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Scientific Nonknowledge and Its Political Dynamics: The Cases of Agri-Biotechnology and Mobile Phoning

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Abstract
While in the beginning of the environmental debate, conflicts over environmental and technological issues had primarily been understood in terms of "risk", over the past two decades the relevance of ignorance, or nonknowledge, was emphasized. Referring to this shift of attention to nonknowledge the article presents two main findings: first, that in debates on what is not known and how to appraise it different and partly conflicting epistemic cultures of nonknowledge can be discerned and, second, that drawing attention to nonknowledge in technology conflicts results in significant

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institutional effects and new constellations of actors in public debates. To illustrate and substantiate this political dynamics of nonknowledge we draw upon examples from the areas of agri-biotechnology and mobile phoning. In a first step, we develop in greater detail the concept of scientific cultures of nonknowledge and identify three such cultures involved in the social conflicts within the two areas. Subsequently, we analyze the specific dynamics of the politicisation of nonknowledge looking at the variety of actors involved and the pluralisation of perceptions and evaluations of what is not known. Then, we point out some of the institutional reactions to the political and cultural dynamics of scientific nonknowledge. We argue that the equal recognition of the diverse cultures of nonknowledge is a key prerequisite for socially legitimate and "robust" decision-making under conditions of politicised scientific nonknowledge.

Keywords
nonknowledge, risk, epistemic culture, agri-biotechnology, mobile phoning

Introduction: From Risk Assessment to the (Partial) Recognition of Scientific Nonknowledge

Over the last two decades, the issue of what remains beyond the reach of scientific risk assessment and how to adequately deal with the resulting unknowns has increasingly gathered momentum in social conflicts over new technologies and their possible consequences. Initially, in the 1970s, there have been repeated attempts at framing the conflicts over environmental and technological issues such as nuclear power plants or potentially harmful chemicals in terms of risk, conceived of as a "fundamentally 'scientific' object" the true nature of which can be revealed by methods of rational analysis (Wynne and Felt 2007, 31). Particularly by the proponents of those technologies and governmental institutions' risk was (and still is) considered the dominant analytical framework and conceptual tool to define, appraise, and communicate possible ecological or health-related harms and hazards associated with new technologies. However, very soon after the institutionalization of risk assessment procedures, both scientific and political debates about the role and relevance of ignorance emerged (e.g., Weinstein and Weinstein 1978; Collingridge 1980; Smithson 1985; Ravetz 1986). Here, ignorance, or nonknowledge, as we prefer to term it,[1] was understood as a phenomenon or condition *beyond* risk and uncertainty (see Faber and Proops 1993, 114). The concept of nonknowledge focuses on the inherent limitations of the dominant framings of "risk" issues and points at the possibility of large areas of unknowns not only beyond the reach and scope of scientific risk assessment but also inadvertently embedded *within* supposedly all-embracing definitions of risk (Wynne 1992). For instance, risk analysis of chlorinated fluorocarbons (CFCs) in the 1930s had been completely unaware of the possibility of harm to the ozone layer caused by those substances—and one can reasonably assume that the same would have applied even for a risk assessment conducted in the 1960s (see Farman 2001).

For a proper understanding of the emerging political and cultural dynamics of nonknowledge, in particular of scientific nonknowledge, two theoretical clarifications are essential. *First*, nonknowledge is not simply the given "primitive or native state" (Proctor 2008, 4) from which the scientific endeavor departs to replace it, sooner rather than later, with complete and reliable knowledge. Quite to the contrary, nonknowledge increasingly *results* from science itself and its technological applications to society and the environment. In the early 1990s, Jerome Ravetz termed this phenomenon "science-based ignorance," which he defined as "an absence of necessary knowledge concerning systems and cycles that exist out there in the natural world, but which exist only because of human activities" (Ravetz 1990, 217). To put it differently, science and technology intervene in the (natural and social) world but frequently are unable to anticipate and recognize in good time the consequences of those interventions, as it has been the case with CFCs, asbestos, thalidomide, or BSE (bovine spongiform encephalopathy, also known as mad cow disease)—to name just some of the best-known and most severe manifestations of science-based nonknowledge (cf., EEA 2001). *Second*, it is crucial to be aware of the fact that nonknowledge is not a homogeneous entity but both "multifaceted" and "socially constructed and negotiated," as Michael Smithson (1985) had emphasized. Given this background, since the 1980s one can observe the emergence of what has been termed the "politicization" of ignorance or nonknowledge (Stocking and Holstein 1993). This notion does not only indicate the fact that "prominent" cases such as CFCs or BSE have increasingly drawn the attention of society and politics to the limitations and shortcomings of scientific knowledge. In addition, the perceptions, definitions, and evaluations in society of the unknown became more and more heterogeneous and pluralistic, that is, linked with different social interests, values, identities, and epistemic perspectives (see Michael 1996), and thus were politicized.

These processes of pluralization and politicization unfold mainly along three dimensions in which social perceptions of nonknowledge can be constructed in contrasting ways (see Wehling 2006). The first dimension refers to the *knowledge* or *awareness* of nonknowledge: Do we know about the gaps and blind spots in our knowledge or are we unaware even of what we do not know? In the latter case, we would clearly have to take into account possibly large areas of potentially hazardous "unknown unknowns" (Kerwin 1993; Grove-White 2001) *beyond* what we know we do not know. The second dimension focuses on the degree to which nonknowledge is attributable to the *intentionality* of social actors. It thus contrasts completely unintended (and therefore seemingly inevitable) nonknowledge with the active, fully conscious refusal of certain cognitions, whereby for science studies, mixed forms, such as nonknowledge due to lack of interest or sticking to inadequate research routines, appear to be more important. The third dimension of differently perceiving and constructing the unknown refers to the *temporal stability* and *persistence* of nonknowledge. It ranges from what is merely not yet known and (presumably) does not raise any substantial difficulties for cognition on one hand to the entirely unknowable and therefore uncontrollable on the other.

