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[Science and the General Public:
Understanding Fragile and Conflicting Scientific Evidence]

Antrag an die DFG
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Summary

The goal of this Special Priority Program is to perform empirical research on the interface between science and the general public. Since the advent of modern information technologies, a great variety of science-related information has become available to anybody with access to a personal computer. This has blurred the borders between the knowledge that laypersons may be able to understand and the expert knowledge that is accessible only to specialists. The Internet has made it particularly easy to access information from many domains of science. People trying to solve problems expect or hope to gain potential solutions from science. However, how do they cope with the fact that science is often only able to offer fragile or even conflicting evidence?

This Special Priority Program should perform empirical studies on the conditions and processes involved in the way in which the general public (i.e., laypersons) basically understands how evidence is gathered and established in science, and it should use these findings to formulate theories on laypersons' understanding of science. It should also work out empirically based principles for designing the communication of science-related information. Part of such a basic understanding is also learning how to productively handle the limits of one's own understanding as a "layperson".

The plan is to integrate research projects from psychology, empirical education science, natural science education , communication science, and the sociology of science in the Special Priority Program. Interdisciplinary cooperation will make it possible to examine not only how science-related information becomes available but also how laypersons process it cognitively, emotionally, and communicatively. The research projects should perform empirical analyses of each of these conditions and processes of basic understanding and fit them together in the Special Priority Program to span the whole arc from the basic academic understanding of science learned at school to the understanding and communication of science-related information presented on the Internet and in the media.

The above-mentioned disciplines have new approaches at their disposal with which they can examine various aspects of the public understanding of how science establishes its evidence. However, until now, no interdisciplinary and empirically oriented research program has addressed the interface between "science and the general public" in either German- or English-speaking countries. The projects in the Special Priority Program should study the following four prototypical

experience domains that confront laypersons with the fragile nature of how science establishes its evidence:

1. Searching for science-related information on the Internet. This includes the active use of available communication facilities for the reception of science (e.g., in Internet forums).

2. The reception of science in the mass media and entertainment industry. This also includes the work of “mediators” between science and the general public such as science journalists. These face the challenge of emphasizing the fragile nature of the way in which scientific evidence is established, while simultaneously paying tribute to the successes and knowledge that science has actually attained.

3. Exhibitions in scientific museums depicting the processes and conditions under which scientific evidence becomes established.

4. The teaching of basic knowledge about establishing scientific evidence at school.

The findings of the Special Priority Program will build up a theoretical and empirical basis for examining a question that education theory has previously addressed mostly in normative terms: What is a modern understanding of science like, and how can its development be promoted so that people can participate in the knowledge society throughout their lives?

Need for the Research Program

Advances in science and technology have led—at least in the industrialized nations—to an enormous growth in scientific knowledge simultaneously accompanied by specialization and differentiation. This trend goes hand in hand with an increasing mechanization of life conditions, with the outcome that ever more complex knowledge systems (in medicine, infrastructure, education) determine the world in which all of us live. The expansion of knowledge along with the growing dependence on knowledge-based systems is leading to a continuously expanding need for the general public (the citizens of our country) to possess not only basic scientific knowledge but also, and in particular, an understanding of the sciences, of how they work, as well as of their potentials and limitations. Hence, a basic scientific education has become a precondition for participating in the public life of a “knowledge society” (in economic, social, cultural, and political terms; Stehr, 1994).

At the same time, society is being **challenged** by growing cognitive and communicative **difficulties in developing** a broad understanding of science in the general public, because:

1. Whereas the general public expects science to provide sound orientational knowledge, a normal feature of scientific knowledge is its uncertainty and provisionality (which we shall label the

fragility of scientific knowledge in the following; Weingart, 2001). Regarding the internal uncertainty within science itself, Dumanoski, Farland, and Krimsky (1998) distinguish, for example, insufficient data, contradictory data, different interpretations of data, uncertainties about causalities, predictive uncertainty about models, or extrapolations and uncertainty about the quality of information. It is the processing of these uncertainties that characterizes everyday routines in the empirical sciences, and competing claims to scientific validity are a matter of course.

2. The above-mentioned trend (dynamic growth in knowledge) is accompanied by an increasing instability or, at least, an ambiguity in the self-concept of science. The question of how scientific evidence is established is itself becoming more and more an object of internal scientific controversy (Nowotny, 1999; Nowotny, Scott, & Gibbons, 2001). This makes it even harder for the general public to understand the process by which science establishes its knowledge.

3. A particular outcome of the close linkage between advances in science and the changes in the science-based systems that determine the world we live in is that the general public is exposed to scientific evidence that is particularly provisional, contradictory, or controversial (Peters, 2000). One reason for this is that fragile findings may at least offer some promise of a solution (e.g., genetic engineering in the field of medicine).

4. The topicality and originality of research is an important criterion not only for quality assurance but also when it comes to legitimizing future or already allocated funding. This encourages actors in the science system to involve the general public in discussions over fragile findings and the methodological problems they raise, because it is precisely such fragile findings that require further research (Dierkes & v. Grote, 2000; Irwin & Wynne, 1996; Weingart, 2005).

The development described here (fragility of knowledge accompanied simultaneously by not only greater personal dependence on this knowledge but also a strong need for the general public to be involved in and control science) is reinforced even further—and in some scenarios, even first becomes possible—through **modern information technologies.** Open access to science-based information on the Internet permits participation in scientific discourses in a way never possible before. At any time, nonexperts can now search not only for scientific evidence that has already been prepared for general consumption but also for information actually intended only for the discourse within science itself.

