractness; hence, the audience needs a high amount of explanation given by journalists (Milde & Hoelig 2011); and they need sophisticated epistemological beliefs to follow these explanations. Molecular medicine is an interdisciplinary research field, often involving risks and uncertainty of scientific knowledge (Milde & Hoelig 2011; Ruhrmann et al. 2013). It integrates methods and findings from the fields of genetics, molecular biology, cell biology and biochemistry, and applies them to issues of human medicine (Ganten & Ruckpaul 2007).

Media representations of issues related to medicine and science, like frames of molecular medicine, can probably transmit epistemological beliefs to recipients. However, it is still unclear, (1) in which frames scientific knowledge of molecular medicine is represented, (2) which epistemological dimensions are depicted in the media, and (3) how epistemological dimensions are related to the frames of molecular medicine. Therefore, the main goal of this paper is not only to find answers to these questions, but to identify the journalistic depiction style that is presumably able to promote sophisticated epistemological beliefs of recipients the best.

In the following previous research findings about the representation of scientific knowledge in the media are presented; this is a major area of communication research. To connect this to psychology and education research, epistemological beliefs will be explained and it will be reasoned why the depiction of sophisticated epistemological dimensions can be important. Following this, the research questions of this study are discussed.

2 MEDIA REPRESENTATION OF SCIENTIFIC KNOWLEDGE

One basic characteristic of scientific knowledge is its uncertainty, fallibility and conflicting scientific evidence. The scientific progress is always related to these characteristics. A high amount of previous research investigated representations of scientific knowledge and scientific evidence in the media (Schaefer 2012); however, an investigation of the depiction of epistemological dimensions in the media is still missing, which can be seen as a research gap.

Wormer (2011) pointed out that the media coverage of medical knowledge lacks information about scientific methods, or limitations of scientific results. Stocking (1999) found that representations of scientific evidence differ according to different media and issues: in some cases the media represent scientific results as more certain than they actually are; in other cases media over-represent the uncertainty of research results. Cacciatore et al. (2012, for emerging technologies in U.S. print and online news from 2009 to 2010), Olausson (2009, for climate change in Swedish newspapers from 2004 to 2005) and Dudo, Dunwoody and Scheufele (2011, for nanotechnology in U.S. newspapers from 1988 to 2009) found an absence of scientific uncertainty in the coverage of scientific knowledge. Opposed to this, Zehr (2000) found that the representation of scientific information about climate change is strongly connected to uncertainty in the U.S. popular press from 1986 to 1995. In line with this, Ruhrmann et al. (2013) found that coverage of molecular medicine in science TV programs in 2008 and 2009 mostly focused on scientific uncertainty. A survey with science journalists according to their nanotechnology coverage in Germany showed that journalists widely differ in their representation of scientific evidence according to the aspects of the issue on which they lay their focus; with uncertainty related to the coverage of risky aspects and certainty related to beneficial aspects of nanotechnology (Guenther & Ruhrmann 2013). As can be seen by these results, no clear picture of the representation of scientific evidence appears.

Racine et al. (2010) investigated news articles on neurotechnology identified as research reports published between 1995 and 2004 in major U.S. and U.K. newspaper and found out that less than half of them provided details about research studies like the number of participants or subjects involved as well as the funding sources and the need for replication. They also identified a gap in news media providing relevant explanations of neurotechnologies. The authors assumed that these gaps can have a negative impact on public's understanding and imply that the validity of neurotechnologies is uncontested.

Results indicate that there are different forms in which scientific knowledge is represented in the media. Until now, the connection between the representation of scientific knowledge and epistemological dimensions was not drawn by researchers working in this field.

3 EPISTEMOLOGICAL BELIEFS AND THEIR DISSEMINATION

Currently, *epistemological beliefs* are a target gaining some attention by researchers in psychology and education research (Conley et al. 2004; Kienhues, Bromme & Stahl 2008; Wegner, Weber & Fischer 2012). Both knowledge and epistemological beliefs affect comprehension and learning of people (Hofer & Pintrich 1997).³¹ Personal epistemologies are mostly defined as relatively large, coherent, and stable

³¹ Knowledge can be understood as a dynamic construct that is developed by learners through experience and is open to continual refinement; beliefs can be defined as forms of understanding which may not have an empirical basis at all and are more firmly structured, static constructs which are acquired through significant episodes of experience (Southerland, Sinatra & Matthews 2001).

cognitive structures, either developmental stages or beliefs (Louca et al. 2004).³² Hofer (2010) posits: epistemological beliefs are “an identifiable set of dimensions of beliefs about knowledge and knowing, organized as theories, progressing in reasonably predictable directions, activated in context, operating both cognitively and metacognitively” (Hofer 2010, p. 98).

Individuals develop epistemological beliefs. This process begins with an objectivist, dualistic view of certain and stable knowledge; it is followed by a multiplistic view in which individuals begin to recognize that knowledge is more complex, relativistic, uncertain and changeable (Kienhues, Bromme & Stahl 2008). Hofer (2010) describes this movement from a position of dualism, in which individuals view knowledge as right or wrong, to a relativistic stance in which all opinions appear equally valid. Further, Hofer (2001) found that a period of subjectivity is typically followed by the ability to acknowledge the relative merits of different points of view and to begin to distinguish the role that evidence plays in supporting one’s position. Naive epistemological beliefs can be identified as a major impediment to the achievement of sophistication in science education (e.g. Hofer 2000).