In all these dimensions, it might be heavily contested among different social actors (such as scientists, governmental institutions, environmental and consumer organizations, or business firms), which perceptions and evaluations of the unknown are considered the "right" ones. It is important to notice that during the last ten or fifteen years, the ability of mainstream science to authoritatively determine and control the social perceptions of what is not known has substantially weakened, not at least due to highly polarized conflicts, for instance over BSE, genetically modified organisms (GMOs), or mobile phoning.[2] In these conflicts, the established framings of the unknown in terms of "known unknowns" and "not-yet-knowns" were seriously challenged and, as a result, have partially lost their credibility and cognitive authority. When we find, for instance, no empirical facts indicating harmful effects of a certain GM plant, this situation can be evaluated in two contradictory, yet equally reasonable ways: either in terms of reliable *knowledge* that there actually are no harmful consequences or in terms of possible *unknown unknowns*—which means that we are unsuspecting where, when, and how hitherto unforeseen effects might occur (or even did already occur; cf., Walton 1996, 140).

Apparently, these social conflicts over the correct assessment of what is known and not known are far from being resolved by the routine appeal to the available evidence. Instead, such conflicts as well as the pluralization of the perception and evaluation of the unknown gave rise to the insight that the sciences themselves are not homogeneous and uniform with regard to how they generate, define, communicate, and investigate nonknowledge. Thus, there exist various epistemic cultures that appear to differ not only in how they make knowledge (Knorr-Cetina 1999) but also in how they deal with nonknowledge (Böschen et al. 2006). In recent years, the emergence and growing awareness of such different "cultures of nonknowledge" within the sciences fostered social, political, and scientific controversies about the unknown.

In regulatory politics and science, we can observe a partial, if frequently unwilling and tentative, recognition of "science-based ignorance" in reaction to the pluralization and politicization of nonknowledge. Against this background, the editorial team of the European Environment Agency's report "Late Lessons from Early Warnings" advised policy makers to "acknowledge and respond to ignorance, as well as uncertainty and risk, in technology appraisal and public policy making." (Harremoës et al. 2001, 168). Quite similarly, the German Scientific Advisory Council on Global Environmental Change argued for the development of strategies "to avoid future ozone holes" (WBGU 1999). Yet, how could such strategies be successfully designed, given both the politicization of nonknowledge and the paradoxical character of calls for responding to what is not known? And to which extent would these strategies indicate substantial changes with regard to the institutional routines of dealing with the unknown?

To address these questions, we will refer to the areas of agri-biotechnology and mobile phoning: In section 2, we develop in greater detail the concept of scientific cultures of nonknowledge and identify three such cultures involved in the social conflicts within the two areas. In section 3, we discuss three examples of what we term politicization of nonknowledge, a process fuelled by the selective and often strategically motivated references of social actor groups to different epistemic cultures. Subsequently, we point out some of the institutional reactions to the political and cultural dynamics of scientific nonknowledge (section 4). In our conclusions, we argue that the equal recognition of the diverse cultures of nonknowledge is a key prerequisite for socially legitimate and robust decision making under conditions of politicized scientific nonknowledge.

Scientific Cultures of Nonknowledge

Our attempt to identify the various ways of addressing and handling nonknowledge within the sciences is primarily based on the concept of epistemic cultures as elaborated by Knorr-Cetina (1999). It is of specific relevance to our empirical findings presented in this section,[3] as it addresses new ideas about the heterogeneity or "disunity of science" (Galison and Stump 1996) and points at the different epistemic practices within science. Knorr-Cetina (1999) develops the concept along two empirical case studies on high energy physics and molecular biology. Her analysis already includes some remarks concerning not only the sciences' production of knowledge but also their relation to nonknowledge. High energy physics is described as being engaged in the production of "negative knowledge" that specifies the evidential limits of the produced data: "Negative knowledge is not nonknowledge, but knowledge of the limits of knowing, of the mistakes we make in trying to know, of the things that interfere with our knowing, of what we are not interested in and do not really want to know." (Knorr-Cetina 1999, 64). Molecular biologists, however, "in the face of open problems" adopt "a strategy of blind variation combined with a reliance on natural selection. They vary the procedure that produced the problem, and let something like its fitness—its success in yielding effective results—decide the fate of the experimental reaction." (Knorr-Cetina 1999, 91) In short, molecular biologists' "blind variation" is based on an ongoing reorganization of the experimental settings until they "work." In most cases, explanations of the initial experimental failure are not sought.[4] Building on this account, it can be assumed that dealing with nonknowledge is an important, if implicit, component of epistemic cultures and that considerable differences between disciplinary or subdisciplinary epistemic cultures exist.

How could such "cultures of nonknowledge" be described in more detail and how should the differences be specified? An analysis of scientific practices provided us with the following six dimensions that appear to be constitutive of cultures of nonknowledge and in which the epistemic cultures under investigation might differ significantly.

The spatial and temporal horizon of the stabilization of knowledge provides information about spatial and temporal levels that are, and are *not*, taken into account. These horizons may thus indicate blind spots of the knowledge produced. Exploring these horizons may include the following questions: How long are observations undertaken until the exposure to a technological application such as a mobile phone, a mast, or the cultivation or consumption of genetically modified crops is considered having no—short- or long-term—negative effect? How far does the search for possible effects reach geographically to rule out possible risks for the environment?

The strategies to react to unexpected results and events throughout the research process are constitutive of the ability to detect unknown unknowns or unrecognized mistakes. Such events may either be interpreted as evidence for a failure to sufficiently control the experimental condition (and hence be answered by "blind variation" of the experimental parameters, cf., Knorr-Cetina 1999), or they may be taken as a hint that the initial assumptions about the object in question were fundamentally wrong (and hence be answered by scrutinizing the adequacy and the limits of the current state of knowledge).

The extent, character of the decontextualization of the investigated object from real-world situations as well as the extent character of the recontextualization of gained knowledge to real-world conditions both affect the significance of scientific results for the societal context. Experimentally gained knowledge is based on highly controlled experimental settings and highly standardized epistemic objects (Rheinberger 2001, 24-30). In relation to the real-world situations that shape the formulation of the initial research questions, such experimental systems are often strongly decontextualized (cf., Bonss, Hohlfeld, and Kollek 1993a, 1993b) concerning not only space and time scales but also the epistemic object itself and its context. The produced knowledge may or may not adequately address the initial question, that is, whether a certain technological application poses a risk to human health, the environment, or social welfare. The amount and kind of the decontextualization undertaken may also be acknowledged, specified, and taken into account in attempts to interpret the research results' significance in the real-world context. Thus, a kind of recontextualization may be achieved and the risk to misinterpret scientific results may be lowered.