Proceeding from a specific problem (on either an individual, social, societal, or global level), it is very easy to obtain a host of scientific or science-based information. This increases the availability of fragile and contradictory evidence along with the need to interpret this evidence and judge how useful it may be for solving the problem at hand. The strong public interest in science programs on television, in the science sections of newspapers, as well as specialized popular science journals indicates how much the general public perceives this need. The various providers on this market also contribute to ensuring that the availability of science-based knowledge is unproblematic. However, it is the **interpretation of this evidence** that becomes a major challenge. Empirical research has shown that when laypersons stumble across conflicting evidence on the Internet, they have great difficulty in performing such evaluation processes (Braten & Stromso, 2006; Braten, Stromso, & Samuelstuen, 2005; Eysenbach & Köhler, 2002; Mason & Boldrin, in press; Stadtler & Bromme, 2007).

The trend described here leads to a major cognitive problem for laypersons: namely, to distinguish between knowledge that it is possible for a layperson to understand and that which can be understood only by experts. Historically speaking, this problem is new, because the separation between the specialized knowledge of experts and educational knowledge (potentially accessible for an educated layperson) used to be marked distinctly. Expert knowledge was available only in specialized journals stocked in specialized libraries, whereas general-education knowledge was the knowledge taught in school curricula (Tenorth, 1994). This clear distinction has only disappeared since the spread of the Internet, because access is no longer a reliable indicator of whether a specific body of knowledge is—in principl—comprehensible for laypersons.

Which Disciplines Should Cooperate in the Special Priority Program?

Up to now, describing and theoretically reconstructing such trends has mostly been the domain of the sociology and philosophy of science. Although **psychology** has considered some aspects in the past, it now has modern approaches at its disposal that are highly suitable for empirical (as well as experimental) studies on the cognitive, motivational, and communicative processes and conditions involved in understanding science. These approaches are to be found particularly in educational, developmental, and social psychology, and they offer not only methodologically appropriate but also theoretically promising starting points for such work.

Relevant Research Approaches

Relevant theories for analyzing and promoting the development of an understanding of science include theories on critical thinking (King & Kitchener, 2002; Kuhn, 2005; Ritchhart & Perkins, 2005; Thoermer & Sodian, 2002) and on the epistemological beliefs of school students and adults (Bromme, Kienhues, & Stahl, in press; Hofer & Pintrich, 2002; Khine, in press). The term epistemological beliefs is used to describe subjective belief systems about the genesis, structure, and validity conditions of knowledge; in recent times, they have been studied intensively in both **developmental** and **educational psychology**. Current theories on the cognitive processing of multiple, heterogeneous documents (Perfetti, Rouet, & Britt, 1999; Rouet, 2006) provide a relevant approach for analyzing the understanding of contradictory science-related information. Approaches addressing conceptual change (Murphy & Mason, 2006; Schnotz, Vosniadou, & Carretero, 1999) deliver a good basis for describing changes in science-related ideas (beliefs and misconceptions). These provide new ways of tapping the motivational foundations for modifying misconceptions (Sinatra, 2005) that are also very relevant for the research questions in the Special Priority Program.

Fragile or conflicting evidence is never communicated, interpreted, or evaluated within a social vacuum. The attendant communication processes and information processing are embedded within the structured relationships of a host of **social psychologically** relevant in- and outgroups. Two research traditions in social psychology are particularly relevant in this context: The first, research on social representations (Moscovici, 1980), reveals that the scientific understanding of laypersons is not based predominantly on facts, but on the ideas that have been worked out by and for one’s own social group in order to stabilize the collective life world (Koivisto, Hursti, & Magnusson, 2003; Wagner, 2007).

A second relevant tradition in social psychology is research on social information processing and on social influence taking. Particularly for laypersons, confrontation with fragile or conflicting scientific evidence is a constant source of uncertainty that they are generally unable to reduce by assessing the relevant contents themselves. Direct and personal assessment is replaced by processes of social comparison or social validation. In Festinger's (1978) terminology, "physical-reality testing" is replaced increasingly by "social-reality testing." As well as taking account of general parameters of social information processing under conditions of uncertainty (Kruglanski, 1989) and parameters of processing depth (Chaiken, Wood, & Eagly, 1996; Petty & Cacioppo, 1986), it is necessary to gain a more profound understanding of the self- and group-related determinants of dealing with fragile or conflicting scientific evidence.

Laypersons are not just passive recipients of science-related information. Through the Internet (posting questions to experts that are frequently made public over FAQ pages) or in Internet forums, they also produce science-related information by processing primary sources, science reports, or personal experience (Collins & Pinch, 2000). Here, the work of the Special Priority Program can draw on recent findings from research on the computer-assisted exchange of information in groups (Fischer, Koller, Mandl, & Haake, 2007; Meier & Spada, 2007) and on Web-based communication between experts and laypersons (Bromme, Jucks, & Wagner, 2005; Jucks, Becker, & Bromme, in press; Nückles, Wittwer, & Renkl, 2005). Not only social psychological theories (e.g., on information pooling in groups; Fraidin, 2004; Mojzisch & Schulz-Hardt, 2006) have proved promising in this work, but also psycholinguistic approaches addressing the relation between knowledge divergence and communication (Clark & Krych, 2004; Keysar, Barr, Balin, & Brauner, 2000).

Alongside psychology, **empirical education science and natural science education** have recently developed promising approaches for the work of the planned Special Priority Program. The OECD (2006) consortium has defined the construct of scientific literacy as a combination of a basic knowledge of science and knowledge about science (i.e., basic knowledge about the processes and criteria for establishing scientific evidence). This theoretical concept of scientific literacy also provides a good starting point for the work of the proposed Special Priority Program—with the emphasis on the second aspect. However, it will be necessary to extend the concept of scientific literacy further and ask about the (empirically as yet hardly explained) mutual interaction between knowledge of science and knowledge about science (Durant, 1993; Gräber, Nentwig, Koballa, & Evans, 2002). This can draw on research into (domain-specific) epistemological beliefs showing how these beliefs do not just influence learning outcomes directly but also indirectly via learning strategies or approaches to learning (deep vs. surface; see Bauer, Festner, Gruber, Harteis, & Heid, 2004; Cano, 2005; Köller, Baumert, & Neubrand, 2000; Pieschl, Stahl, & Bromme, in press; Priemer, 2006; Trautwein & Lüdtke, 2007; Urhahne, 2006). Numerous empirical studies have now confirmed that the difficulties school and college students have in understanding natural science research reports are not just due to a lack of basic knowledge about the single biological and physical concepts, but above all to deficits in understanding how evidence is established in the natural sciences (Abd-El-Khalick & Lederman, 2000; McComas, Clough, & Almaroza, 1998). When processing reports, they confuse descriptions with explanations of natural science phenomena as well as scientific cause with effect (Norris, Phillips, & Korpan, 2003).