Hofer and Pintrich (1997) distinguish epistemological beliefs on the basis of four contiguous, empirically supported dimensions (shown in Figure 1), which are the core of many studies (e.g. Hofer 2001; Hofer & Pintrich 2002; Hofer 2004a)

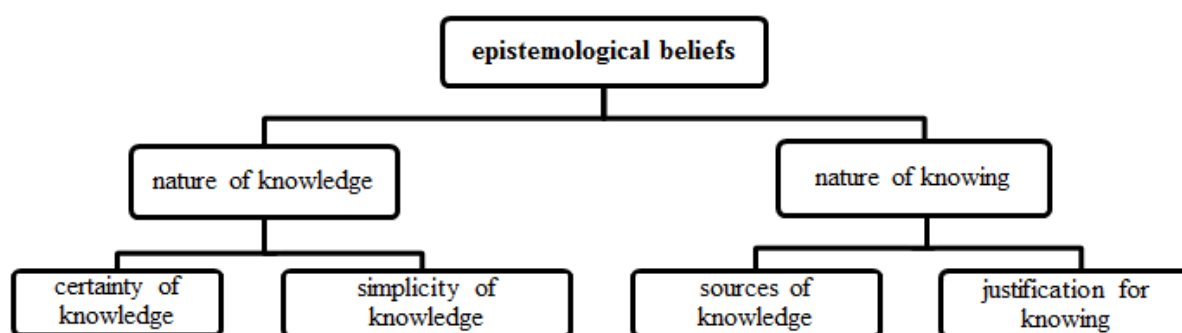


Figure 1: Model of epistemological beliefs by Hofer and Pintrich (1997)

The first dimension is the *certainty of knowledge*, its perceived stability and strength, its insecurity and tentativeness. This dimension represents the degree to which knowledge is seen as fixed and absolute true or temporary, growing, changing and constantly evolving. For instance, scientific knowledge of research in the field of molecular medicine can be perceived as rather certain or rather uncertain. The second dimension refers to the structure and *simplicity of knowledge*. Results of molecular medicine research can either be stored in mind as single data and facts or as embedded in larger theoretical and methodological contexts. The first two dimensions of epistemological beliefs represent the nature of knowledge (what one believes knowledge to be); the following two dimensions represent the nature or the process of knowing (how one comes to know). So does the third dimension with respect to *the source of knowledge*. Knowledge can be acquired from one external source like an expert (e.g. politician) or internally protected by the juxtaposition of several sources like studies and scientific experts. The fourth dimension, *justification for knowing*, deals with the fact that knowledge can either be justified scientifically or non-scientifically; and asks in which way underlying data or information is weighted. According to Conley et al. (2004) the justification dimension is defined in ways people use evidence

³² There are of course other concepts e.g. Louca et al. (2004) view personal epistemologies as made up of finer grained cognitive resources whose activation depends sensitively on their context.

and evaluate claims. They make clear that in the domain of science, “justification is primarily concerned with the role of experiments and the use of data to support arguments” (Conley et al. 2004, p. 190). For instance, in the field of molecular medicine knowledge can either be seen as closely related to science and scientific results supporting arguments, or related to opinions of single persons without data verifying arguments.

Epistemological beliefs are multidimensional and interrelated (Hofer 2004b). People develop different epistemological beliefs; hence, people gain different subjective theories and ideas about the knowledge and the acquisition of knowledge (Hofer & Pintrich 1997). Individuals can simultaneously hold both sophisticated and naive views on different dimensions of epistemological beliefs (Kienhues, Bromme & Stahl 2008). Buehl, Alexander and Murphy (2002) found that beliefs are multidimensional and differ by domain, but beliefs about knowledge are also, to some degree, general. In sum, it can be expected that epistemological beliefs are domain-specific and are largely domain general (Hofer 2010).³³

There exists a clear positive correlation between age and development of epistemological beliefs (Hofer & Pintrich 1997). Research showed epistemological beliefs significantly related to academic performance (Hofer 2000), conceptual change (Mason 2003) and text comprehension (Schommer, Crouse & Rhodes 1992). What recipients learn is strongly influenced by what kind of epistemological beliefs they gained and by how information is presented to them. Current findings in education research show that sophisticated epistemological beliefs can lead to positive learning effects, and positive effects on handling, acquisition and use of personal knowledge (e.g. Wegner, Weber & Fischer 2012). Participants viewing knowledge as a simple collection of isolated facts employed less sophisticated strategies when processing a text, and demonstrated a lower comprehension than participants viewing knowledge as more complex (Schommer, Crouse & Rhodes 1992). Participants who believe in the changing nature of knowledge were more likely to accept conflicting evidence to their prior conceptions and to change them than those not believing in the changing nature of knowledge (Mason 2003). A study by Mason and Boscolo (2004) found that epistemological understanding also affects the conceptual understanding and critical interpretation of a scientific controversy.