Ways of addressing the complexity of a research object are another specific source of contextualization as they define whether a given level of system complexity is reduced or maintained. Such complexity may be found in the exposed object (e.g., a living organism), the effected harm (e.g., cancer promotion), or in the context of exposure (e.g., the diverse modes and patterns of exposure to electromagnetic fields [EMFs]). A high degree of reduction may result in the elimination or alteration of crucial aspects and therefore in false positives or false negatives among the results. A low degree of reduction may result in the impossibility to produce any kind of reliable results.

The ways of explicitly addressing nonknowledge and the limits of knowledge determine whether and how scientific nonknowledge is specified and communicated and can thus be taken into account later on, in other contexts or fields of expertise. Hereby, it is of relevance which kinds of nonknowledge are acknowledged explicitly (the not-yet-known, unknown unknowns, the unknowable, etc.).

A scientific fields' *propensity to reflect on knowledge and nonknowledge in disciplinary, interdisciplinary, and transdisciplinary contexts* is therefore also central. It depends on the existence of *fora* and routines of theoretical and methodological deliberation. Integrating the results of such deliberations into applied research helps avoiding blind spots within disciplinary research that may translate into societal risks later on.

Based on these dimensions, our empirical analysis of the various scientific fields active in the risk and uncertainty assessment of agribiotechnology and mobile communication technology allowed us to identify three ideal types of scientific cultures of nonknowledge: a control-oriented one, a complexity-oriented one, and a single case-oriented one (see below table 1).[5]

The *control-oriented* scientific culture of nonknowledge (which in our sample is represented prominently by molecular biology) is characterized by an epistemic focus on the control of the experimental conditions and the avoidance of disruptive factors. In the words of an interviewed molecular biologist[6]:

> I have to define my system very precisely to get answers [at all]. If I have too many variables which aren't under my control, I usually can't interpret the results. (I 19, 249)

The *complexity-oriented* culture (under which ecology or epidemiology can be subsumed) is characterized by a high degree of openness toward unanticipated events as well as uncontrollable and context-sensitive settings or as an interviewed ecologist put it:

> We often go out relatively unencumbered and just look: What is actually happening outside? And then we allow ourselves to be surprised by what we find: We observe this and then try to evaluate our findings without looking for a specific systematic condition that has to be achieved. (. . .) It is our recurrent finding that self-organised natural systems are highly resistant to our planning. This aspect of self-organisation is perceived not as a disturbing factor that has to be eliminated, but rather as an actual characteristic of the systems. (I 4, 202)

The third culture of nonknowledge is based on professional expertise and concentrates on *single case-based experience*. The most eminent example here is the medical profession and the analysis of medical case histories. This cultural type is characterized by a very low degree of decontextualization but shows a tendency to define nonknowledge as a problem of the

Table 1. Three Types of Scientific Cultures of Nonknowledge

Scientific Cultures of Nonknowledge: Types/Traits	Control Oriented	Complexity Oriented	Single Case Oriented
Spatial and temporal horizon	Small: independent of space and time	Middle to wide: related to a geographic and temporal context	Middle: situated in a certain context of action
Dealing with unexpected events	Interpreted as failure to control	Interpreted as failure to fully understand	Acknowledged as case specificity
Decontextualization and recontextualization	Decontextualization in vitro or in vivo of primary importance	Observation in situ (and calculation in silico) decontextualization of secondary importance	Anamnesis/intervention in situ lowest decontextualization
Dealing with complexity	Reductionist approach: avoidance of uncontrolled conditions	Acknowledgment of complexity: theoretical and methodological openness	Acknowledgment of the single case: nonknowledge as individual shortcoming
Explication of nonknowledge and reference to dimensions of nonknowledge	Focus on the not-yet-known or known unknowns	Focus on unavoidable uncertainty and unknown unknowns	Critique of existing abstract knowledge, sometimes alluding to intentional ignorance
Disciplinary, interdisciplinary (ID), and transdisciplinary (TD) deliberation	ID with sciences from the same type; TD with product development	ID with sciences from the same type; TD with precautionary politics	ID with either type 1 or 2; TD intrinsic to professional activity

individual expert. The amount of available scientific knowledge contrasts heavily with the amount of knowledge possibly appropriated and applied by the individual practitioner. Moreover, the aptitude of scientific evidence for the practical context and the individual case is challenged. Similarly, clinical research is challenged by every-day professional experiences. In the account of an interviewed clinician:

> New research questions normally arise throughout the daily professional practice. A certain vaccination is administered and no one knows how it works. And then you start thinking and you try to see what happens: Is it really these specific cells? Do they accumulate? What I investigate currently in clinical research is mostly derived from this clinical approach. I notice that there is no evidence-based treatment available and if I am interested enough, I start looking for answers. (I 28, 376)

To fully understand social and political conflicts over nonknowledge, it is of paramount importance to acknowledge that all three epistemic cultures of nonknowledge are equally valid in general terms, although for a long time the control-oriented type has been most influential within science and society. Therefore, the three types cannot be arranged according to a general "scientific—unscientific" or "reliable—unreliable" scheme. They represent different approaches that have to be evaluated in relation to the specific case and context in question. All three types imply certain strengths and weaknesses. The control-oriented approach is undoubtedly strong in producing "hard facts" (or reproducible knowledge) and functional technoscientific artifacts. Yet, it withdraws attention from contextual factors or persisting real-world uncertainties. The complexity-oriented approach tries to avoid blind spots of perception but runs the risk of producing only "weak evidence" without any predictive power and is faced with the difficulty that any observation is dependent on a specified and necessarily restricted horizon of expectations. The approach based on single cases can account for the observation of complex case histories over time and the case-specific application of therapeutic treatments. However, it is of limited use concerning large-scale patterns and the evaluation of more general causal relations. As to the before-mentioned three dimensions of nonknowledge that become relevant in contexts of scientific controversies and political decision making, it is the control-oriented type that focuses on the not-yet-knowns and the known unknowns. The complexity-oriented type also acknowledges unknown unknowns and irreducible nonknowledge due to the complexity of the systems under study. The single case-oriented type is most likely to refer to a sort of (scientific) unknowability, in the sense that abstract, decontextualized knowledge is unable to explain the respective individual case. It also allows for conceding intentional ignorance (unwillingness to know) when its expertise is repeatedly ignored and dismissed as insignificant "anecdotal evidence."

