Chapter 6
Systems Biology Goes Public: Representations in German and Austrian Print Media

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Abstract Media are central for communicating science and its achievements to the public, for the public's discussion of science, and for transferring public opinions and perspectives back into science. In this chapter, we focus on the representations of systems biology in German and Austrian print media. The public perception is analyzed both quantitatively and qualitatively and focuses on the images of systems biology communicated to the public, including its application, research funding, and regulation. These images are derived from an analysis of metaphors that enables us to describe the underlying metaphorical frames and concepts. As we take into account the national differences and compare the public images of systems biology in Germany and Austria, we find some significant differences between both countries in the predominant metaphorical frames. The public image is well reflected in these metaphors, and we suggest that they have an important role in the public understanding of systems biology.

Keywords Systems biology • Media • Public • Science and Society • Metaphor

Media are central for communicating science and its achievements to the public, for discussing research in and by the public, and for transferring public opinions and perspectives back into science. The way this is done has a strong impact on the perception and discussion of science in society. Media representation hence also presents relevant aspects of the public perception of and perspective on systems biology. Metaphorical framings used in these settings influence the perception significantly due to their underlying meaning.

This chapter presents the results of a media analysis of systems biology: it focuses on images and metaphors used to depict systems biology, its approach and goals. We start with a broad analysis of how systems biology is depicted in the media, and discuss three questions: (1) which images of systems biology are communicated to

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the public, (2) what images are used to frame research funding and regulation, and (3) are there national differences between Germany and Austria that stand out?

Following a short introduction into print media as a mediator between science and society (Sect. 6.1), we discuss the relevance of metaphor analysis to identify public images of systems biology in the media, introduce our methodological approach, and describe how we set up the media corpus for our sample (Sect. 6.2). For Germany, we provide an overview of the different metaphorical frames we found in our sample before we continue with a more in-depth analysis of the most important frames and their underlying metaphorical concepts (Sect. 6.3). For Austria, we follow the same approach, starting with an overview followed by the analysis and excerpts for selected metaphorical concepts (Sect. 6.4). Based on this detailed analysis, we compare the public images of systems biology in Germany and Austria, bring attention to similarities and some significant differences between both countries, and develop conclusions and consequences from the use of metaphorical descriptions of systems biology relevant for understanding the current and future role of an emerging approach (Sect. 6.5).

6.1 Print Media as Mediator Between Science and Society

It is without question that media in general have an important function for both science and society today[1] as the relationship among science, media, and the public has changed: media do not only react to scientific developments but take on a more and more proactive role that influences not only society but also science and politics. Knowledge, however, is not simply passed on from scientists to the public. In fact, science, the media, and the public interdepend and influence each other. Thus, there is no one that can be identified as the main actor. Instead, all participating systems act and react to one another. Accordingly, this communication cannot be described as a one-way transfer of knowledge from science to society as there is clear evidence that public perception also influences science, its practice, and direction through the media. As Weingart (2001, 241) argues, feedback resulting from published research and the interaction between public opinion and scientific practice must be taken into consideration by scientists. With the "medialization of science" (Weingart 2005, 28), media do not only communicate scientific results to the public: they define a new relationship between science and society. Science is "construed" in public and becomes "public science". At the same time, science refers to public expectations and demands, thus creating its own, new public, Weingart's "science of public" (ibid.; translation by the authors).

As a result, science becomes more and more visible in the media. Also public opinion is reflected and passed on to science.[2] Our increasingly medialized society is

[1] Rödder (2011) for example, provides an overview of several longitudinal studies of news coverage on the relationship of media and science.

[2] The feedback system also includes politics, industry, and other stakeholders. Its complex internal structure of interrelationships requires a more thorough analysis; compare in more detail Chap. 5.

thus characterized by a greater acceptance and stronger significance of media as an intermediary between different sectors or systems of society.[3] The manner in which scientific information is communicated has a strong influence on its public perception and vice versa. Therefore, media must be considered an important source for the examination of the depicted, communicated, and perceived role and meaning of new developments in science, such as systems biology. This exchange, and the media's mediating function require a critical reflection.

Analysis of print media therefore is a useful tool for examining not only the public perception of science, but also how science is positioned and framed in the media, and how political, scientific, and public discourse interrelates. Our perspective on this circle of interaction is enabled by a print media analysis that acknowledges how scientific concepts or results of systems biology are communicated to the public, but also takes into account how public opinion takes on and reflects systems biology, both regarding its role in shaping the future and its assumed implications. This leads us to the central question of this chapter: how is systems biology addressed and conceptualized in the media? And what role does this representation play for science and the public?

6.2 Metaphors in the Press: Media Images of Systems Biology

Before presenting the different media images of systems biology in the German and Austrian press, we first outline the rationale for using metaphor analysis as a tool for investigating depictions of systems biology in the media. In order to do this, we identified and studied the metaphors used in media language. Metaphor analysis aims at uncovering "patterns of meaning including their ideological attachments" (Fairclough 1989, 119) or "loadings" (Halliday 2001, 190). We use it as a tool to understand interpretations of systems biology that can be found in the media. Drawing from cognitive linguistics, we thus aim to understand how the conceptualization of systems biology underlies and informs public discourse.

6.2.1 Analytical Goals and Methodological Approach

For the present analysis, we used an approach which assumes that a new field such as systems biology is figuratively represented by a set of different metaphors; its perception is diverse and its meaning and purpose have not yet been defined in the public discourse. As such, metaphors not only create and influence conceptual relations but also have an impact on our daily life, be it public or scientific. They help to identify the conceptual frames permeating the news-speak, and thus enable a

[3] Some authors have therefore started using the term media society (comp. in detail Vowe et al. 2008).

deeper analysis and understanding of the possible meanings and interpretations of such a new field, in this case of systems biology. It is important to remember that metaphors take on a double role: they are both a representation of the interpretation of its owner, and a tool to shape the interpretation of others.