Most research found that the attainment of a general high sophisticated, critically aware stance toward knowledge is not the standard in adulthood. Evidence gathered to date suggests that most individuals do not achieve a level of epistemological understanding allowing a level of reflective judgment (Hofer 2001). In sum, one cannot assume that the average recipient of the adult target group of a science TV program has already developed sophisticated epistemological beliefs. Such beliefs should be continually cultivated and encouraged, in general and especially by the media. According to information related to health and medicine, science TV programs can help individuals to develop sophisticated epistemological beliefs. “Monitoring our own understanding of the complexity of problems, the certainty and limits of knowledge, and the evaluation of evidence enables the critical thinking necessary to solve the most pressing problems we may face as individuals and as a society” (Hofer 2001, p. 365).

Presented epistemological dimensions in science reporting may influence epistemological beliefs of recipients; this is a new field of research already receiving some evidence. First empirical studies in education research and psychology demonstrated that student’s epistemological beliefs are significantly influenced by mediation styles and epistemological dimensions they get presented by their lecturers (Staub & Stern 2002, see also Hofer 2004a). Research by Gill, Ashton und Algina (2004), and Kienhues, Bromme and Stahl (2008) show that even short media features can cause a change of epistemological

³³ Hofer (2010) analyzes the empirical work and comes to the conclusion that individuals can be tested about general epistemological beliefs, about their disciplinary perspective on beliefs, and about their discipline-specific beliefs. It is still unclear if these strands work together and interact cognitively.

beliefs from naive to more sophisticated. In more detail, Gill, Ashton und Algina (2004) investigated on pre-service teachers of mathematics and found that those exposed to a refutational text, e.g. including causal arguments and multiple sources, were more likely to change and develop epistemological beliefs than those exposed to a non-refutational standard text reflecting typical textbook writing. Kienhues, Bromme and Stahl (2008) showed in experiments that students receiving a refutational epistemological instruction were more likely to focus on uncertainty and difficulties in DNA fingerprinting, and more likely to change their epistemological beliefs towards a more sophisticated view, whereas students receiving an informational instruction were in turn more likely to focus on a certain and stable view, changing towards a more naive standpoint. Both studies provide indications that a unique reception can change epistemological beliefs (at least domain-specific and short-term).

Research in educational psychology supports the importance of promoting more sophisticated epistemological beliefs and sees this as a major contribution to learning and education (Bendixen & Rule 2004). Recipients with naive epistemological beliefs may less understand and interpret facts according to complex scientific information. Hofer (2001) pointed out that epistemological development is an aim of education. Educational TV like science TV programs can foster epistemological development. Wormer (2011) postulated that the role of journalists may be expanded to include training the public on how to understand medical information.

4 RESEARCH AIMS AND RESEARCH QUESTIONS

This study analyzes traditional frames of molecular medicine to get an insight into media's typical representations of scientific knowledge. In a second step and according to depicted epistemological dimensions in the media, it is under investigation how certain (certainty of knowledge), simple (simplicity of knowledge), proved (sources of knowledge) and justified (justification for knowing) knowledge of molecular medicine is represented. Lastly, this study investigates the relationship between media frames and depicted epistemological dimensions to identify media depiction styles which are presumably able to promote sophisticated epistemological beliefs of recipients the best. Hence, the research questions are:

RQ1: What frames of molecular medicine can be identified in the media?

RQ2: Which epistemological dimensions are represented in the coverage of scientific knowledge about molecular medicine in the media?

RQ3: How do media frames of molecular medicine relate to depicted epistemological dimensions?

5 METHOD

5.1 Sample

A comprehensive content analysis is the best method to answer the proposed research questions. As shown before, the general public is especially relying to TV as a main source of issues related to health and medicine, in which molecular medicine takes on a leading position as an issue which is hard to understand by recipients. That is why recipients mainly depend on the journalistic way to present this issue in the media. Science TV programs cover issues such as molecular medicine in more detail than general news; this is why such programs are important for this investigation. The sample of TV clips ($n = 204$) was obtained through a survey of every clip of molecular medicine broadcast by ten public and

private German science TV programs, between January 2008 and December 2009.³⁴ A list of keywords, developed with the help of the definition from Ganten and Ruckpaul (2007), was used to identify relevant TV clips. The investigated TV clips represent a full sample of coverage about molecular medicine in German science programs.³⁵

5.2 Data collection

A codebook measured variables important to answer the research question; therefore, it measured (1) variables with reference to the framing analysis, and (2) variables with reference to depicted epistemological dimensions. Epistemological beliefs of people can change over time; this is a generally accepted fact in research (Kienhues, Bromme & Stahl 2008). It can be assumed that a change of epistemological beliefs of recipients through the media can mainly be affected by a long term intervention. An analysis of media frames can be used in order to identify the typical patterns of science coverage over a certain period of time. To identify typical patterns of science coverage on an evidence-sensitive issue such as molecular medicine, an analysis of *media frames* according to Entman (1993) was performed. This method was already proved in previous studies investigating typical representations of science in general and for science TV coverage in particular (Matthes & Kohring 2008; Milde & Ruhrmann 2006).³⁶ Media frames are defined as media representations emphasizing certain aspects of an issue, while at the same time others are neglected. According to Entman (1993) there are four frame elements constituting a frame: (1) problem definition, (2) causal attribution, (3) (moral) evaluation, and (4) treatment recommendation. For instance, a TV clip about molecular medicine can first show a recent problem of cancer research, can then explain why this problem occurs, how it can be solved and at the same time give judgments on new developments in research. In a first series of studies, single frame elements are operationalized in content analysis and later on cluster-analyzed to identify media frames (Matthes & Kohring 2008, Milde & Ruhrmann 2006, see also Guenther et al. 2013). A frame is a “certain pattern in a given text that is composed of several elements” (Matthes & Kohring 2008, p. 263); cluster analysis increases the reliability of content analyses since frames are not predefined but are determined by variables that are collected empirically. An analysis of media frames is suitable for the present study due to the fact that (1) typical depiction styles of science coverage can be compared to (2) depicted epistemological dimensions. The four frame elements by Entman (1993) were operationalized as follows (see also Donk et al. 2012, Matthes & Kohring 2008, Milde & Ruhrmann 2006). To analyze *problem definition* the content analysis coded the relevant actors and central issues according to every TV clip. Problem definition refers to a central substantive aspect to which at least one actor makes a statement. The *causal attribution* identifies the causes and reasons for the presented problems. This includes