Politicizing Scientific Nonknowledge: Interactions of Social Actors and Epistemic Cultures

Whereas the politicization of nonknowledge is fuelled by the contrasting perspectives on knowledge and nonknowledge offered by different epistemic cultures, the specific dynamics of such processes of politicization depend on the variety of actors involved. The competing perceptions of nonknowledge are adopted selectively by various social actor groups to pursue their respective political agendas. The cultures of nonknowledge are thus included in specific processes of deliberation and decision making related to specific sociopolitical settings. In these settings, the competing evaluations of what is known and not known appear to intensify the conflicts and make evident the epistemic incompatibility of contrasting framings of the unknown. There exist certain strategic as well as cultural affinities between specific social actors such as industrial companies and lobby groups, governmental institutions, environmental nongovernmental organizations (NGOs), and specific cultures of nonknowledge (cf., fig. 1).[7]

The following short examples, taken from the conflicts over agri-biotechnology and mobile phoning, serve to illustrate such interactions of various social actor groups and scientific cultures of nonknowledge, which result in a (further) politicization of scientific standpoints and nonknowledge.

Epigenetics Versus Genetic Engineering: NGOs' Reference to Different Epistemic Cultures Within Molecular Biology

The political impact of contrasting perceptions of scientific nonknowledge becomes particularly evident and crucial when participants in social conflicts over risk technologies play off one epistemic approach against another. With regard to agri-biotechnology, one illustrative example is given by the joint Greenpeace and Oeko-Institut "Epigenetics initiative" in Germany.[8] In 2004, both organizations issued a paper on "The out-dated paradigm of

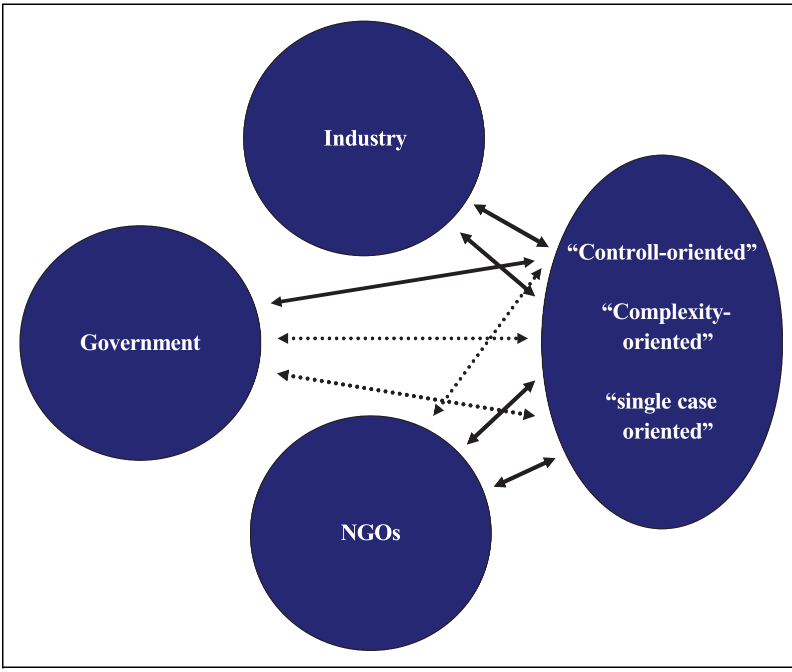

Figure 1. References of different actor groups to scientific cultures of nonknowledge.

genetic engineering” (Moch 2004) to emphasize the limits to scientific knowledge resulting from the complexity of mechanisms involved in genome–phenotype interrelations. In December 2005, the public conference “Epigenetics, transgenic plants & risk assessment” mobilized not only the argumentative resources but also the authority of invited scientific speakers—mostly well-established biologists—to strengthen this perspective.[9] Although the scientific arguments included no radically new or contested scientific information, the aspects highlighted as relevant for risk assessment and the inferences drawn for risk regulation departed considerably from the then mainstream expert opinions. The seven invited speakers “highlighted (. . .) the *complexity* of genome regulation and of the so-called secondary metabolism, *inherent uncertainties* of the genetic engineering of plants, the challenge of facing and coping with *knowledge gaps* and last but not least the implications that these uncertainties have.” (Moch 2006, 4, emphases added) In addition to the strong reference of Greenpeace and the Oeko-Institut as NGOs to ecology, they referred to the epigenetic paradigm, which can be understood as a complexity-oriented approach *within* the control-oriented culture of molecular biology. Thus, a major effort was made to establish a complexity-oriented approach not only within the political debate on agri-biotechnology and its appropriate regulation but also in the more general perception of molecular biology as a scientific field. Remarkably, insights from basic research in molecular biology were mobilized by the two NGOs to challenge the established practices and perceptions of applied agri-biotechnology including its focus on not-yet-knowns and its routine neglect of possible unknown unknowns. Thus, the focus is no longer only on the unknown ecological risks of GMO release but also on the unknowns inherent to the practice of genetic engineering itself. As a result, the widespread public perception (at least in Europe) of genetic engineering as a scientific and technological practice producing unforeseeable and uncontrollable risks is reinforced.