Similar problems become apparent in the context of current topics in the public discourse such as air pollution, the greenhouse effect (Österlind, 2005: Skamp, Boyes, & Stanisstreet, 2004), or HIV (Keselman, Kaufman, & Patel, 2004). However, research on this discourse also shows that any description and improvement of the layperson's understanding of science-related information proposals has to take account of the context of the public discourse on issues in the natural sciences. The individual development of understanding is always embedded within the context of a host of science-related information proposals whose competing claims to validity often reinforce the impression of the fragility of scientific evidence (Zehr, 1999).

The strengths of approaches in psychology and empirical educational science lie in their access to single processes and conditions of scientific understanding. However, they often fail to examine the "provider side" of science-related information from the empirical perspective. Therefore, the planned Special Priority Program should also study the mediators who *produce* science-related information for the general public (e.g., science museums and science journalists). This requires interdisciplinary cooperation with **communication scientists, empirically oriented museum researchers, and sociologists of science** who study the cognitive and communicative processes involved in *designing* science-related information for the general public and analyze the relations between the media, science, and various forms of public relations. For a long time, communication science conceived science journalism simply as a mediator of the most exact information possible about established scientific findings. Empirically—mostly working with content analysis—it has repeatedly unearthed discrepancies between scientific findings, the cited researchers, and evaluations of findings (Bushman & Craig, 2001; Göpfert, 1999; Haller, 1987; Kepplinger, Ehmig, & Ahlheim, 1991). However, up to now, hardly any content analyses have examined how the media treat scientific ambiguity (Brosius & Schwer, in press), although, in recent times, there has been increasing interest in how science mediators (journalists, science museums) themselves modify and interpret the information they obtain from science. Communication science is increasingly assuming that the work of these "mediators" delivers science-related information proposals that join the scientific research reports (that are also widely available for laypersons through the Internet) in becoming part of the public discussion on science (Blöbaum, in press; Blöbaum & Görke, 2006; Friedmann, Dunwoody, & Rogers, 1999; Kua, Reder, & Grossel, 2004).

Scientific Program

Goal of the Special Priority Program

The proposed Special Priority Program should perform empirical research on the conditions and processes involved in the general public's (i.e., laypersons') basic understanding of how scientific evidence is gathered and established. It should also contribute to the formulation of empirically tested design principles for imparting science-related information. This basic understanding also includes learning to deal productively with the limits of one’s own understanding as a “layperson”.

The Special Priority Program may contain research projects from psychology, empirical education science, and natural sciences education research , as well as communication science and the sociology of science. The decisive inclusion criterion is a strict orientation toward the research question addressing the understanding on how scientific evidence is generated.[1] Interdisciplinary cooperation will make it possible to examine not only how the available science-related information

[1] **Which sciences are involved?** This proposal deals with the communication and reception of the contents of the empirical sciences, that is, all natural sciences including medicine as well as the social sciences (e.g., psychology) insofar as they bide by the processes for establishing evidence applied in the natural sciences. Naturally, similar problems and trends to those described above can also be found in the procedures for establishing evidence in the traditions of hermeneutics and cultural science. Nonetheless, for the sake of maintaining the coherence of the Special Priority Program, we propose not including these scientific domains as subjects of study.

is generated, but also how laypersons process it cognitively, emotionally, and communicatively. The single research projects should empirically analyze individual conditions and processes of this basic understanding, and the Special Priority Program as a whole should span the entire range from the basic scientific understanding learned at school up to the understanding and communication of science-related information provisions on the Internet and in the media.

The interdisciplinary cooperation in the Special Priority Program is essential in order to take into account and reflect on the relation between individual science-related information provisions and processes of understanding science. Hence, the cooperation in the proposed Special Priority Program forms the necessary basis for handling **the embedment of the individual layperson's understanding of science within not only the science-related experiences over the life course but also in the complexity of the public discourse on science**. This is because one feature of the trend described above is the heterogeneity of the available scientific information. Even the classis media (newspapers, television) offer very heterogeneous information (in terms of its content and editing) on the single topics addressing how scientific evidence is established. In addition, the Internet provides information services that encourage active search and evaluation behavior among users in very different ways, and there are also special initiatives offering further science-related information.[2]

Communicating and understanding the ways in which evidence is gathered and established in science also points to the need for (while simultaneously revealing the deficits in) prior knowledge through the basic training in the natural sciences acquired in general school education (Trautwein & Lüdtke, 2007). By studying theoretically based intervention measures, the projects in the Special Priority Program should also **work out and empirically test ways to promote such a comprehension of science**. Such interventions can target informal learning settings (e.g., through encouraging individual Internet searches or in museums) as well as the school classroom.