³⁴ We selected German science TV programs broadcasted by the public networks ARD, ZDF, ARD-offshoot regional channels (BR, MDR, SWR, WDR) and 3sat. The only private channel in the sample was RTL2, since other private channels had no relevant material. TV clips of the sample are individual clips without moderator comments. A definition of molecular medicine helped to find suitable TV clips: Molecular medicine is an interdisciplinary research field integrating methods and findings from genetics, molecular biology, cell biology and biochemistry, and applies them to issues of human medicine (Ganten & Ruckpaul 2007).

³⁵ Seven trained coders worked on the content analysis. Reliability was tested on 20 clips of the sample material and gained results were satisfactory. Inter-coder reliability was determined by Cohen's kappa with $K = 0.98$ for formal variables, $K = 0.49$ for the variables with reference to depicted epistemological dimensions and $K = 0.52$ for variables with reference to the frame elements. The value of the formal variables represents a very good agreement and the value for variables with reference to the frame elements and depicted epistemological dimensions can be regarded as acceptable or moderate due to the high number of coders and the very complex codebook (Wirtz & Caspar 2004).

³⁶ For a critical discussion of this approach, see Scheufele and Scheufele (2010).

characteristics or roles of occurring actors and their respective arguments. For this frame element the content analysis measured attributions of responsibility and their reasons. In addition, it measured benefit and risk assessments, as well as responsible actors for the problems. (*Moral Evaluation* deals with valued statements and moral classifications of problems. For our purpose, the content analysis was interested in the tenor of judgments. A *treatment recommendation* is formulated by journalists either related to persons or situations according to the problem definition that has been established before. With the use of specific statements journalists can show how to solve a given problem. This element was operationalized in terms of represented demands and solutions, as well as the tenor of future prospects.

To measure *epistemological dimensions* represented in science media about molecular medicine, the codebook defined variables with respect to every dimension of epistemological beliefs (Hofer & Pintrich 1997). Thus, for the *certainty of knowledge* it was measured if molecular medical research results were presented as rather certain or uncertain. A certain representation of knowledge of molecular medicine is given when research results are represented as absolute and unequivocally (Kienhues, Bromme & Stahl 2008). An uncertain representation of knowledge of molecular medicine is given when the TV clip mentions that the results of a study are tentative, conflicting, against predictions of a theory or evidence for existing research gaps. For *simplicity of knowledge* it was collected if TV clips represented conflicting results or controversies of molecular medicine or simple statements representing one direction of argumentation. Conflicting results are contradictory research results; for instance, two scientists have different conclusions about the effectiveness or applicability of a form of molecular therapy against breast cancer. Controversy means intra-scientific, research-related disagreement between at least two actors (Gill, Ashton & Algina 2004). *Source of knowledge* was identified via occurring actors who make statements about issues of molecular medicine. An actor is a person who visually appears in the clip and is expressed in the original sound or is explicitly addressed via the voice-over information. *Justification for knowing* is investigated with the help of a category measuring whether knowledge of molecular medicine is represented in a non-scientific way (e.g. opinions) or justified by empirical data (e.g. studies). For instance, when a scientist relies on results produced by an empirical study, his knowledge is justified with empirical data. In contrast to this, a patient sometimes only talks about her or his feelings; in this case knowledge is justified non-scientifically. Variables with reference to depicted epistemological dimensions were collected for every TV clip separately. A systematic study of such dimensions is not yet available for science media coverage in general or science TV coverage in particular.

5.3 Data analyses

To determine the media frames, the variables with reference to the frame elements, which were collected dichotomously, went into a hierarchical cluster analysis. "The aim of this analysis is the grouping of [TV clips] to specific clusters with high differences between the clusters and low differences within a cluster" (Matthes & Kohring 2008, p. 264). We used Ward method for binary variables, because this procedure is considered as a good algorithm on grouping variables, the measure of distance was the squared Euclidean distance; both Ward method and Euclidian distance are among the most common measures in cluster analyses (Morey, Blashfield & Skinner 1983; Backhaus et al. 2008). In order to assess the homogeneity of clusters in this study, the F- and t-values were analyzed.³⁷ The clusters are internally homogeneous (Table 1).

³⁷ The smaller the F-value, the smaller is the variance of the variables within the cluster in comparison to the reference population; F-values should be smaller than 1. The t-values are important for cluster interpretation; with positive t-values indicating an over-representation of the variable in the cluster (Backhaus et al. 2008).