This example illustrates, on one hand, that scientific disciplines are not homogenous in the ways they deal with the unknown and, on the other hand, that social actors refer to epistemic cultures in a flexible and strategic way. Contrary to NGOs, actors from agro-industry mostly referred to molecular biology and agricultural sciences as control-oriented sciences, which are held to *reduce* nonknowledge instead of increasing it. Governmental agencies also included ecological expertise but were accused of ultimately relying on control-oriented approaches. Interestingly, none of these actors drew on expertise from environmental or practical medicine; in this way, specific restrictions in the use scientific expertise defining the scope of the unknown are maintained even by NGOs.[10]

Political Struggles over the Role of Epistemic Cultures in GMO Risk Regulation

In the course of the implementation of the guidelines on the deliberate release of GMOs in Germany, the relevant national polity structures were transformed as well (Boschert and Gill 2005). Throughout this phase of legal and institutional rearrangements, each political party tried to assign the competence for GMO risk assessment to specific research and advisory institutions, which were held to be rooted in different epistemic cultures with diverging views on the scope and importance of what is known and not known and which risks were at stake. The both scientific and political struggle over definitional power in GMO risk regulation between a control-oriented and a complexity-oriented epistemic culture played out and resulted in a general shift of regulatory politics to a setting more accessible to complexity- or single case-oriented epistemic cultures. In particular, with the Federal Agency for Nature Conservation (Bundesamt für Naturschutz, BfN), an explicitly complexity-oriented authority was charged with the task of environmental risk assessment in 2004, as had been demanded by proponents of the Green Party that was part of the Federal Government at that time. The scientific background and expertise of BfN lies mainly in ecology; it advocated a more precautionary approach to GMO release, emphasizing both the unknown long-term consequences and the risks to specific ecological settings and landscapes. BfN thus combined a complexity-oriented and a single case-oriented perspective and laid emphasis on the lack of scientific knowledge about the consequences of GMO release. Simultaneously, the position of the Central Commission for Biological Safety (ZKBS), which follows a more control-oriented approach (Kapteina 2000, 109), was weakened, although it remained the dominant scientific advisory board in GMO regulation. In the course of the institutional reorganization, the Commission became part of the Federal Agency of Consumer Protection and Food Safety (BVL), the most important authority of the Ministry of Food, Agriculture, and Consumer Protection. Since the BVL combines control- and complexity-oriented approaches, the dominance of the mainly control-oriented view previously adopted by the ZKBS was restrained. Still, control-oriented approaches remain highly influential in the field of agri-biotechnology regulation in Germany.[11]

These examples not only illustrate the selective and interest-driven preferences of political actors for certain cultures of nonknowledge they also highlight the ambiguous role of the central political actor, the Federal Government. On one hand, it aims at supporting technological innovation and economic growth; on the other hand, it is in charge of preventing risks to the citizens' health and the environment. To meet these requirements, government is structured by a highly differentiated set of ministries and agencies involved in the process of agri-biotechnology regulation. Therefore, the conflicts are not solved but transformed into another scheme of conflict solving. Obviously, this constellation is likely to continuously create spaces and opportunities for political actors to mobilize one way of framing the unknown against the other.

Competing Cultures of Nonknowledge in Research on Mobile Phone Risks: the Case of Hardell and His Critics

Within normal science, the different epistemic approaches usually do not come into conflict with each other, because they occupy different niches in a highly specialized, disciplinary environment. It is the societal objective to assess the risks of a given technology that induces the multidisciplinary engagement, the formulation of different expert opinions on the same subject and the emergence of epistemic conflicts. These developments then highlight the incompatibility of the cultures of (non-)knowledge involved, by triggering controversies about specific research results and their correct evaluation and interpretation.

With regard to mobile phones, the debate concerning a series of epidemiological studies carried out at the Karolinska Institute in Sweden can serve as an example. According to the oncologist and epidemiologist Lennart Hardell and his colleagues who conducted and published these studies, they demonstrate a correlation between the long-term use of mobile phones and the prevalence of a certain kind of brain tumor. The authors conclude that the EMFs emitted by mobile phones constitute a health risk (for an overview, see Hardell, Carlberg, M., et al. 2007). Hardell's critics countered that a weak statistical correlation could not be equated with a causal connection in the absence of any knowledge about the underlying physiological mechanisms. They also criticized an alleged lack of statistical accuracy and validity, especially in relation to Hardell's analysis of subgroups in his sample. The first point of criticism can be interpreted in terms of a controversy between a control-oriented approach and a complexity-oriented approach. The second point seems to come from another direction: Here, it is the demand for statistical accuracy (a complexity-oriented skill) that plays the part of critique: Hardell's approach is criticized as (too) single case- (or subgroup-) oriented.[12] Overall, Hardell's group combined a specific methodological approach with a declination to find "the needle in the haystack" and a belief that there might be such a (hitherto undetected) needle in the first place. The "needle" was found, following both a complexity-oriented approach according to which everything is interrelated, and there is always an effect of some kind somewhere and a high recognition of single cases.[13]

The divergence between Hardell and his opponents thus is a threefold one: Hardell's group did not translate "*finding* nothing" into the conclusion that there "*was* nothing," they found something where others did not, and they interpreted this something as evidence of risk where others did not. This threefold divergence can be explained with reference to differing experimental systems and epistemic cultures, including contrasting assumptions about unknown unknowns. Since Hardell's findings repeatedly received considerable media attention, the scientists themselves became, willingly or not, a kind of political actors, doing epistemic politics with regard to the evaluation of what is known and not known about possible mobile phone risks. In this way, they provided the public with contrasting views on the likely risks which, nevertheless, appeared to be equally valid, if only within different cultures of nonknowledge.

Institutional Reactions to the Politicization of Nonknowledge

As we have demonstrated, in political conflicts over new technologies, the different epistemic cultures of nonknowledge outlined above interact in complex ways with the interests, norms, and institutional perspectives of a great variety of social actors in politics, economy, civil society, and, not least, the sciences themselves. This constellation results in a pluralization and politicization of knowledge and nonknowledge claims, while at the same time, well-established inner-scientific hierarchies ("hard" versus "soft" science, or control-oriented vs. complexity-oriented epistemic cultures) are challenged, alternative epistemic styles are (partly) acknowledged, and new strategies for defining and handling nonknowledge are being elaborated.

Apparently, the politicization of nonknowledge threatens to hinder or even block up institutional routines and established legitimatory strategies of political decision making. It exacerbates the question of the factual rationality of decision making under ignorance, already raised by Collingridge in 1980, as well as of the social robustness and legitimacy of such decisions. Over the last ten years or so, scientists and policy makers had to learn that it becomes increasingly insufficient and unconvincing to simply dismiss diverging perceptions, constructions, and evaluations of the unknown, for instance reference to possible unknown unknowns, as irrational or hysterical. It thus comes as no surprise that we can currently observe more serious institutional efforts to take into account the plurality of valid perspectives on nonknowledge and its potential consequences.