Metaphors are an important and irreducible social part of language (see also Chap. 3 and glossary). In a metaphor, meaning is "carried somewhere else"[4]. The classic definition of a linguistic metaphor focuses on words[5] and suggests that in language some words are static and others carry transferred meaning. In its Aristotelian interpretation, the primary function of metaphors is purely ornamental. In modern cognitive linguistics, however, metaphors are perceived as an essential quality of language; they transfer meaning from a source domain to a target domain; thus, they describe or at least indicate conceptual relationships between those domains. Conceptual metaphors were introduced to the wider scientific community by the linguists Lakoff and Johnson (1980), and subsequently developed further into conceptual metaphor theory (e.g. Johnson 1987; Lakoff 1987, 1993; Lakoff and Turner 1989).

Conceptual metaphors help to describe the framework used to think about a topic and to illustrate it. They are an indispensable means of perceiving and understanding the world. According to Lakoff and Johnson (1980) "metaphor is pervasive in everyday life, not just in language, but in thought and action. Our ordinary conceptual system […] is fundamentally metaphorical in nature" (Lakoff and Johnson 1980). They describe conceptual mapping as a transfer from a source to a target domain. This transfer has a central role in explaining and understanding as the unknown is made accessible through the known, by blending into one another: "And this is a result of the massive complex of our culture, language, history, and bodily mechanism that blend to make our world what it is" (Lakoff and Johnson 1987, 104). This mapping is consequently realized in language. Lakoff and Johnson used the example of "LOVE is WAR" to illustrate how we speak (and think) about a very human feeling. For instance, the saying that "he is slowly gaining ground with her" highlights aspects of rivalry, competition, and fighting in a most positive human feeling and makes them explicit. Different submetaphors can also be part of a broader conceptual system as they "jointly provide a coherent understanding of the concept as a whole" (Lakoff and Johnson 1980, 89). Although an analysis of linguistic metaphors might not reveal all conceptual metaphors that structure our mental representation of the world around us, they are seen as an important "source of hypotheses about the structure of abstract concepts" (Casasanto 2009, 143).

Metaphor analysis is thus an instrument to unravel the linguistic and conceptual framework that underlies new areas of interest in society and science. It is a central tool to detect changes in language, and especially to demonstrate the individual and societal meanings assigned to an emerging field such as systems biology. Changes in language used in texts describing scientific research and its results can be induced by a change of perspective that itself might be a result of scientific or technological

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[4] Literal translation of the origin greek verb *μετα-φορέω*, (to) carry over.

[5] More correctly: *lexemes*. Lexemes mean the abstract unit of a morphological analysis.

progress. Even scientific texts are not immune to meanings introduced by metaphors; they can “generate new ideas,” and be understood as a “productive form of meaning” (Gehring 2009, 81). Therefore we study “metaphors as cognitive *and* social devices, as being anchored in human experience *and* as being anchored in shared cultural experiences” (Nerlich et al. 2002, 93). The use of metaphors also has a societal dimension because they enable us “the control of the world that we make for ourselves to live in” (Richards 1936, 135; cited in Nerlich et al. 2002, 92).

Several studies have already examined the sociocultural role of metaphors. Nelkin (2001) worked on metaphors deriving from science, for example, for genes in public discourse (Nelkin 2001), Kamara (2009) on the language used in green biotechnology. Döring and Nerlich (2004) used metaphor analysis to investigate the public discourse on stem cells in the United Kingdom. With regard to systems biology, Ouzounis and Mazière (2006) reflect on the current use of metaphors in this field, challenging the conception of systems biology.

Investigating the use of metaphors in the media might be able to support a critical reflection of how science sees and positions itself. Three arguments can be brought forward in support of this hypothesis: First, such metaphors were used within the scientific community to describe the new field of systems biology; second, some scientists appropriated the metaphors to explain their practice and thinking to the public; finally, journalists reused them to convey their perspective on science and communicate it to the greater public. Because the media are not only used by scientists in order to spread an opinion about science, but also by politics, the public, or journalists, it can be seen as a means for multidirectional communication between the public, science, and politics.

Our research focuses on the question of how systems biology is conceptualized in the media by using metaphors from different fields of origin and on the meaning that is given to systems biology by the use of these metaphors. To analyze these metaphorically structured patterns of meaning, several steps are necessary (see Box 6.1; compare Döring 2005, 163; Jäkel 1997, 153–154; Jäkel 2003):

Box 6.1: Steps of Metaphor Analysis

1. *Compilation of a text corpus and characterization of text sources* (e.g., for daily papers and journals regarding target group, political periodicity, etc.).
2. *Extraction of linguistic metaphors on a word by word basis*. The relevant lexemes are marked and initially tagged in the corpus and a list of metaphors is compiled.
3. *Identification of a source domain for each metaphor based on the literal use of the lexemes*. The metaphors are tagged in the corpus using the source domain (e.g., for “time is money” the source domain is money/currency).
4. *Lookup of lexemes and identification of semantically similar units*. The meaning of all identified metaphors is checked (simply using a lexicon or for ethical aspects also in co-occurrence databases to check the source domain).

(continued)

Box 6.1: (continued)

5. *Development of conceptual metaphors*. Based on all identified lexemes, a conceptual metaphor is developed and phrased in the form of "target concept *is* source domain". An identification of coherences and connections between the conceptual metaphors prepares the next step of creating a structured overview of all identified metaphors
6. *Development of a construction frame for the conceptual metaphors*. The conceptual metaphors are grouped to create greater units of meaning that help summarize different directions for metaphors as cognitive and social devices.

With these steps, it is possible to identify, structure, and label different conceptual metaphors. However, as in every categorizing approach, some details in difference between metaphors are lost by this procedure. In order to increase transparency and to present our approach, we therefore not only list the construction frames and conceptual metaphors we arrived at, but also depict some exemplary metaphors in detail.