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	t-values			F-values		
	New scientific procedures	Reporting of basic research	Critical reflection on current scientific deficits	New scientific procedures	Reporting of basic research	Critical reflection on current scientific deficits
<i>problem definition</i>						
Genetic diseases	-.03	-.50	.47	.96	.23	1.28
Viral diseases	-.28	-.08	.63	-.11	.78	2.40
Applications of mol. medicine	.17	-.07	-.29	1.26	.89	.45
Therapeutic options	.31	-.17	-.47	1.41	.69	.00
Basic research findings	-.25	.86	-.18	.57	1.53	.70
Scientists as actors	.41	-1.10	.05	.47	.73	.96
Medical doctors & patients as actors	.22	-.66	.08	1.02	.35	1.03
Politics & economists as actors	.18	-.26	-.15	1.45	.25	.57
Interest groups as actors	.01	-.13	.08	1.04	.45	1.36
<i>causal attribution</i>						
Benefits	.33	-.06	-.61	.27	1.13	1.77
Scientists responsible for benefits	.46	-.19	-.75	.84	.95	.34
No scientist responsible for benefits	-.01	-.24	.22	.96	.00	1.80
Risks	.10	-.64	.31	.90	1.20	.62
Scientists responsible for risks	.08	-.13	-.06	1.21	.66	.85
No scientist responsible for risks	-.07	-.23	.33	.70	.00	2.24
<i>(moral) evaluation</i>						
Pos. judgments	.45	-.24	-.70	.40	1.17	1.11
Neg. judgments	.10	-.81	.43	.97	.49	.74
<i>treatment recommendation</i>						
Demands	.07	-.38	.14	1.14	.16	1.26
Solutions	.31	-.46	-.25	.71	1.08	1.10
Pos. future prospects	.56	-.42	-.78	.80	.74	.21
Neg. future prospects	-.02	-.52	.46	.97	.00	1.44
N	107	43	54	107	43	54

Table 1: t-values und F-values of the three clusters

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Table 2: Means of the variables within the three clusters

	New scientific procedures	Reporting of basic research	Critical reflection on current scientific deficits
<i>problem definition</i>			
Genetic diseases	.25	.05	.48
Viral diseases	.01	.07	.28
Applications of mol. Medicine	.26	.16	.07
Therapeutic options	.31	.12	.00
Basic research findings	.10	.56	.13
Scientists as actors	.89	.19	.72
Medical doctors & patients as actors	.53	.09	.46
Politics & economists as actors	.16	.02	.06
Interest groups as actors	.06	.02	.07
<i>causal attribution</i>			
Benefits	.96	.81	.61
Scientists responsible for benefits	.70	.37	.09
No scientist responsible for benefits	.06	.00	.11
Risks	.76	.42	.85
Scientists responsible for risks	.14	.07	.09
No scientist responsible for risks	.04	.00	.13
<i>(moral) evaluation</i>			
Pos. judgments	.91	.58	.37
Neg. judgments	.60	.14	.76
<i>treatment recommendation</i>			
Demands	.20	.02	.22
Solutions	.79	.42	.52
Pos. future prospects	.73	.23	.06
Neg. future prospects	.21	.00	.41
N	107	43	54

Results of the cluster analysis revealed the formation of three clusters, which are defined as media frames. This decision was indicated by the elbow criterion (Backhaus et al. 2008). Other cluster solutions were considered; however, they did not implicate a meaningful improvement of cluster solution.³⁸ For interpretation of the frame, mean values were calculated according to every single variable (Table 2). Due to the explorative character of the cluster analysis and to determine the quality of the clusters, a discriminant analysis was performed subsequently. This analysis is used for “validating structures of patterns and is therefore suitable for assessing the quality of a cluster solution” (Donk et al. 2012, p. 15). The frame variables all significantly contribute to the formation and separation of clusters (Backhaus et al. 2008). Agreement is 95 percent (for a similar approach see Donk et al. 2012, Guenther et al. 2013); and thus, can be considered as good cluster solution.

To get an insight into the representation of epistemological dimensions in science TV, the variables with reference to the dimensions were analyzed descriptively. To measure the relationship between the typical depiction styles of science coverage (frames) and depicted epistemological dimensions group comparisons were performed using chi-square tests. We gained the following results:

6 RESULTS

The cluster analysis according to Entman’s frame elements (1993) revealed two complete frames and one incomplete frame.³⁹ The answer to Research Question 1 is that three frames represent the typical depiction styles of molecular medicine in science TV programs. To illustrate the frames, a prototype according to every cluster is also presented. Clusters have been named after the unique characteristics of every frame.

(Complete) Frame 1 (n = 107; 52%): New scientific procedures

The frame predominantly represents new discoveries, procedures and methods according to applications (26%) and therapeutic options (31%) in the field of molecular medicine. Mainly scientists (89%) are the actors that occur; with medical doctors and patients (53%) as the second biggest group of actors. Less represented are political and economic actors like stakeholders from industry (16%). According to new discoveries of molecular medicine more benefits (96%) than risks (76%) are shown. Responsible actors for these benefits are mainly scientists (70%). As a result of this, judgments given in this frame are far more positive (91%) than negative (60%) with future prospects given also mostly positive (73%). A variety of solutions through these new molecular medical procedures and methods are demonstrated (79%).