To illustrate this in greater detail, we will briefly refer to two examples of such institutional reactions with regard to the fields of agri-biotechnology and mobile phoning: (1) the establishment of the so-called post-market monitoring of GMOs as a means to detect harmful effects that had not been foreseen in previous laboratory research and controlled field experiments; (2) the (at least partial) recognition of diverging views on the possibility of unknown risks of mobile phoning and the emergence of specific institutional reactions such as safety research programs or public deliberation. These examples certainly indicate that the issue of how to adequately respond to nonknowledge is increasingly taken serious in science and politics as well as in society. Such tentative reactions to nonknowledge are, however, highly contested among the different groups of social actors and should therefore not be overrated and misunderstood in terms of a linear and irreversible process of social and institutional learning. Instead, it ultimately depends on the resources (such as definitional power, ability to mobilize support, access to media, etc.) of the various actors, which framing of the unknown becomes dominant in the respective controversies.

(1) The establishment of obligatory postmarket environmental monitoring (PMEM) of GM plants according to the EC-directive on deliberate release of GMOs ranks among the most significant institutional reactions to the politicization of nonknowledge, and the growing concern with unknown unknowns in particular. As already mentioned, the monitoring aims at detecting unintended effects of genetic modification that have not been detected in previous laboratory research operating under temporally and spatially restricted conditions. It thus can be interpreted as a rather explicit institutional recognition of the possibility or even probability of unanticipated effects and unknown unknowns. Moreover, the establishment of the postmarket monitoring breaks with the hitherto widespread and taken-for-granted assumption "that if there were harmful effects, evidence would emerge of its own accord and in good time for corrective action" (Harremoës et al., 2001, 172). Instead, the search for unforeseen or unrecognized effects now is to be actively and systematically organized, as advocated by Collingridge as early as 1980 in his discussion of decision making under ignorance.[14]

With regard to monitoring, a distinction is made between "general surveillance" (GS) and "case-specific monitoring" (CSM). The former is obligatory for all GM plants and aims at detecting unforeseen consequences, in particular, possible long-term or cumulative effects, which had not been identified in prior risk assessment, while the latter focuses on testing specific hypotheses about harmful effects, which had been defined in the risk assessment (see Züghart et al. 2005). At least in principle, the monitoring offers opportunities to bring together in a complementary and productive way different perceptions of the unknown as well as different scientific cultures of nonknowledge. While control-oriented scientific disciplines are confronted with the task of defining testable hypotheses about uncertain, "not yet" fully known risks, complexity-oriented disciplines are requested to search for the unexpected, to be sensitive to exceptional phenomena and to continuously question and extend the established foci of scientific attention. Single case-oriented cultures finally can provide knowledge and experience about particular geographic or social contexts, which might be misrepresented by decontextualized scientific knowledge. Against this background, one can reasonably regard the postmarket monitoring as an important step toward explicitly recognizing the equal validity of the various scientific cultures of nonknowledge as well as of the multifarious perspectives in society on what is not known. Nevertheless, it would be mistaken to neglect its both conceptual and practical limitations. For instance, it is still unclear and highly contested which spatial segments are to be observed in general surveillance and which time-spans are relevant to detect unexpected effects of GMO release; which kind of indicators might be informative; which and how many nontarget organisms should be included; or, more basically, what is to be understood as an exceptional phenomenon that should trigger further research or political action.[15] What ultimately remains open in all these political and scientific debates is the fundamental question of how the *observability* of harmful effects can be warranted in cases in which we do not know where, when, and how we should search for them. PMEM certainly offers an institutional context for integrating a plurality of scientific cultures of nonknowledge, thus strengthening both the factual rationality and the social legitimacy of technological and political decision making. Yet, inasmuch as it tacitly relies on the timely observability of undesired consequences, it still sticks to the "epistemological optimism" (Strand 2000) characteristic for control-oriented epistemic cultures.[16] Since the monitoring is obviously neither able to assure that harmful consequences of released GM plants will be detected "in good time for corrective action" nor able to provide the definite answer to the question of how to correctly deal with nonknowledge, one can reasonably assume that it is more likely to foster than to stop the ongoing politicization of nonknowledge.

One important conceptual move beyond the still widespread epistemological optimism can be seen in the search for what we have elsewhere termed "second-order indicators of nonknowledge" (Böschen et al. 2006, 2008). By this term, we mean novel indicators that do not point to already specified and calculable risks of certain technological interventions but are intended to denote the possibility, probability, or even inevitability of unknown and unforeseeable dangers due to the amount of nonknowledge produced by those technological interventions. Originally developed in the field of environmental chemicals regulation (Scheringer 2002), this concept responds to the fact that, on one hand, we are unable to gain complete positive anticipatory knowledge of all possible effects and interactions of the about

100,000 chemical substances already released to the environment, but, on the other hand, we cannot necessarily rely on the fact that we will detect hazardous consequences early enough when they occur, as the case of CFCs prominently highlights. A promising solution to this predicament might consist in looking for indirect indicators of the probability of unknown unknowns inherent to a scientific or technological artifact. With regard to environmental chemicals, the temporal persistence and spatial range of the respective substances appear to be such useful second-order indicators: "According to the precautionary principle, chemicals with high persistence and/or spatial range should not be released to the environment. Although their effect potential is unknown, the potential for long-term and widespread exposure is a problematic property by itself." (Scheringer 2000, 94)[17]