We start with both the analysis of German (Sect. 6.3) and Austrian (Sect. 6.4) media with a brief description of a general conceptual frame and look at conceptual metaphors[6] with linguistic examples that help to illustrate the different perspectives evident in the media discourse.

Following the national analysis, we compare the public discourse in Germany and Austria. Although both are German-speaking countries and thus draw from the same metaphor resources, the two countries are of very different size and have been through different historical and cultural developments. Regarding systems biology, Austria has perhaps the longer history, going back to Bertalanffy presenting his *Allgemeine Systemtheorie* in the early 1930s (comp. Drack et al. 2007 and see Chap. 2 in this book). With regard to today's situation, however, research funding for systems biology in Germany is stronger than in Austria.

6.2.2 Media Sample

For this analysis, we selected printed media for reasons of their high-quality information standard. Our aim was to gather a rich sample with social relevance and a balance between weekly and daily newspapers as well as between political positions that include the most important and influential print media for both Germany and Austria. For Germany, the sample contains three daily newspapers: *die tageszeitung*, *Die Welt*, *Frankfurter Allgemeine Zeitung* and *Süddeutsche Zeitung*. Also, two magazines and weeklies were included in the sample: *Der Spiegel* and *Die Zeit*. Finally, *Spektrum der Wissenschaft* was chosen as a popular science magazine clearly aiming at science communication with the public. For Austria, the sample

[6] A full account of the identified metaphors is in preparation and will be published elsewhere.

includes the daily newspapers, *Der Standard*, *Die Presse*, *Kleine Zeitung*, *Neue Kronen Zeitung*, and *Salzburger Nachrichten*. The weekly newspaper *Profil* completes the sample.

6.3 Systems Biology in the German Press

Two concepts of metaphors that stood out very prominently characterized German press coverage. Metaphors relating to the first concept stem from the domain of orientation and are used both for the subject of research and the scientific discipline of systems biology itself. Examples for the second concept frame the subject of control. As we show, the concepts include different aspects of the promise bound to or associated with systems biology. Starting with the different metaphors we identified—and taking their relative importance and relation into consideration—we built a conceptual frame characterizing the picture of systems biology in German media. We defined the frame as ***Doing SB is Needing Orientation and Getting Control***. It consists of many metaphorical concepts, of which the most important are introduced here.

6.3.1 Systems Biology and the Search for Orientation

The central metaphorical concept ***Doing systems biology is looking for orientation***[7] has two sides: systems biology is still being conceptualized as an emerging science that has not achieved the establishment of a clear direction in public perception. At the same time, it is seen to hold the promise to provide direction, also beyond its immediate goals and boundaries. Several subconcepts represent different aspects of this search for orientation and address topics such as *way*, *mapping*, and *transfer*.

Examples for the *way* metaphor include an article from *Der Spiegel* on March 5, 2008 stating that "The program supports highly innovative projects in Eastern Germany with a total of 45 million Euros. Optical microsystems were selected as well as the research areas […] medical systems biology […]. Schavan called the support of these six pilot projects a "***milestone for the promotion of innovation***."""[8] Further examples are that "[i]n the United States, the establishment of the first center for systems biology in Seattle already ***set the course for this***"[9] (*Spektrum* 8/2002), and "[i]n Germany, too, one should continue to pave **the way** ***that has***

[7] Metaphors are set bold and italic.

[8] German original: "Das Programm fördert hochinnovative Projekte in Ostdeutschland mit insgesamt 45 Millionen Euro. Ausgewählt wurden außer optischen Mikrosystemen die Forschungsgebiete […] medizinische Systembiologie […]. Schavan bezeichnete die Förderung dieser sechs Pilotprojekte als "**Meilenstein für die Innovationsförderung**.""

[9] German original: "In den Vereinigten Staaten wurden mit der Gründung des ersten Zentrums für Systembiologie in Seattle bereits **die Weichen dafür gestellt**."

already been taken by promoting genome research and effectively bundle knowledge by establishing such centers. ***The first steps in the right direction*** have been taken. But since nobody is able to predict ***how long the path will still be,*** we can only hope that support will not run out of steam halfway through"[10] (*Spektrum* 8/2002).

As the quote cited above and others show, *way* metaphors have moved from their source domain into a development and project context. In short, this indicates that system biology is represented as a scientific area that is still underway and has not yet reached its destination. Systems biology is not perceived as an established field, but as a discipline that has successfully taken some first steps but needs further support. Here, public perception is not so much influenced by scientific progress or individual results, but the focus is more on establishing the discipline itself in the scientific landscape.

On a more reflexive level, the scientific need for orientation surfaces in the metaphorical concept ***Doing systems biology is mapping the biological space***. This refers to the need to get oriented in science by mapping a field to get an overview and put single parts together. This concept is exemplified by metaphors such as "Everything falls within the category of systems biology. It is supposed to examine the new 'inventory lists' of biological systems at a ***higher level***"[11] in *Süddeutsche Zeitung* (January 7, 2004). Another example is "***Complete mapping*** of all disease gene variants of all patient genomes permits the application of dosages and combinations of pharmaceuticals specific to the individual. Each person has all their genome's information on a chip that physicians use for diagnoses and pharmacists for determining dosages"[12] in *Die Welt* (December 29, 2005). And also, "Systems biology, too, is showing progress that makes it possible to bring together the body's metabolic processes ***on a kind of map***: for example, 8,000 chemical signals in the complex network result in the programmed death of a cell"[13] in *Die Welt* (December 23, 2005) or "Mycoplasma pneumonia is systems biology's first model organism: ***Systems biology observes life from a higher vantage point***. It seeks to understand all molecular processes and to produce computer simulations of them. Its goal is

[10] German original: "Auch in Deutschland sollte man **den Weg, der durch die Förderung der Genomforschung bereits eingeschlagen wurde**, weiter ebnen und mit der Schaffung solcher Zentren Wissen effektiv bündeln. **Die ersten Schritte in die richtige Richtung** sind gemacht. Aber da niemand vorherzusagen vermag, wie lange der Weg noch sein wird, bleibt nur zu hoffen, dass der Förderung nicht auf halber Strecke die Luft ausgeht."