One prototype of this frame is a TV clip representing nanotechnology as a new procedure in cancer therapy. The technology is introduced as an improvement towards the weakness of other therapeutic options. Without side effects so far, nanotechnology can help to destroy brain tumors. The new scientific technology developed by researchers did already help some patients. Recommendations for the future

³⁸ When considering the elbow criterion, the squares of error sums are relevant. Grouping should be stopped at the point where the *biggest step* according to heterogeneity dimensions appears (Backhaus et al. 2008). The heterogeneity values of the analysis are as follows: 516 (five clusters), 540 (four clusters), 576 (three clusters), 621 (two clusters). Until the third cluster solution the coefficients rise continuously in differences from 20 to 25. From four- to three-cluster solution the difference is 36, then 45. Therefore, the three-cluster solution was chosen.

³⁹ Frames can be complete or incomplete. Complete frames name relevant variables to at least two of the frame elements given by Entman (1993). Incomplete frames are also referred to as *non-frames* and are still a relevant and common journalistic depiction style.

are given: Due to first promising results, nanotechnology cancer therapy shall further be developed for other types of cancer.

(Incomplete) Frame 2 (n = 43; 21%): Reporting of basic research

This frame represents basic research findings of molecular medicine (56%). Other thematic aspects are not taken into account in this frame; furthermore, this depiction style can exist without a high amount of occurring actors. It corresponds to a classic educational film, an explanatory TV clip. If this frame represents judgments then they are slightly more positive (58%) than negative (14%); however, judgments in this frame are rare. As the t-values reveal (Table 1), this coverage type contains only one frame element, namely the problem definition.

One prototype is a TV clip giving a basic understanding of genes, e.g. what they are, how they work and what current research in this area offers the public. The tone of the sample clip is neutral, without judgments or evaluations of risks or benefits. Clips such as this give a purely descriptive overview of scientific facts.

(Complete) Frame 3 (n = 54; 27%): Critical reflection on current scientific deficits

The third frame focuses on health problems: genetic (48%) and viral diseases (28%). Researchers (72%) are occurring quite frequent, as well as medical doctors and patients (46%). Less frequently interest groups (7%) appear in the clips. In contrast to the first frame, risks (85%) are predominantly addressed in this frame; however, scientists are not responsible for these risks (13%). As a result of this, judgments of these current research gaps and methods are generally more negative (76%) than positive (37%), with future prospects also more negative (41%) than positive (6%). There are some demands formulated (22%).

One prototype of this frame is a TV clip documenting a case study of Alzheimer's disease. This clip works with a woman discussing how she deals with her disease and how she interacts with her medical team. So far, no therapy helped her, or any other person suffering from Alzheimer. That is why the disease offers a high risk for the individual. The given judgments are negative and there are current scientific deficits depicted. Future prospects are presented negatively as well, as it is not sure how to best help the woman with her disease.

Research Question 2 asked which of the epistemological dimensions are represented in the coverage of knowledge of molecular medicine in the media. As far as we know, this is the first time epistemological dimensions are investigated in the media content. Single epistemological dimensions are depicted as follows:

Dimension 1 – Certainty of knowledge: As the frequencies show, science TV programs on molecular medicine rarely present scientific research findings as exclusively certain (7%). However, in almost one third of sample TV clips (30%) the scientific certainty or uncertainty of molecular medical findings is not addressed. But, the majority of the reports explicitly and exclusively presents research findings as uncertain (45%) or addresses certain and uncertain knowledge at the same time (17%).

Dimension 2 – Simplicity of knowledge: In about two-thirds of the sample TV clips (71%) knowledge of molecular medicine is represented as very simple; thus, neither scientific controversies nor conflicting scientific results are depicted. Only one fifth of the TV clips on molecular medicine (22%) shows either scientific controversies or conflicting scientific results. In a few cases (7%) even both are represented. All in all, controversial content is depicted in 30 percent of the TV clips only; thus, knowledge of molecular medicine is generally represented as rather simple.

Dimension 3 – Source of knowledge: In a fifth of all sample clips (21%) only one actor occurs as source of knowledge of molecular medicine and in about the same number of TV clips (22%), however, no

source of knowledge is represented. In more than half (58%) of the sample TV clips more than one source is depicted. This implies that science journalists quite frequently use multiple sources to show different perspectives on issues of molecular medicine. Thereby, as dimension 2 showed, they rarely use these sources to create controversies.

Dimension 4 – Justification for knowing: In about one third of the TV clips (40%) knowledge of molecular medicine is represented as scientifically justified but in almost as many clips (39%) there is no justification at all. Remaining clips of molecular medicine (21%) justify the presented knowledge through opinions or experiences of scientific and non-scientific experts. It can be concluded that knowledge of molecular medicine is only partially depicted as empirically justified.

Research Question 3 is interested in the correlation between media frames of molecular medicine and depicted epistemological dimensions. As shown in Table 3 the frames of science reporting differ significantly according to the depicted epistemological dimensions except for dimension 2 (structure of knowledge).