Special Priority Program Research Questions: Analyses of Four Experience Domains That Expose the General Public to the Fragility of Scientific Evidence

The projects in the Special Priority Program address four different experience domains that are prototypical for the "public" confrontation with gathering and establishing scientific evidence. In the following, we shall start by describing each domain in turn, before introducing specific research

[2] Examples of informal learning provisions on scientific topics in Germany are the *Wissenschaftsjahre des BMBF* (www.abc-der-menschheit.de); *Wissenschaft im Dialog des Stifterverbands* (www.wissenschaft-im-dialog.de); science days, which already focus on preschools (www.science-days.de); natural science museums and exhibitions (e.g., the Deutsches Museum, Munich (www.deutsches-museum.de; http://phaenomenta.de/Luedenscheid/); theme-specific exhibitions (e.g., on nanotechnology at the Deutsche Museum); so-called *Kinder-Unis*, special courses for children offered by several German universities (e.g., www.hu-berlin.de/kinderuni); and *Nacht der Wissenschaften* (science nights) held in several university towns.

questions and describing the theoretical approaches to the **state of research** in these domains. We draw on the detailed sketches prepared by the applicants working on this submission. Nonetheless, the classification of theories to experience domains should not be regarded as exclusive. Instead, the following presents only those theoretical approaches that are expected to lead to a general gain in knowledge for the entire Special Priority Program.

Experience Domain A: Informal Learning When Handling Science-Related Information on the Internet

The Internet offers an informal learning setting not only for the acquisition of basic knowledge but also for problem-specific searches for science-related information. Prototypical examples are searches for health-related lifestyle information or the search for a "second" opinion on the diagnosis and treatment of some disease.

The first research question addresses information search. **It seeks to explain how laypersons initially select the science-related information they intend to inspect more closely. How does the search and selection process relate to evaluations of the Web pages found?** The focus of current psychological research on using the Internet lies on **finding** information and the decision-making processes that lead to the selection of specific hyperlinks: in other words, the preliminary evaluation of Websites (Gerjets & Hellenthal-Schorr, in press; Marchionini, 1995). One example is Information Foraging Theory (Pirolli, 2007; Pirolli & Card, 1999), currently the most important model plotting the preliminary evaluation of accessible Websites on the basis of little information. Modeled on the way animals forage for food, it views navigation behavior in the Web in terms of evaluations of the relevance of available information. Up to now, research has focused on Internet search tasks in which the difficulty for laypersons has been due to the amount and the eye-catching attraction of the information found (Fogg, 2003; Tombros, Ruthven, & Joemon, 2005) and not to competing claims to validity. The impact of typically scientific design features of Websites (e.g., combinations of text, graphic illustrations, and diagrams) on their evaluation has hardly been studied here. For example, one hypothesis is that specific representation formats (e.g., graphic illustrations) will already influence a layperson's preliminary evaluation of Websites and encourage further inspection. Nonetheless, in the subsequent, deeper processing, this may well contribute to underestimating the fragility of scientific findings. Transferring theories from cognitive psychology on the integration of pictures, animations, and text during learning (Bodemer, Plötzner, Bruchmüller, & Häcker, 2005; Kirschner & Gerjets, 2006; Schnotz, 2005) to the study of such evaluation processes opens up new and interesting perspectives for theoretically reconstructing how laypersons search for science-related information.

The second research question addresses the process of cognitively integrating information from different sources and developing an understanding of the heterogeneity of that which has been found. **Which features of the documents, the reception context, and the recipient influence the cognitive integration of information and the understanding of the heterogeneity when handling multiple documents in the Internet?** Particularly when topics are controversial, different documents on the Internet evoke an incoherent picture of the subject matter. Hence, it may be possible to perform a theoretical reconstruction of the way of handling specialized scientific information in the Internet as **learning with multiple text documents**. This type of information processing has been analyzed in the Theory of Learning With Multiple Documents (Perfetti, Rouet, & Britt, 1999; Richter, 2003; Rouet, Britt, Mason, & Perfetti, 1996; Stadtler, 2005). An adequate understanding of multiple texts places three successive demands on recipients: First, they have to identify the propositions taken in each of the texts and represent these together with a source tag. Second, they have to reconstruct argumentative relations between information from different texts; for example, to recognize that one specific empirical finding documented in one research report contradicts a second finding from another research report (intertext relations: see Britt, Perfetti, Sandak, & Rouet, 1999). Third, they have to form a total representation that recognizes possible incoherencies as being intrinsic to the content or the text (and not attributed to, e.g., one's own lack of general understanding as the reader) (documents model: Britt et al., 1999). Mastery of these demands calls for metacognitive monitoring and control strategies, and the conditions under which these are acquired have still not been explained empirically. No empirical findings are available on which role either prior knowledge over the text genre and genre-typical evidential tags (verbal design features that signalize the fragility of the information in a text) or hyperlinks play in text processing when multiple documents have to be integrated cognitively (Richter, Schröder, & Wöhrmann, resubmitted). Moreover, intervention measures to promote the use of metacognitive strategies when handling heterogeneous scientific evidence need to be developed and tested empirically. Simple measures based on the principle of regular prompting have proved very promising here (Stadtler & Bromme, 2007, in press).

The usual models of text comprehension and learning with texts from cognitive and educational psychology are of very limited use when it comes to reconstructing the reading of multiple texts. These models describe text comprehension as receptive-constructive information processing in which readers use their prior content knowledge to interpret, link together, and enrich information components with the goal of producing a coherent model of the situation from the text (Schnotz & Dutke, 2004; Zwaan & Radvansky, 1998). Nonetheless, the underlying assumption in traditional models of text comprehension that the reader is primarily interested in coherence is highly questionable (Rouet, 2006). By focusing on the processing of multiple electronic documents, the projects in the Special Priority Program will contribute to the further development of theories of text processing that have previously been formulated mostly in experimental settings focusing on the processing of single texts. Beyond this, the Special Priority Program offers the possibility of coordinating the joint selection of the topics to be studied as examples throughout the entire project. This is a major advantage in terms of research strategy compared with single experimental studies on text processing in which different topics and genres are selected from one project to the next.