(2) Institutional reactions to the politicization of nonknowledge are also observable in the social conflicts around the possible health risks of radiation from mobile phones and masts (if certainly in a less explicit and prominent form). Policy makers, following the majority of scientific experts, continue to emphasize that there are no risks resulting from EMFs generated by phones or masts since the acceptable exposure levels, which focus on thermal effects currently are far from being exceeded. Nevertheless, political actors increasingly take notice of and institutionally react to concerns expressed by citizens and dissenting experts about unknown and unanticipated risks to human health, for instance related to long-term use of mobile phones (see section 3 and Stilgoe 2005, 2007; Soneryd 2007). While the political reasons for such institutional efforts may be largely strategic, mainly motivated by the will not to jeopardize the enormous economic success of the mobile phone technology with ill-balanced and untrustworthy risk communication,[18] they actually take into account that in society a plurality of perceptions of what is not known about mobile phone risks persists and that these perceptions cannot or should not simply be marginalized as unfounded and irrational. In 1999, the UK government for instance installed a new, independent group of experts on the possible health risks of mobile phone technology (IEGMP), when the established advisory board, the National Radiological Protection Board (NRPB), was criticized in the public sphere "for its apparent narrow-mindedness in the consideration of scientific uncertainty and its rejection of nonexpert considerations" (Stilgoe 2005, 56). The independent group was by far more open to a plurality of views and public concerns about hitherto unknown effects or long-term consequences of mobile phone use, and in its report, it gave more room to a precautionary approach, including the

recommendation that children be discouraged from using mobile phones (Stilgoe 2007, 51ff).

Quite similarly, a public deliberation exercise conducted in Sweden in 2004 and 2005, the "Transparency Forum for Mobile Phone Communication" followed the aim to include "various conceptions of knowns and unknowns" (Soneryd 2007, 305). Reacting to emerging social protest against the so-called third generation of mobile phone nets based on the Universal Mobile Telecommunications System (UMTS) standard, the Swedish Radiation Protection Authority (SSI) arranged the forum and, besides other actors, explicitly invited two groups to participate, which are known to be critical of mobile phone communication, one of them the Swedish Association for the ElectroSensitives (Soneryd 2007). While this inclusion of critics and their views can be interpreted as an acknowledgment of different evaluations of what is known and not known about mobile phone health risks, the debates during the forum seemed to demonstrate, above all, the incompatibility of the different cultures of nonknowledge as well as the continuing dominance of the control-oriented epistemic culture in institutional risk regulation. An SSI official rejecting the idea of "anecdotal evidence" as a sort of potentially valid single case-specific evidence is quoted by Soneryd (2007, 305) as follows: "The basis for SSI is scientific, and as I see it, anecdotal evidence is something else. I don't know how to deal with that."[19] As Lezaun and Soneryd (2007, 292) conclude, the SSI "appears keen to mobilize stakeholders in a (. . .) dialogue on the risks of mobile telephony, but does not seem particularly willing to be itself moved by the process of consultation."

Conclusion

Obviously, the pluralization and politicization of nonknowledge claims pushed forward by the various societal actors is a crucial phenomenon in both controversies, resulting in new institutional reactions. In the agribiotechnology as well as in the mobile phone debate, control-oriented epistemic cultures are faced with the threat of losing their authority to define the unknown and its relevance (albeit to a different degree in the two areas). The routine focus on known unknowns is countered when environmental or consumer NGOs, Green Parties, or scientists from different epistemic cultures appeal to the possibility of unknown unknowns as frequently exposed by historical experience. Emphasis on the "not-yet-knowns" is contrasted with references to effects that might remain undetected for long periods of time or be entirely intangible for understanding and control.

Thus, what we have tried to highlight in our article is the fact that not only knowledge and risk are implicitly normative concepts (as has repeatedly been demonstrated by numerous STS scholars) but nonknowledge as well. Instead of representing a simple, amorphous lack of knowledge, nonknowledge is constructed, assessed, and communicated in contrasting or even incompatible ways by social actors who selectively refer to different epistemic cultures within the sciences.

The above illustrated pluralization of nonknowledge claims seems to exacerbate social conflicts over technological risk, at least at first glance. For epistemic and political dissent is expanding and shifting from the valid interpretation of what is known to the evaluation of what is *not* known, any effort to settle such disputes by reference to the available evidence becomes self-refuting in the face of possible unknown unknowns. Nevertheless, as already implied by the examples given in the previous section, *the plurality of cultures of nonknowledge should be understood as furthering rather than hindering or even rendering impossible responsible and socially robust decision making*.

Yet, the unrestricted recognition of the three cultures of nonknowledge (portrayed in section 2 as equally valid and rational ways of dealing with what is not known) has only halfheartedly been conceded by the established regulatory institutions. To recognize and use this plurality would certainly help increase the factual rationality as well as the social legitimacy of risk regulation, while, by contrast, the continuing marginalization of complexity- and single case-oriented epistemic cultures would be likely to fuel and perpetuate social conflict and public mistrust. However, what we argue for is not simply "more" participation of "more" social actors but rather an epistemologically sensitive institutionalization of participation, which makes sure that the variety of different epistemic cultures is equally represented and acknowledged.

This request for full recognition also applies to the argumentative reference to "unknown unknowns," although the latter can obviously be used merely strategically to obstruct any technological innovation. Nevertheless, the appeal to possible unknown unknowns is highly valuable because it sensitizes for the limits of the established scientific practices and *foci* of attention, initiates the search for second-order indicators for potential unknown risks, and emphasizes that negative effects of technological innovation will not always be detected easily and in good time. Arguments from unknown unknowns thus make clear that conflicts over technological innovations cannot be resolved on the basis of matters of fact but require an ultimately *political* decision about what unknown and unforeseeable risks social groups or societies are willing to undergo. Although there will be no definite, consensual solution to the political dynamics of scientific nonknowledge, it seems indispensable to establish transparent, pluralistic, and unbiased processes of deliberation and decision making under conditions of contested nonknowledge claims.