Table 3: Relationship of depicted epistemological dimensions and frames of molecular medicine (in percent)

	New scientific procedures	Reporting of basic research	Critical reflection on current scientific deficits
<i>Epistemological dimension 1 (certainty of knowledge)**</i>			
No uncertainty and certainty addressed	10.8	11.3	8.8
Certainty addressed	4.5	1.0	1.5
Uncertainty addressed	37.3	8.8	16.2
<i>Epistemological dimension 2 (simplicity of knowledge)</i>			
No controversy or conflicting results	35.8	15.2	19.1
Controversy or conflicting results	12.7	3.4	6.4
Controversy and conflicting results	3.9	2.5	1.0
<i>Epistemological dimension 3 (sources of knowledge)***</i>			
No source	.00	16.2	4.4
One source	11.3	2.5	7.4
More than one source	41.2	2.5	14.7
<i>Epistemological dimension 4 (justification for knowing)***</i>			
No justification	11.3	16.7	11.3
Non-scientific justification	13.2	1.5	6.4
Scientific justification	27.9	2.9	8.8
Number of TV clips	107	43	54

high significant ($p < 0.01$) * highly significant ($p < 0.001$)

Compared to the other frames, frame 1 “New scientific procedures” deals significantly more often with the uncertainty of molecular medical research results ($\chi^2 = 15.93$, $df = 4$, $p < 0.01$). Represented are applications and therapeutic options with reference to their tentativeness; but nevertheless they are evaluated highly positive. Furthermore, in comparison to all other frames in this frame the certainty of molecular medical knowledge is emphasized the most often. Frame 2, “Reporting of basic research”, however, the most often neither represents certainty nor uncertainty. Less frequently than in frame 1 “New scientific procedures” the certainty or uncertainty of molecular medical research findings are addressed in frame 3 “Critical reflection on current scientific deficits”.

According to the simplicity of knowledge no statistically significant differences appeared. At this point in time it should be noted that mostly no controversy or conflicting results of molecular medicine are discussed in the TV clips at all. If they occur, they most frequently seem to be part of frame 1 “New scientific procedures”, and least likely to be part of frame 2 “Reporting of basic research”.

In every TV clip of the frame “New scientific procedures” at least one source of knowledge of molecular medicine occurs. This frame is identified to show the most frequently different actors as sources, while at the same time the frame “Reporting of basic research” most often shows no sources at all; this difference is highly significant ($\chi^2 = 114.89$, $df = 4$, $p < 0.001$). Frame 3 “Critical reflection on current scientific deficits” takes a middle position.

There are highly significant differences between the frames ($\chi^2 = 43.99$, $df = 4$, $p < 0.001$) also with respect to the fourth dimension (justification for knowing). In Frame 1 “New scientific procedures” knowledge of molecular medicine is represented the most frequently as scientifically justified and the least frequent non-scientifically justified or not justified at all. Depiction type 2 “Reporting of basic research” rarely justifies represented knowledge of molecular medicine. Slightly more common knowledge of molecular medicine is represented as scientifically justified in frame 3 “Critical reflection on current scientific deficits”.

In the following section, identified results are interpreted and discussed.

7 DISCUSSION

Dentzer (2009) suggested that journalists' reporting on health care influences behavior of patients. She believes public health messages from journalists are inevitably inadequate or distorted when they ignore complexities or fail to provide context. She demands that the news media should become more knowledgeable in fully delivering all scientific details for the public. Therefore, the general public needs an understanding of medical studies and statistics (Dentzer 2009).

Models such as “scientific literacy” and “public understanding of science” are quite common among communication researchers; with “public engagement” recently developed in view of the weakness of former models to improve the complex relationship between the scientific field and the public (Kurath & Gisler 2009). To be literate, understand and participate, the lay audience needs to understand scientific knowledge; however, the promotion of sophisticated epistemological beliefs may be an appropriate solution to knowledge production. To understand concepts such as scientific evidence, uncertainty or tentativeness of research finding of molecular medicine, recipients in general need at least domain-specific sophisticated epistemological beliefs. Health-related issues like molecular medicine in average are not easy to understand. In TV representations, the audience hears about stem cell research and genetic research, cloning and tissue engineering; with most recipients needing an understanding of scientific knowledge, research results, methods or scientific conflicts to keep the information of the clip in mind. This is especially true for research results in nano- or biological technologies that do not directly

affect the everyday lives of many; recipients need sophisticated epistemological beliefs to understand depicted scientific knowledge.

Kienhues, Bromme and Stahl (2008) already advised teachers to always talk about uncertainty and controversies about issues to avoid a presentation of knowledge as certain, which would presumably not promote sophisticated epistemological beliefs of learners. In mass media's science reporting some basic statistical and methodological information should always be communicated (see also Wormer 2011). This should be one goal of high-quality science reporting on TV. It is important to promote sophisticated epistemological beliefs due to the recipient's need to take a *sophisticated standpoint* in a knowledge society (Kienhues, Bromme & Stahl 2008, p. 546). A certain level of sophisticated epistemological beliefs is necessary for recipients, but the public only gradually learns about scientific knowledge, uncertainty or scientific evidence. This level can probably be promoted by the mass media; it refers to a basic education of sophisticated statistical and methodological information.

This study detected three frames to represent the typical depiction styles of molecular medicine in science TV programs. Mostly new discoveries, procedures and methods of molecular medicine with scientists, medical doctors and patients as occurring actors are depicted in the biggest frame "New scientific procedures". It predominantly covers benefits of this discoveries, procedures and methods; with a positive tenor and positive future prospects. This frame opens solutions according to problems in the field of molecular medicine. The second frame was characterized by its neutral tenor about facts of molecular medicine and the absence of any occurring actors. This type of coverage was identified as classic educational film, but at the same time as an incomplete way to depict knowledge of molecular medicine. Lastly, the third frame represented some critical reflections on current deficits of molecular medicine, in which risks and disadvantages are predominantly shown with negative judgments and future prospects. Hence, there is also a criticized tenor in the science media coverage about issues of molecular medicine.