The third research question is: **How does active participation in the communication of science influence understanding of how scientific evidence becomes established?** The Internet offers a host of possibilities for laypersons to communicate on science-related topics. Moreover, the way questions to experts are formulated in Web-based advice forums already discloses the problem descriptions and experiences of laypersons, because this dialogue is frequently made public (as so-called FAQs). More detailed possibilities of communication are provided by forums in which laypersons report their experiences on specific topics (e.g., diseases, threats to the environment) and share advice. Another aspect here is that they present their reception of primary scientific sources, they "translate" specialist texts into everyday language for other laypersons (the changes that occur here have not yet been studied systematically), and they comment on them. In these conditions, laypersons function not only as recipients but simultaneously as mediators (see also Experience domain B) of science-related information as well.

Recent approaches have revealed the significant impact of systematic knowledge differences (experts vs. laypersons) between communication partners on comprehension and on joint decision-making. Studies on Web-based cooperation in learning- and workgroups (Cress, Kimmerle, & Hesse, 2006; Rummel & Spada, 2005; Strijbos & Fischer, 2007) and on Web-based expert-layperson communication (Baker, Wagner, Singer, & Bundorf, 2003; Bromme, Jucks, & Runde, 2005) offer good starting points for empirical research on communicative action under conditions of systematic knowledge divergences between laypersons and experts and within different "public domains" (e.g., sufferers vs. outsiders regarding problems for which science-based problem solutions are expected). Particularly in cooperative settings, one can expect to find promising findings on cognitive conflicts (Meier, Spada, & Rummel, 2007; Rummel & Spada, 2005; Teasley, 1995). It would be interesting to examine, for example, cooperative settings in which two or more (lay) persons try to appraise a certain content on the basis of the information available on the Internet and finally reach an action-relevant decision. Because different persons (e.g., from different domains of experience) also bring different information with them, this situation should be reconstructed with theoretical models of group information pooling.

New Web 2.0 technologies (e.g., collaborative tagging[3]) have given rise to new forms of communication in which both laypersons and experts discuss and present scientific topics together. For example, Wikis—and, most prominently, *Wikipedia*—enable very different persons to work together on a joint article. This permits both individual learning and collaborative knowledge-generation processes. Such a setup can be used to test the hypothesis that the individual knowledge of the persons involved in the interaction and the information contained in the artifact mutually enrich each other and lead to the construction of new knowledge (Cress & Kimmerle, in press).

This experience domain particularly reveals how the borders between experts and laypersons can, at times, become blurred—for example, when laypersons as sufferers in particular problem domains accumulate a great deal of specialized knowledge. Whereas the sociology of science has already engaged in intensive discussions over changes in the roles of experts and laypersons (Hitzler, Honer, & Maeder, 1994), empirical questions regarding the other- and self-categorizations as experts and laypersons accompanying scientific communication over fragile scientific evidence remain unanswered. Analyses of the processes of social categorization in experts versus laypersons and their effects on the processing of fragile scientific evidence can draw on the tradition of social categorization research and identity research (Eiser & Stroebe, 1972; Simon, 2004; Turner et al., 1987) and the studies on social influence to which this has led (Turner, 1991). In addition, research on science-related stereotypes and self-stereotypes (Hannover & Kessels, 2004; Kessels, Rau, & Hannover, 2006) also offers good starting points for analyzing the motivational conditions involved in the cognitive processing of conflicting information (Molden & Higgins, 2005). One starting point here is the hypothesis that people draw on social categorizations in order to interpret contradictions meaningfully and thereby reduce uncertainty. Classifying different findings to different social or societal blocs and associated expert groups (Our data, your data! Our experts, your experts!) grants findings a new order and clarity. Moreover, innovation research in social psychology (Buchs et al., 2004; Mugny et al., 1995) suggests that the social categorization into in- and outgroups and the accompanying social dissensus can facilitate deeper cognitive exploration of a controversial content. As a result, social categorization may well also promote a more far-reaching understanding of science, its findings, and its methods (critical thinking). Such a hypothesis can be tested empirically on laypersons who are actively involved in the communication of science via the Internet.

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[3] A good example of collaborative tagging systems is http://de.citeulike.org/. On this Website, scientific articles are collected by individual users and described with tags. These tags are aggregated across all users for each article, so that it is also described in the sense of a bottom-up classification (folksonomy).

Experience Domain B: The Development of an Understanding of Science Through the Mass Media

Mass media such as daily newspapers, television programs, and radio programs that reach large sectors of the general public serve an equally important role in the development and transformation of the understanding of science as those provisions targeting laypersons with a greater interest in science such as science magazines, science sections in newspapers, and special Internet formats. The mass media draw public attention to scientifically generated knowledge; they open up opportunities for a reception of scientific topics. They serve as transformers of specialized communication into layperson communication (Friedman et al., 1999; Kohring, 2005).

Analyses of the contents of science reporting in communication science assume a similar differentiation to that presented above in the context of the concept of scientific literacy: knowledge of science versus knowledge about science. Current scientific reporting frequently deals with problem-related knowledge on single issues (knowledge of science) for which scientific evidence is available. In contrast, knowledge about science, for example, knowledge about methods and research logic or about the ambiguity of scientific findings is rarely reported (Kohring, 2004). If the fragility of establishing scientific evidence is addressed at all, it is characterized as a special problem and as something accompanying social conflicts (e.g., over genetic engineering or atomic power) to which the scientific evidence refers. It is not discussed as the standard situation in scientific work. Indeed, in controversial cases, journalists tend to seek out those scientists who take a stance similar to their own opinion (opportune witnesses; Hagen, 1992).