[11] German original: "Über allem steht der Begriff der Systembiologie. Sie soll auf einer **übergeordneten Ebene** die neuen ‚Inventarlisten' biologischer Systeme untersuchen."

[12] German original: "Die **Gesamtkartierung** aller Krankheits-Gen-Varianten aller Patientengenome erlaubt die Anwendung von individuumspezifischen Dosierungen und Medikamentenkombinationen. Jeder trägt die gesamte Information seines Genoms auf einem Chip, die beim Arzt zur Diagnose oder Apotheker zur Dosierung abgerufen wird."

[13] German original: "Fortschritte zeigt auch die Systembiologie, die es möglich macht, die Stoffwechselvorgänge des Körpers **in einer Art Karte** zu vereinen: Zum Beispiel führen 8,000 chemische Signale im komplexen Netzwerk zum programmierten Tod einer Zelle."

the virtual cell"[14] in *Frankfurter Allgemeine Zeitung* (December 2, 2009). Mapping can thus be seen as an experimental practice that seeks orientation in an undiscovered field.

In contrast to the metaphorical concept of finding a way, these quotations show that it seems to be a part of systems biology itself to strive for orientation. As systems biology is described as mapping process, concepts such as discovery are invoked: science becomes a tool *to map out* unknown territory, for instance in *genome mapping* which aims at representing the human genome.[15] We saw that the very subject of systems biology itself needs to be defined in public perception, however, systems biology is at the same time seen as holding a promise for discovering and mapping out areas in other life sciences, medicine, and health.

Finally, the metaphorical concept of ***biological processes are transfer*** appears in this context. An example from this domain is *Der Spiegel* reporting "One near-term goal, however, is to ***inject*** genomes into bacteria shells that will transform the single-cell organisms into mini-factories. The era of genetic engineers has already begun"[16] (December 27, 2008). The German connotation of *einschleusen* goes back to water gates which are used in inland waterways. In the quotation they denominate the cell *gates* through which genetic material is inserted into bacteria. Yet, there is also a link to illegal immigration, something that is forbidden and associated with potential negative impact. For systems biology, this metaphor is closely linked with communication and networks: information is often transferred from one domain into another; two areas become linked that were previously set apart (cf. Cellular Networks: Ouzounis and Mazière 2006). When the different connotations are combined, it becomes clear that transfer in systems biology is perceived to have an element of transgression; an element of unpredictability that is bordering risk resonates as existing frontiers are crossed. The ***biological processes are transfer*** metaphor is often used when authors do not clearly distinguish between synthetic biology and systems biology, or the latter is seen as a tool for the former. Thus, synthetic biology as a more exposed scientific discipline is often employed to explain the emerging approach of systems biology.

All three conceptual metaphors on orientation, mapping, and transfer relate to the same domain: that of orientation. However, they highlight that orientation has several meanings in the context of systems biology and that there is a dynamic change in the discipline itself, in its subject, and in the public expectation towards the new development.

[14] German original: "Mycoplasma pneumonia ist erster Modellorganismus der Systembiologie: **Die Systembiologie schaut von einer höheren Warte aufs Leben.** Sie will alle molekularen Prozesse verstehen und im Computer simulieren. Ihr Ziel ist die virtuelle Zelle."

[15] See http://www.genome.gov/. Accessed November 15, 2014.

[16] German original: "Ein naheliegendes Ziel aber ist, in Bakterien-Hülsen Genome **einzuschleusen**, die die Einzeller in Mini-Fabriken verwandeln. Die Ära der Geningenieure hat schon begonnen."

6.3.2 Controlling Nature

In the media discourse, systems biology means not only orientation and the search for it, but goes one step beyond: doing systems biology also means to get under control. While mapping points more to the structuring of the field, getting control refers to acquiring a better grasp or more power. This is reflected in further important metaphor that introduces the notion of control: for ***Doing systems biology is getting control*** we identified six subconcepts that concern engineering, machines, industrial production, vessel, tools, and architecture.

As one prominent example, ***biological processes are industrial production*** is used as a metaphor. Systems biology is compared with historic images of industrial production; its subject is associated with the efficient manufacturing of results. It also means that processes can be understood, and regulated in order to optimize or match certain production criteria. As already reported, *Der Spiegel* wrote, "One near-term goal, however, is to ***inject*** genomes into bacteria shells that will transform the single-cell organisms into mini-factories. The era of genetic engineers has already begun" (December 27, 2008), and *Der Spiegel* further reported: "The type of genetic engineering that has so far usually followed the motto, "***inject*** a new gene into an organism and see what happens," is in effect supposed to be replaced by real engineering to design new organisms. Systems biology provides the basis for this: Every genetic network in organisms is to be ***disassembled into individual components, modules that can then be combined in new ways, as is normally possible with technical components.*** The model is the IT sector that started out from individual circuits developed separately and builds processors using standard parts today"[17] (December 27, 2008). We also found a newspaper discussion of a new book authored by philosopher Klaus Mainzer that demonstrated a more reflected perspective on the machine metaphor: "If humans were machines, it would be possible to calculate their lives. This notion has fascinated and frightened people since the Renaissance. In synthetic biology, robotics, and artificial intelligence, it now seems to be becoming reality. But only at first glance. After all, the further researchers decode the interplay of the ***little molecular screws, levers, and cogs*** in our cells, the more clearly they see that the machine metaphor is inappropriate: it has long been replaced by the complex dynamic system. And its ***analysis tool*** is not calculation, but ***computer simulation***. […] In systems biology, the idea of the dynamic system is the **key**