Notes

1. Introducing the unknown with its various forms and multiple meanings into social theory and sociology of knowledge raises a number of rather difficult conceptual and terminological questions (cf., Smithson 1989, 2008; Wynne 1992; Stirling 2006; Wynne and Felt 2007; Gross 2007; Stilgoe 2007). By contrast to Stilgoe (2007, 58, note 3), we will not use "uncertainty" as a sort of catch-all-concept for *any* form of absent or incomplete knowledge but rather emphasize the analytical difference between uncertainty, as a variant of knowledge, if incomplete, and nonknowledge, understood as the absence of knowledge. Contrary to other scholars such as Gross (2007, 749) or Smithson (2008, 210) and to avoid the negative evaluation occasionally linked with the term "ignorance" in the sense of actively and consciously "ignoring" something knowable, we prefer to use nonknowledge rather than ignorance as a kind of general cover term for the different variants of not knowing.
2. With regard to BSE see for instance van Zwanenburg and Millstone (2005), with regard to GMOs see Wynne (2001); Levidow, Carr, and Wield (2005); Boschert and Gill (2005); Bonneuil, Joly, and Marris (2008), with regard to mobile phones Stilgoe (2005, 2007); Drake (2006); Soneryd (2007).
3. Our empirical investigation of scientific cultures of nonknowledge draws on expert interviews as well as on the analysis of scientific papers and textbooks. The selected research fields include molecular biology, plant breeding science, ecology, biomedicine, radiation physics, and epidemiology; two professional fields, practical medicine and "building biology" were also included. The research was conducted within the research project "Cultures of Non-Knowledge" (Nichtwissenskulturen), funded by the German Federal Ministry of Education and Research (BMBF) between 2003 and 2007.
4. Knorr-Cetina emphasizes that this comparison does not imply a general superiority of one epistemic culture over the other. Instead, she is concerned with a symbolic conception of epistemic cultures that points at the relative differences between the epistemic strategies of the two fields.
5. Due to restrictions of space, this typology is only roughly described and explicated here. For a more detailed account of molecular biology and ecology as exemplary cases, see Böschen et al. (2006); for a comparative account of the three ideal types and their interrelation, see also Kastenhofer (2007). In a similar

way, Bonneuil (2006) discerns and compares diverging epistemic cultures within the GMO debate, namely the ones of molecular biologists, population geneticists, and agronomists.

6. The German interview passages have been translated into English by the authors.
7. To illustrate this, we carried out an analysis of the arguments used by experts from various institutional fields concerned with either agri-biotechnology or mobile phone safety. Overall, 67 interviews were undertaken between 2004 and 2007. Interviewees were selected from relevant governmental organizations, private industry, NGOs, and public research institutions. In both areas, more than half of the arguments deployed were found to refer to nonknowledge in some way or another, more than a third referred to nonknowledge in a rather strong way. The question of how to correctly conceive and appraise what is not known therefore becomes an increasingly important arena of social conflict whereas science, due to epistemic pluralization, is no longer able to offer a consensual and authoritative definition.
8. The Oeko-Institut is an independent research institute that was founded during the 1970s to lend the German antinuclear movement scientific support.
9. The mobilization of scientific authority for an alternative epistemic approach was also achieved by presenting a conference reader with interviews with nine established scientists (Greenpeace 2005).
10. The constant ignorance of experts from the field of environmental medicine was accompanied by the creation of environmental medicine NGOs (e.g., the "Interdisziplinäre Gesellschaft für Umweltmedizin" and the "Ökologische Ärztebund"). These NGOs publish expert opinions and organize workshops on issues such as the possible societal impacts of agri-biotechnology.
11. A special case in point is the German bio-safety research program (Biologische Sicherheitsforschung) of the Federal Ministry of Education and Research (BMBF). At least for the time being, this research program is highly selective with respect to the different epistemic cultures and follows a control-oriented approach defining the scope of nonknowledge rather narrowly[0]. Struggles to shape and influence the program can also be read as struggles to influence which cultures of nonknowledge are included in and which are excluded from risk assessment processes. Moreover, these struggles point at the more general difficulty of the double remit of the BMBF to both support and regulate innovation.
12. The scientists identified specific subgroups in which a significant statistical correlation between the usage of mobile phones and the incidence of cancer could be found. These subgroups included people who had been using the mobile for a longer time period or people who reported use of the mobile phones

on the same side where the brain tumour occurred (cf., Hardell, Carlberg, and Mild 2006).

13. Hardell and colleagues themselves criticized other studies with regard to the selection criteria for the study groups (too short tumor-induction periods, early mobile phone users are not representative of the whole population in socioeconomic terms, the cohort only includes adults of more than eighteen years of age, while highest risk is assumed for exposure before age twenty) and control groups (exposure of control groups is not assessed correctly), thereby enacting a complexity oriented approach. From the few studies they do approve of, they conclude that "most of these results are based on low numbers but nevertheless may together give a pattern of increased risk." This confidence in small numbers and refined interpretative methods mirrors a single case-orientation (Hardell, Mild, and Kundi 2007, section 10, p. 3).
14. See Collingridge (1980, 30): "Whatever decision is made, factual information which would reveal it to be wrong must be searched for (. . .)." Strikingly, this claim, derived from Popperian philosophy of science, has been largely ignored by institutional politics for more than two decades.
15. Furthermore, it remains open to discussion whether and how far the general surveillance should be based on environmental data, which are already available but were collected for quite different purposes. In addition, environmental NGOs such as the British *Soil Association* criticized the insufficient scope of the monitoring, for instance, the abandoning of human health monitoring (Soil Association 2003).
16. With the terms "epistemological optimism" and "epistemological naivety" Strand (2000) characterizes the implicit or explicit belief held throughout the life sciences that knowledge generated in the controlled and artificial context of the laboratory will be valid also in real-world situations, and thus there will be no relevant unanticipated effects caused by unknown interactions outside the laboratory.
17. A first effort to transfer this concept to the cultivation of GMOs has been undertaken by a German research group (see Züghart et al. 2005). The group developed an assessment matrix along the criteria of persistence and spatial reach. An assessment along these parameters results in a negative appraisal of the cultivation of rape in Germany while a cultivation of corn seems acceptable in this biogeographic region.
18. It thus comes as no surprise that, particularly in the United Kingdom, policy makers, and regulatory institutions were anxious not to repeat mistakes made during the BSE disaster and the early stage of the GMO regulation (see Stilgoe 2005, 2007; Drake 2006).
19. The British IEGMP, by contrast, argued in its report that "anecdotal evidence should be taken into account" (quoted from Stilgoe 2007, 53), thus

acknowledging, at least rhetorically, the validity of a single case-oriented epistemic culture and its objections to decontextualized and generalized scientific knowledge.

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