The first research question here addresses the **selection mechanisms and routines that guide journalists in their reconstruction of science**. Empirical studies should clarify which self-images in science journalists (from experts to laypersons) and which understandings of roles (mediator of information, explainer, entertainer) relate to variations in presenting how scientific evidence is established**.** To clarify this question, different types of science reporting have to be distinguished theoretically and analyzed in relation to their presentation of science. Such research can take the form of content analyses, surveys of journalists, field studies in editor's offices, or surveys of specific segments of the general public. Proceeding from the assumption that the orientation toward the general public in journalism/the media delivers an important incentive for journalistic science communication (Staab, 1990), it is necessary to determine which quality criteria journalists follow when selecting sources for science journalism and what view of the general public science communicators possess (Blöbaum & Görke, 2006). The understanding of science in the general public does not just depend on the topics and findings offered by science that reach recipients through the media. The recipients of the mass media in turn also influence the selection strategies, the choice of topics, and the forms of presentation in the media.

Scientists also participate in the process of science communication. Within certain topics, one can identify supporters of different scientific positions who do not just represent their points of view within science but also present them to the general public in order to generate acceptance and tap potential resources (Gilbert & Mulkay, 1985; Weingart & Pansegrau, 1998)**.** Up to now, hardly any research has addressed this interface between the self-presentation strategies of science and the processing mechanisms of the media system. It would be interesting to analyze, for example, how journalists (as laypersons) arrive at an appraisal of the topics and findings presented to them by the science system (how they deal with conflicting and fragile findings), and under which conditions representatives of the media react to topics presented by science or actively generate scientific topics themselves. It would also be interesting to analyze how experts (scientists) and laypersons (e.g., politicians) communicate science-based information at public meetings (hearings, workshops; Weingart, 2004).

The second research question addresses the **impact of entertainment provisions on the understanding of science in the general public**. In recent times, changes have been diagnosed for journalism and the media in both their organizational procedures and their objectives (e.g., selection programs, types of presentation, singling out new fields of topics and events; Blöbaum, 2005). The interactions between information and entertainment are particularly interesting here (breaking down of borders, hybridization, infotainment). However, hardly any research has examined how entertainment contributes to presenting the fragility of scientific evidence. It might also be interesting to ask how science or specific subdisciplines are presented in movies (Weingart, Muhl, & Pansegrau, 2003) or computer games. The rapidly growing computer game market seems to be a particularly important—though previously scarcely explored—field of analysis, because many such games propose science-based problem-solving strategies. During the course of play, they often suggest to players that they should process complex forms of organized and structured knowledge (Krotz, 2007; in press). Science plays a role as a resource and an institution in simulations of human life domains (e.g., SIMCITY; Schlütz, 2002; Vorderer & Bryant, 2006) in which players have to function successfully in economic, social, or political fields for which they need to draw on science and scientific experts—for example, when mining and marketing mineral resources or developing a company to do this. Such games refer particularly frequently to medicine, engineering, and the natural sciences (Fritz & Fehr, 1997).

This topic also illustrates the advantages of the interdisciplinary cooperation in the proposed Special Priority Program. Certain display elements of computer games (e.g., animations, graphic displays of data) can also be found in science-related displays for learning in schools, in the

Internet, as well as in museums. While such games require a degree of prior knowledge in players, they also help to disseminate such knowledge and provide practice in using it. Hence, when empirically analyzing the development of an understanding of science through games, it is necessary to take account of the activities of participants (e.g., adolescents) in other experience domains, and, vice versa, also take account of the science-related experiences acquired as a "secret curriculum" in entertainment contexts when performing empirical analyses of the development of the understanding of science in museums and schools.

Experience Domain C: Informal Learning From Exhibits in Museums Depicting the Process of Gathering Knowledge and Establishing Evidence

For some time now, science museums no longer just exhibit established knowledge, but also current and controversially discussed research topics (e.g., nanoscience). However, empirical studies show that learning in museums takes place within narrow temporal and cognitive constraints. Visitors are limited in how willing they are to use the individual exhibits for a detailed learning experience. This makes it necessary to ask how much and what type of fragile or conflicting scientific evidence should be displayed in museums. Current models of learning in museums assume that visitor behavior can be described as "free-choice learning" (Falk & Dierking, 2002; Rounds, 2004), and that it is based on an interest in the guided, selective, and self-guided acquisition of the contents of an exhibition (Rounds, 2004). This confronts the designers of exhibitions with an even stronger need to awaken and maintain situational interest in the contents of their exhibitions (Rounds, 2004)— than that needed in school contexts (with their externally set learning goals) or in Internet-based searches (that are initiated on the basis of already existing knowledge goals).

A further difference compared with other experience domains is the way in which contents are conveyed: The essence of exhibition practice in museums is to display authentic objects (Korff, 2002) supplemented by various media (from explanatory texts to computer terminals; Schwan, 2005). Analyses of current exhibitions (Schwan, Zahn, & Reussner, in press) and findings on visitor research (Zeidler & Surber, 1999) reveal that exhibitions can be categorized as ensembles of thematically coordinated objects and media. These ensembles can be conceived as frames providing an interpretation pattern that influences what recipients think about topics, persons, or events; which attitudes they develop toward these; and how far they remember them (Unz, in press).

As the models of visitor behavior show (Rounds, 2004), museums have to present scientific contents in a form that awakens interest. This is reflected in the choice of framing strategies (see, for an overview, Schwan et al., in press): Alongside outline presentation formats, we also frequently find frames organized in a narrative and illustrative way (Schwan, Trischler, & Prenzel, 2006). It is known from research on the mass media that such narrative and illustrative frames evoke greater interest and more attention in recipients (Unz, in press), thereby meeting the major criteria for a visitor-oriented design of exhibitions.