[17] German original: "An die Stelle einer Gentechnik, die bislang meist nach dem Motto operiert, "**schleuse** ein neues Gen in einen Organismus und schaue, was passiert," soll quasi echte Ingenieurtechnik beim Design neuer Organismen ran. Grundlagen dafür liefert die Systembiologie: Jedes genetische Netzwerk in Organismen soll in **Einzelteile, Module, zerlegt werden, die sich dann wie technische Bauteile standardmäßig neu kombinieren lassen**. Vorbild ist die IT-Branche, die ihren Ausgangspunkt auch von individuell entwickelten einzelnen Schaltkreisen nahm und heute mit Normteilen Prozessoren baut."

to the complexity of life, Mainzer said."[18] (*Frankfurter Allgemeine Zeitung*, November 23, 2010). Describing bacteria as being turned into factories and machine modules by the media suggests that as a start their parts can be analysed and their whole working mechanism be understood. Also, biological parts work together like parts of a machine; if one part of the whole fails, it can be replaced by another part, be it natural or artificial. The well-known image of a machine is no longer sufficient to describe complex processes. Nonetheless, it is still useful to have an image at all to explain a new topic (the complex interplay) drawing from a well-known image (the machine). Even if the discussion highlights the limitations of the machine metaphor with regard to the modeling of biological complexity, it remains within the same framework when replacing the mechanical machine with the computer simulation as an analogy. Perhaps due to the lack of a better analogy, perhaps due to its power in highlighting the strategic aim of systems biology in analyzing smaller parts in order to understand and predict the behavior of larger systems, the mechanical metaphor is reused even when it is limited with regard to what can be said and thought: it is used as it aligns with experiences made previously in other fields.

A further metaphoric concept relates to the aspect of ***Doing Systems Biology is engineering***. Examples relating to this subconcept include the *Frankfurter Allgemeine Zeitung* asking "What do the new biovisionaries have to say? ***Engineering mindset*** flourishing in synthetic and systems biology: Do limits exist for the genome creatures? Germany, the land of the ***bioengineers*** and genome creators?"[19] (November 12, 2008). Another example is *Spektrum der Wissenschaft* reporting "But is the protein really necessary for the life-extending effect? Unequivocally yes, as shown, for example, when its gene was artificially ***switched off***. After all, in the case of the fruit fly, an organism which is quite complex, a lack of food extended their life span only in the presence of the corresponding gene"[20] (Spektrum 10/2006). Further examples include "One of the more than 30,000 molecules of the cell gave a fatal command, all the molecules listened and brought about the division of the entire cell: The ***mini-particle's***

[18] German original: "Wäre der Mensch eine Maschine, wäre sein Leben berechenbar. Diese Vorstellung fasziniert und erschreckt die Menschen seit der Renaissance. In der synthetischen Biologie, in der Robotik und der Künstlichen Intelligenz scheint sie nun Wirklichkeit zu werden. Aber nur auf den ersten Blick. Denn je weiter Forscher das Zusammenspiel der **molekularen Schräubchen, Hebelchen und Zahnrädchen** in unseren Zellen entschlüsseln, desto deutlicher sehen sie, dass die Maschinenmetapher hinkt: An ihre Stelle haben sie längst das komplexe dynamische System gestellt. Und dessen **Analyseinstrument** ist nicht die Berechnung, sondern die **Computersimulation**. […] In der Systembiologie ist die Idee des dynamischen Systems der **Schlüssel** zur Komplexität des Lebens, so Mainzer."

[19] German original: "Sprechstunde bei den neuen Biovisionären: **Ingenieursdenken** blüht in Synthetischer und Systembiologie: Gibt es Grenzen für die Genomkreationen? Deutschland, das Land der **Bioingenieure** und Genomschöpfer?"

[20] German original: "Doch ist das Protein für den lebens- verlängernden Effekt auch wirklich notwendig? Eindeutig ja, wie beispielsweise ein künstliches **Ausschalten** seines Gens zeigte. Denn bei immerhin schon so komplexen Organismen wie der Taufliege verlängerte sich die Lebensspanne bei Nahrungsmangel nur, wenn das zugehörige Gen vorhanden war."

mistake can now destroy all 10^{15} cells that make up the human body"[21] (*taz*, February 16, 2006) and "Progress in nanotechnology, stem cell research, systems biology, bionics is already part of the plan to proceed from synthesizing viruses to synthesizing bacteria and higher life forms. […] Now, viruses are only half organisms; the creation of a synthetic bacterium including a membrane seems to be more complex by orders of magnitude, which is why experienced ***bioengineers*** currently tend to smirk about grandiloquent pronouncements, for example those made by Craig Venter"[22] (*FAZ*, July 6, 2006). These examples indicate the degree to which the thinking not only about synthetic biology but also systems biology is technical and engineering-influenced and how it can be understood in mechanistic terms: you simply have to assemble different components in order to figure out the right solution, and the correct approach for finding that solution is analogous to the physical domain where you can enable and disable circuits in order to test their function and to determine how exactly they need to be put together. In consequence, engineering thus first serves as a source domain for vocabulary that suggests the practicability of a structured approach in the domain of the living as well. Second, it suggests the applicability of existing engineering virtues for getting control, even over the (self-declared) complex subject (of research) of systems biology.

The similarity of the metaphors used to describe systems biology in relation to the concept of ***engineering*** with the manner in which synthetic biology is described in the media suggest that there is significant overlap between the conceptualization in the German media. Even though synthetic biology has a much stronger focus on application, the aspect of engineering, and especially of reverse-engineering, as a method of generating knowledge is shared between the two disciplines (comp., e.g., Boudry and Pigliucci 2013; Gschmeidler and Seiringer 2012).