This study of depicted epistemological dimensions in science TV programs revealed some deficiencies, but also beneficial points. At first, the vast majority of sample TV clips on molecular medicine reports explicitly the scientific uncertainty of knowledge. Knowledge is not represented as naive or something absolute or represented as universal truth (certainty of knowledge). It is often explicitly mentioned in a depiction in which the results of research in molecular medicine are represented as preliminary and uncertain. This should presumably encourage recipients to build more sophisticated epistemological beliefs. Furthermore, mainly multiple sources and thus different perspectives are represented (sources of knowledge), with scientific actors occurring most frequently in the sample TV clips. Highly critical is the aspect that scientific controversy and conflicting scientific results are only rarely represented in clips of molecular medicine. Occurring actors seldom show counterpoint positions. Therefore, knowledge of molecular medicine is covered in a more simple way (simplicity of knowledge). Furthermore, knowledge of molecular medicine is rarely justified scientifically or empirically (justification for knowing). These latter representation features are presumably not suitable to promote more sophisticated epistemological beliefs of the recipient.

Based on the results, we assume that knowledge of molecular medicine should not be reported as it was found in frame 2 "Reporting of basic research" and frame 3 "Critical reflection on current scientific deficits". Although depiction style 3 critically discussed current practices and diseases, there is only rare depiction of the tentative nature of knowledge, especially controversial positions and empirical data are less frequently reported. A representation like that in frame 2 should be entirely avoided. This depiction style is no frame in the proper sense and similar to a classic textbook representation of an issue. Topics covered here are represented rather neutrally because neither certainty nor uncertainty is addressed. There are no controversial positions shown and knowledge is usually represented without sources and unfounded. This form of representation is presumably less suitable to promote more sophisticated

epistemological beliefs. Kienhues, Bromme and Stahl (2008) and Gill, Ashton and Algina (2004) already discussed that.

It can be summarized that knowledge of molecular medicine is predominantly represented as uncertain; this result contrasts findings of Cacciatore et al. (2012), Olausson (2009) and Dudo, Dunwoody and Scheufele (2011) indicating an absence of scientific uncertainty in the coverage of scientific knowledge. On the other side, results of this paper are in line with Stockings (1999) and Guenther and Ruhrmanns (2013) findings that representations of scientific evidence differ: In some cases journalists present research findings as more certain than they actually are (like in frame 2) and in other cases the media over-represent the scientific uncertainty of research results (like in frame 3). In general, the coverage about molecular medicine points out the limitations and uncertainty of scientific results (like in frame 1 and 3) and only in a small portion of sample TV clips such facts are omitted and thereby certainty is represented (like in frame 2).

Knowledge of molecular medicine should be displayed in a way that enables recipients to understand, evaluate and discuss the scientific knowledge represented. Therefore, research results should not be reported to the public non-discussed and in a textbook style, but TV programs should reflect the tentativeness and uncertainty of scientific research and discuss them with reference to multiple sources. Only then it can be ensured that the image of science among the public is adequate and that recipients do not develop problematic explanations for conflicting evidence and unrealistic expectations of science. Future research on depicted epistemological dimensions might help to understand how individuals resolve competing knowledge claims according to media coverage, evaluate represented scientific evidence and obtain new information. Education is a precious commodity in our society. Consequently, it is increasingly important to explore how the general public can be best taught scientific knowledge.

There are some important limitations of this study. Regarding the variables that were recorded for depicted epistemological dimensions, this investigation should be regarded as a pilot study. Here, for the first time, the depicted epistemological dimensions were examined in media coverage and the survey instrument must first be confirmed by further research and may be expanded in order to further validate initial findings. Moreover, concepts and methods for detecting the media frames are discussed in the research literature (Scheufele & Scheufele 2010). Further, the three frames should be tested in a long time design on recipients to determine whether more sophisticated epistemological beliefs are developed by representations alike frame 1 "New scientific procedures" opposed to a textbook style as given in frame 2 "Reporting of basic research" and furthermore, if this is more efficient for domain-specific issues or domain-unspecific ones. Lastly, results stated here were measured for (1) the domain of molecular medicine and (2) in science TV programs only. Although there were plausible arguments to start research in this field with this domain and media channel, further studies should enlarge the specific domain and take news coverage and other media into account.

To improve public's perception and understanding of medical, health-related and general scientific information, Wormer (2011) stated that recommendations and results from educational, cognitional and psychological research can be taken into account and made applicable to research on mass media. He also formulated that implementations of this research are impacted for instance by the need to attract a large and unspecific audience, furthermore, journalists are forced by economic pressures. Hence, journalists' coverage of issues should be as much appealing and understandable as possible, it should be ensured that the average recipient will be able to understand and comprehend scientific presentations and not break up reception because of undefined reasons. When we say that media representations should follow the frame 1 "New scientific procedures" we do not forget about economic pressures of science journalists. But it is very important to depict knowledge of molecular medicine in a way that has the potential to sophisticate epistemological beliefs of recipients; as it is the aim to promote a public understanding of science or public engagement in science.

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