Hence, in summary, the imparting of information in museums and exhibitions is characterized by: (a) the use of diverse combinations of objects and multiple media, (b) the tendency to organize objects and media using narrative and illustrative frames, and (c) the goal of inducing interest and curiosity in visitors as a precondition for knowledge acquisition. When considering how to deal with fragile and conflicting cadres of knowledge, these conditions raise a series of questions that the research projects need to address:

(1) How far are narrative and illustrative frames in principle appropriate to promote the understanding of the fragile and conflicting status of scientific evidence? Empirical findings show that narrative contents are preferentially processed in an episodic mode associated with a transportation of the recipient into the event on display (Gerrig, 1993; Green & Brock, 2002). This is accompanied by a stronger heuristic processing of information as well as a striving to generate a situational model of the content on display that is as free of contradictions as possible (Vorderer, 1992). It can lead to the assumption that when narrative and illustrative frames are used, the conflicting or fragile status of the underlying scientific evidence will frequently remain unnoticed or unreflected by the recipient. This is particularly the case for illustrative visual displays, for which it has been shown that the great amount of detail frequently makes it difficult for observers to identify central elements, despite developing the (mistaken) belief that the visualization has enabled them to understood the content well (Rozenblit & Keil, 2002).

(2) Can the way that museums work with objects and media (i.e., multiple external representations) be used to derive counterstrategies that will create an understanding for the conflicting and fragile status of the underlying evidence despite the use of narrative and illustrative frames? An appropriate theoretical starting point would seem to be the DeFT Model (Ainsworth, 2006). In contrast to other theories of multimedial learning (Mayer, 2005), it assumes that different symbol systems are not simply exchangeable information channels, but that they adopt specific functions in conveying a content. The model can be used to derive various constellations under which the evidence-related status of a narrative and illustrative element of an exhibition may be qualified and become cognitively graspable for the recipient. One possible way of doing this would be to provide information on the exhibit in a symbolic-abstract format, or also to contrast two contradictory narrative and illustrative formats so that they acquire the character of a visual argument (instead of a representation of the "true" content; Oestermeier & Hesse, 2000).

(3) Which conceivable social-communicative mechanisms in museums could make visitors more aware of conflicting and fragile evidence? This includes embedding a museum visit in a formal (school) education measure, which results in a direct relation to the topics addressed in Experience Domain D but also in the use of interpersonal communication processes within the museum. These include approaches that either assume that the choice of a specific external representation can exert an influence on associated collaborative interpretation processes (e.g., with regard to the attribution of the status of fragility; representational guidance: Suthers & Hundhausen, 2003) or that awareness of the interpretation processes of other visitors to the exhibition exerts an influence on one's own comprehension process (social awareness: Bodemer & Buder, 2006).

Experience Domain D. The Integration of Concepts on Fragile and Conflicting Evidence When Teaching a Basic Understanding of Science in Schools

The projects in the Special Priority Program should focus on informal learning. However, to the extent that students are (or should be) prepared for the life-long critical analysis of the fragility of gathering scientific evidence in formal learning settings (schools), they should also address learning in schools. The main concern here (as in the experience domain of the museum) is how to link the acquisition of a basic stock of natural science knowledge with insight into the fragility of evidence. Even today, the introduction to scientific modes of thinking and working plays a subordinate role in the teaching of natural sciences (particularly in Germany; Baumert & Köller, 2000; BLK, 1997; Prenzel & Parchmann, 2003). Up to now, the emphasis has been on imparting conceptual knowledge that teachers, authors of textbooks and curricula take as established (Reyer, Trendel, & Fischer, 2004; Seidel, Prenzel, Rimmele, et al., 2006). Only exceptionally do natural science lessons at school teach scientific controversies or the daily routine of research characterized by contradictory and fragile evidence (Labudde, 2000).

The first research question in the school experience domain addresses the relation between a basic understanding of single concepts in the natural sciences and the understanding of how scientific evidence becomes established. For example, the following issues need to be clarified: Does a metaconceptual understanding of the relation between theory and evidence that transcends single domains promote the acquisition of content knowledge in the natural sciences? Does insight into how scientific knowledge is gained—and thereby the fragile and often conflicting status of scientific evidence—help to break down misconceptions and promote understanding of scientific concepts and explanations? How far does the understanding of science among students change as a result of actively dealing with contradictory information in school lessons?

Earlier research findings suggest a reciprocal relation here: On the one hand, appropriate beliefs about the nature of knowledge, its generation, and its validity conditions (epistemological beliefs) are preconditions for successful learning. For example, a longitudinal study by Trautwein and Lüdtke (2007) has shown that students who strongly believed that knowledge should be conceived as scarcely mutable had poorer academic grades than students who conceived knowledge as provisional and mutable—even after controlling for intelligence and family background.

On the other hand, because such beliefs are formed only through interaction with the subject matter, they should be conceived as a goal of learning. Some evidence is available—though to a markedly lesser extent—on the effect of the content knowledge acquired at school on science-related beliefs (Elen & Clairebout, 2001; Smith, Maclin, Houghton, & Hennessey, 2000; Uhlmann & Priemer, in press). However, closer analyses of the conditions under which the confrontation with conflicting contents impacts on the understanding of science are still lacking. Some of these questions can already be studied in preschool- and elementary-school-age children from a developmental perspective (Bullock, & Sodian, 2003; Carey, & Smith, 1993). Developmental psychology has traditionally assumed that the ability to think "scientifically" depends on attaining the stage of formal operations. However, recent research has shown that major components of scientific thinking can already be demonstrated in simple tasks given to preschool- and elementary-school-age children, and that an understanding of the process of scientific knowledge acquisition can even be promoted in elementary school (Koerber, Sodian, Thoermer, & Nett, 2005). However, up to now, little is known about the relation between formal scientific thinking and the conceptual grasp of content areas in the natural sciences.

The second research question in this experience domain addresses the influence of representational formats on students' understanding and evaluation of fragile evidence and on their motivation. Prior research on learning with media in schools has focused intensively on the information processing of various types of representation (e.g., using school textbooks containing text, illustrations, or formulas or using films). It has studied the cognitive integration (Bodemer, Plötzner, Bruchmüller, & Häcker, 2005; Schnotz, 2005) and optimal arrangements of representations built of different codes and modalities (Brünken, Plass, & Leutner, 2004; Gerjets, Scheiter, & Catrambone, 2005; Mayer, 2005). It is now necessary to clarify:

1. Whether and in which way the type of presentation influences judgments on the certainty of the knowledge presented (as a central component of the epistemological judgment).