6.4 Systems Biology in the Austrian Press

Compared to Germany, the representation of systems biology in the Austrian media is substantially different with regard to three points. First, we found a number of confrontation metaphors that range from conflict to war. Second, several metaphors that were often used to characterize the nature of research in systems biology

[21] German original: "Eins der mehr als 30,000 Moleküle der Zelle hat ein fatales Kommando gegeben, alle Moleküle haben gehorcht und die ganze Zelle zum Teilen gebracht: Der Fehler des **Mini-Teilchens** kann jetzt die Gesamtheit der 10^{15} Zellen zerstören, die den menschlichen Körper ausmachen."

[22] German original: "Fortschritte in Nanotechnologie, Stammzellforschung, Systembiologie, Bionik sind bereits eingeplant, um in der Synthese vom Virus zum Bakterium und zu höheren Lebensformen zu schreiten. […] Nun sind Viren nur halbe Lebewesen, die Erzeugung eines synthetischen Bakteriums samt Membran erscheint um Dimensionen komplexer und läßt erfahrene **Bioingenieure** angesichts großspuriger Ankündigungen, etwa von Craig Venter, derzeit eher schmunzeln."

revolve around the concept of play. And finally, some metaphors that relate strongly to fate and fortune were frequently used when reporting about the effects of systems biology. In short, borrowing from the two most important themes in the media the framing of systems biology in Austria can be summarized as ***Doing systems biology is play and doing science is confrontation***.

6.4.1 Strategic Game or Giving Systems Biology a Try?

Systems biology seems to be associated with role play and gaming, respectively, trying out playfully in the public media. This ***Doing systems biology is play*** becomes visible as ***party game*** or ***theatre***. Reference to playing or acting in the context of systems biology is for instance being made in *Der Standard*: "Classical biologists cannot achieve that alone, agrees Karsten Schürrle of the Society for Chemical Engineering and Biotechnology (DECHEMA) in Frankfurt. The Society is coordinating the ***interplay*** of the working groups involved in the liver cell project across the country. Cell biologists and computer scientists, genetic researchers and control systems engineers, mathematicians and liver specialists must collaborate to ***piece the bio-puzzle together***"[23] (May 12, 2003). Another metaphor refers to interplay: "The new simulation process developed by researchers at the German Cancer Research Center can be used to represent how the genes ***interact*** in this process and thus to determine which molecular targets must be hit in which order for the tumor cells to stop migrating"[24] (*Der Standard*, July 13, 2008). By comparing scientific practice with child's play, innocent and harmless behavior is suggested. Similar to what Kamara (2009) found in his interviews with system biologists, research is also a strategic game for grownups. This is a less benign metaphor and connects closely with the concept of war: games are more than a set of rules; they also require a certain behavior and social interactions. Scientists exploit opportunities. They deal with setbacks by cooperating with money sources, important heads, or sponsors. They use disguise, shepherding, and lobbyism and even team up with rivals as their goal is to win, to strike a decisive hit, a big breakthrough, or a valuable discovery, and be the first to publish it in a high impact journal.

A further aspect of play is exemplified by a quote from an article in *Der Standard* in which play is shifted to a theatre stage: "A spectacular project that will soon

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[23] German original: "Klassische Biologen können das alleine nicht leisten, sagt auch Karsten Schürrle von der Gesellschaft für Chemische Technik und Biotechnologie (DECHEMA) in Frankfurt. Dort wird das **Zusammenspiel** der beteiligten Arbeitsgruppen im Leberzell-Projekt bundesweit abgestimmt. Zellbiologen und Informatiker, Genforscher und Regelungstechniker, Mathematiker und Leberspezialisten müssen zusammenarbeiten, um das **Bio-Puzzle zusammenzusetzen**."

[24] German original: "Mit Hilfe des neuen Simulationsverfahrens der Forscher aus dem Deutschen Krebsforschungszentrum lässt sich darstellen, wie die Gene in diesem Prozess **zusammenspielen**, und dadurch ermitteln, welche molekularen Ziele in welcher Abfolge getroffen werden müssen, damit die Tumorzellen aufhören zu wandern."

proceed ***onto the international stage of systems biology*** will be presented at the chemical engineering forum ACHEMA, which will begin this coming Sunday in Frankfurt. The German ministry of research (BMBF) is forking out 50 million euros for the program, which is scheduled to run for 5 years"[25] (May 12, 2003). "Only in recent years have geneticists come to know that those areas of the genetic substance ***play*** a decisive ***role*** in gene control that so far have been called genetic junk because they are not turned into proteins themselves"[26] (*Der Standard*, July 16,2007). This association with the realm of *theatre* suggests that the media conception of systems biology includes the need for science to present itself on stage. Projects are created, developed, and then presented to the public, with the goal of obtaining funding and recognition. This suggests that, following Goffman (2003), it might be appropriate to speak of a backstage and a front stage aspect to systems biology. Reviewing the examples for metaphors on play, it becomes apparent that different aspects are being covered in the media, from the harmless child's play referring to the way scientific progress is seen to be achieved, to the more competition-focused and explicitly political game to achieve first funding, then success, and finally public recognition.

6.4.2 Systems Biology and the Struggle in Science

Another aspect of the media discourse in Austria can be described as ***Doing research is confrontation and war***. The general description of actors in science, and also in the media, is very confrontational: *Der Standard* wrote on August 21, 2006: "The genome research institute ImGuS is being shelved for now despite a financial commitment: it had barely seen the light of day when the elite university in Gugging (previously AIST) claimed ***its first victim***: ImGuS, the planned institute for medical genome research and systems biology will not be realized as conceptualized as a standalone solution on Dr. Bohr-Gasse."[27] Even examples describing collaboration with the aim of adding value through cooperation borrow from war-like metaphors: "***Alliance of disciplines***. The British found this out by going beyond the usual lab experiments. They established an alliance with their highly non-biology colleagues

[25] German original: "Auf der Chemietechnikmesse ACHEMA, die am kommenden Sonntag in Frankfurt beginnt, wird ein spektakuläres Projekt vorgestellt, das sich in Kürze **auf die internationale Bühne der Systembiologie** begibt. Das deutsche Forschungsministerium (BMBF) lässt dafür 50 Millionen Euro springen. Das Programm ist auf fünf Jahre angelegt."