2. Whether and in which way such judgments impact on the depth of information processing.

3. How the perceived certainty of knowledge impacts on the affective evaluation of school subjects as a function of the type of presentation selected.

It is necessary to test the hypothesis that students will generally view information expressed in the form of mathematical formulas as being more certain than text descriptions of the same information. Moreover, concrete presentations in pictures and structural overviews may lead to different assumptions about the fragility of establishing scientific evidence than those obtained with abstract presentations. It is not known whether animations (e.g., three-dimensional, animated displays of models of atoms) help students to form mental models that, in turn, encourage inadequate ideas on how scientific evidence becomes established. Other forms of visualization (e.g., concept maps; Hauser, Nückles, & Renkl, 2006) could be particularly suitable for presenting argumentative relations. Testing such expectations simultaneously opens up various options for designing the presentation of the processes of establishing scientific evidence.

It is also necessary to analyze here how experiences gained in single subjects (e.g., mathematics lessons) in the use of proofs and deductions (Reiss, Hellmich, & Thomas, 2002; Reiss et al., 2006) shape expectations regarding the foundations of the ways in which scientific evidence is established. One hypothesis to be tested is whether certain mathematical concepts such as those dealing with probabilistic conclusions and the estimation of risk (Ben-Zevi & Garfield, 2004; Hoffrage, Lindsey, Hertwig, & Gigerenzer, 2000; Kurz-Milcke, Gigerenzer, & Hoffrage, 2004) impact particularly significantly on the general understanding of how scientific evidence is established, and this not only in the school context (i.e., in other subjects apart from mathematics) but also outside it.

Hence, the planned projects in the Special Priority Program do not just aim to extend existing theories on the processing of scientific information prepared by the media, but simultaneously harbor the potential of designing intervention measures to promote how students handle fragile scientific evidence. For example, the influence of different instructions on the way students construct hypermedia products with given building blocks containing contradictory scientific information could be tested empirically. We would expect a clear impact of the type of instructions on the way students handle contradictory information and presentations in the media (cf. Stahl, 2001; Stahl, Zahn, Schwan, & Finke, 2006). When testing such hypotheses and didactic design options, it is necessary to include the relation to experiences outside of school. The cooperation with the projects in other experience domains provides particular opportunities here.

Particularly in the school context, the goal of natural science teaching is not just to impart subject knowledge. Building up an interest in the contents of the subject plays a decisive role in forming the foundations of motivated learning, and it is also reflected in later subject choices (Krapp, 2003, 2005). Hence, the third question is: **How does the integration of conflicting evidence in school lessons on the natural sciences impact on study motivation and the (affective) judgment of school subjects?** The negative attitude in many school and college students toward the "hard" natural sciences feeds on the perception that these sciences permit neither discussion nor creativity, but simply read off the "one correct answer" given in the "book of nature" (Kessels & Hannover, 2006). Realizing that the natural sciences also work with fragile and conflicting evidence should encourage positive attitudes toward natural science and have advantageous effects on motivation and interests.

On the other hand, confrontation with fragile and contradictory scientific evidence can be expected to have aversive effects as well: *Information overload* and *choice overload* for example, lead to the application of simplified heuristics such as the elimination of information (Timmermans, 1993) or to attempts to simply avoid situations in which one has to make a choice and reach a decision. Therefore, this aspect of the confrontation with conflicting scientific evidence could have correspondingly negative effects on motivation and interest (Iyengar, Huberman, & Jiang, 2004; Iyengar & Lepper, 2000). It can be assumed that personal and situational conditions (such as directional motives, nondirectional motives like *need for cognition* and *need for cognitive closure* and the threatening nature or relevance of information) moderate such relationships.

Anticipated Yield of the Special Priority Program

The work of the Special Priority Program will deliver findings on the cognitive, communicative, and motivational conditions under which laypersons handle the fragility of scientific evidence throughout their lives and thereby permit a theoretical reconstruction of the layperson's understanding of how fragile and conflicting scientific evidence becomes established. It will also test possible ways of designing information provisions that will contribute to a better understanding of how scientific evidence is established. The key issue is one that has long been viewed as a problem in education theory although little empirical work has been done on it up to now (American Association for the Advancement of Science [AAAS], 1993; Baumert 2002; Tenorth, 1994): What form must a modern understanding of science take in order to permit life-long participation in the knowledge society, and how can we encourage its development? Up to now, most discussions of this issue have been normative, and there have been few empirical approaches. Nonetheless, an international perspective is now revealing new ways of tackling this issue empirically with methods from the social sciences. With its interdisciplinary approach and the methods available to the disciplines involved, the proposed Special Priority Program will make a major contribution to structuring and defining this research field. At the same time, it will train young scientists able to carry out both research and practical work on the interface between science and the general public. In this sense, the program will open up new career opportunities.

Interdisciplinary access to the different experience domains of laypersons as well as to the agencies that mediate between the actual producers of knowledge (the scientists) and the general public will form the basis for theory formulation in the program. Further work on constructs such as "critical thinking," "epistemological beliefs," and "scientific literacy" will contribute to this just as much as findings on the role of information processing when performing searches, on handling conflicting evidence in multiple documents, and on dealing with different representational formats. The Special Priority Program can deliver new knowledge here, because it relates the results on cognitive and motivational information processing to the analyses of information provisions performed by communication science. And it will become clear how significant the communicative activity of laypersons (who go beyond the role of being mere recipients) is for the development of an understanding of science in the general public. Through a cross-project, Web-based documentation of data and assessment procedures, the program will simultaneously promote an interdisciplinary exchange of methods (from experimental designs to field observations) and thereby contribute to the development of an appropriate methodology for this new field of research.

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