[26] German original: "Erst seit wenigen Jahren wissen Genetiker, dass bei der Steuerung der Gene auch jene Bereiche auf der Erbsubstanz eine entscheidende **Rolle spielen**, die bis dato als genetischer Schrott bezeichnet wurde, weil sie selbst nicht in Proteine umgewandelt werden."

[27] German original: "Genomforschungsinstitut ImGuS wird trotz Finanzierungszusage vorerst auf Eis gelegt: Kaum das Licht der Welt erblickt, fordert die Exzellenz-Uni in Gugging (vormals AIST) **ihr erstes Opfer**: ImGuS, das geplante Institut für medizinische Genomforschung und Systembiologie wird in der konzipierten Form als Stand-alone-Lösung in der Dr. Bohrgasse nicht realisiert."

from experimental physics as well as mathematicians and computer scientists."[28] (*Der Standard,* October 7,2007). Not only the interaction within science is confrontational, also the aim of systems biology is being described using a language that is usually reserved for weapons of mass destruction: "The goal of genome research and systems biology is rather to understand disease processes. This knowledge will enable [us] to ***create hard-hitting pharmaceuticals and use them in a targeted fashion***."[29] (*Salzburger Nachrichten,* April 6, 2004). Evidently, there is a large variety of different conflict-type descriptions, sometimes only borrowing from confrontation, sometimes from the realm of war. The language becomes especially tough when the subject of discussion is of monetary nature, but institutions are metaphorically also in greater conflict than issues discussed between individual scientists.

6.4.3 Fateful Science

Finally, a complex of metaphors relates to ***Systems biology is fate***. Here, systems biology takes on the rather challenging task of predicting the future: *Der Standard* wrote that "As small as the object of desire may be, so large are the aspirations: generating computer simulations of all the processes in a cell is truly a Herculean task. The new, aspiring discipline venturing to take on such projects is called systems biology. Sometime in the distant future, virtual cells could be able to ***predict*** what happens when a disease agent enters the cell, a gene is switched off artificially, or a patient takes a medication"[30] (*Der Standard,* May 12, 2003). Not only can the behavior of cells be predicted, but a model built of virtual cells can foretell the behaviour of organisms and their reaction to dramatic interventions. Another article from *Der Standard* states: "In any case, the scientists have gotten very close to the point in time when the **fate of cells** is decided for the first time during embryonic development: embryo or placenta?"[31] (*Der Standard*, January 24, 2011). Here, the fate of cells can

[28] German original: "**Allianz der Fächer**: Herausgefunden haben die Briten das nicht allein über gewöhnliche Laborexperimente. Sie gründeten vielmehr eine Allianz mit ihren sehr nicht biologischen Kollegen aus der experimentellen Physik, Mathematiker und Informatiker."

[29] German original: "Ziel der Genomforschung und der Systembiologie sei es vielmehr, Krankheitsprozesse zu verstehen. Mit diesem Wissen könnten dann auch **schlagkräftige Medikamente geschaffen und zielsicher eingesetzt** werden."

[30] German original: "So klein das Objekt der Begierde auch sein mag, so groß ist der Anspruch: Sämtliche Abläufe in einer Zelle am Computer zu simulieren, ist eine wahre Herkulesaufgabe. Systembiologie heißt die neue, aufstrebende Disziplin, die sich an solche Projekte heranwagt. Irgendwann in ferner Zukunft könnten virtuelle Zellen **vorhersage**n, was passiert, wenn ein Krankheitserreger eindringt, ein Gen künstlich ausgeschaltet wird oder ein Patient ein Medikament schluckt."

[31] German original: "Jedenfalls sind die Wissenschafter dadurch schon ganz nahe an jenen Zeitpunkt heran gekommen, an dem sich das **Schicksal von Zellen** in der Embryonalentwicklung zum ersten Mal entscheidet—Embryo oder Plazenta?"

be interpreted, and broken down into smaller decisions through the insight of systems biology.

On the other end of the spectrum, we found that systems biology itself is seen as an endeavor that requires some faith in (good) fate to believe in: “To Frank Eisenhaber, the head of the Bioinformatics Group at the IMP (Research Institute of Molecular Pathology) in Vienna, systems biology is, on the other hand, more a ***pious hope***. How, he asks, could one speak of such a metascience if we do not even understand the molecular mechanisms in detail?”[32] (*Der Standard*, August 29, 2005).

We found a large number of metaphors that deal with fate, religion, or mysticism, something entirely missing from the German discourse. Indirectly, this echoes the aim of systems biology to provide tools for simulation of organic systems: using these tools to create predictions of how these systems react, the future becomes more conceivable.

6.5 Different Countries: Different Perceptions? Concluding Remarks

The perception of systems biology differs between Germany and Austria. By investigating the use of several metaphors (such as ***Doing systems biology is looking for orientation*** (Germany) and ***Doing systems biology is play*** (Austria)), we have shown that metaphors echo different social experiences through diverse important conceptual framings. We found metaphors related to the source domains of confrontation, play, or fate for Austria. In contrast to this, the main concepts in Germany are orientation and getting control. In the following, we suggest some reasons for how and why the perception of systems biology varies that much in the media of the two countries.

In Germany as in Austria, the **aim** of systems biology is not clearly defined. It is only spoken of in indirect terms. The discourse thus focuses more on the *contents* of science and uses the concept of orientation to explain what approach system biology applies (transfer; mapping the space), and that it is still an emerging science. A further reason for the lack of a defined goal of systems biology is the fact that it is often seen more as an approach (that can be applied in many fields) than a scientific subject era or field in its own right.

In Austria, we found that questions regarding the **aim** of systems biology are often superseded by the quest for funding and infrastructure to start research. The aim itself thus plays a less prominent role as scientists use the media to communicate the deficits in infrastructure. A large number of articles in Austria only speak of the establishment of research programs, or of their dismissal (see also Sect. 5.1).

[32] German original: “Für Frank Eisenhaber, den Leiter der Gruppe Bioinformatik am Wiener IMP (Institut für Molekulare Pathologie), ist die Systembiologie hingegen mehr ein **frommer Wunsch**. Wie könne man von einer derartigen Überwissenschaft sprechen, wenn man noch nicht einmal die molekularen Mechanismen im Einzelnen verstehe?”

In Austria, the focus is not on systems biology's aims, but it is on the (further) development of scientific research and on pragmatic ways of establishing and promoting it.

Thus, in Austria play is used as a metaphor for **describing the method of systems biology**. This comes a bit as a surprise, as the goal is not clearly defined. However, play focuses on two aspects that make it a useful metaphor for scientist: making tactical moves and playing out different positions, and on the other hand making the discipline seem more harmless and innocent. The latter can probably be explained by a conscious use of the metaphor in order to prevent scepticism, because Austria was, for example, very critical regarding green biotechnology.

In Germany, **orientation receives the status of methodology**. This concept demonstrates the need for creating connections between disciplines as well as for finding ways to get an overview about large amounts of data, and to compile them into useful results; play does not have a significant role. Numerous metaphors in the German press are associated with orientation. This indicates that systems biology is in Germany still underway and understands itself as an emerging, moving, and still somewhat elusive discipline.

Fate metaphors are an exception as they relate to a foggy promise of systems biology and a predictability of reactions and cellular processes. However, such descriptions remain vague and cautious. Nevertheless, prediction here claims and replaces the role of fate. In Germany, systems biology is depicted as mastery of nature, looking at the large number and importance of metaphors of **control**. Control is assumed to be an (indirect) aim of systems biology, the method (e.g., play) moves into the background.

The establishment of **systems biology in Austria seems to be a delicate topic**. In this country, financing is an important issue, and open funding for systems biology is very limited compared to Germany. The choice of metaphors highlights how scientists need to fight for funding and resources. In contrast to this, the media touch financial aspects only rarely in Germany.

Based on a linguistic media analysis presented above we were able to show that a number of relevant differences can be identified between Germany and Austria in the public discourse on systems biology. Due to the fact that media are a central element of communication and discussion of scientific outcomes and development, as well as of funding by politics or funding organizations, it is important to ask what the implications of this discourse are, and what it holds for the future of systems biology. We thus now come to our conclusions based on the analysis of the metaphorical concepts.

6.5.1 First, Systems Biology Is Depicted as an Emerging Discipline

In both countries, the media image of systems biology is that of a discipline or an approach that still has to be established. In Austria, where funding is low, the press describes acting in the field of systems biology as conflict and war (e.g., regarding subsidies), and its establishment seems to be indirectly questioned by the media themselves. The choice of metaphors suggests that in Austria, public perception of systems biology lacks an agreed frame and centers on the difficulties and conflicts of finding that framing: systems biology as an approach is still on its way to establish itself. In Germany, the state of establishment is regarded as much more advanced; it is seen as an accepted method of a wider field (the life sciences) that, as a whole, needs to further establish itself firmly and prove its worth. In the German discourse, the media acknowledge an agreed set of goals for systems biology. The need for further establishment refers primarily to the structure and practice of systems biology, and not as much to the general development. Establishment in Germany thus means to demonstrate the value of selected applications by following an established direction rather than setting a new course to follow.

6.5.2 Second, Systems Biology Is Too Complex to Be Accessible for a Public Media Discussion

Both, the German and Austrian media, provide different understandings of systems biology. This can be drawn from the fact that articles referring to definitions contain significant differences. No attempt is made to resolve these differences; we found no reference to other, more authoritative definitions and no attempt to clarify what systems biology might be or encompass compared to other scientific approaches in the life sciences. This pattern was observed in both countries. We assume that it is rooted in the complexity of the subject, but that it is, on the other hand, also promoted by a lack of easy to comprehend explanations and explications of what systems biology is and aims to do. A lack of concrete examples for possible application may add to this still nebulous picture. Public comprehension of scientific results seems limited as the spectrum of definitions for systems biology varies ranging from describing it as a new scientific discipline to an auxiliary approach. Referring to the latter understanding, Rheinberger's (2012, 4) definition of systems biology focuses on technology. Therein, systems biology does not primarily refer to biological systems, but rather to the huge amounts of data that are created in laboratories, and to the computation necessary to process this data: "Consequently, we would first and foremost be concerned with the characteristics of a technical system—namely the organization of the biologists' work, and there—with a parallel world of data production and data processing—and less with the characteristics of the organism that this work is devoted to in the end"[33] (ibid). Against the backdrop of such diverse interpretations and understandings, which is complemented by perceptions

[33] German original: "Wir hätten es folglich in erster Linie mit den Eigenschaften eines technischen Systems zu tun—nämlich der Organisation der Arbeit der Biologen und da—mit einer Parallelwelt von Datenproduktion und Datenverarbeitung—und weniger mit den Eigenschaften des Organismus, dem diese Arbeit letztlich gilt."

of systems biology as a completely new science or organization of science, it is impossible to say which conceptualization of systems biology is present or even prevails in the media. This is true for Germany as well as for Austria.

Systems biology—so it seems—is by now such a highly complex science (or an organizational form thereof) that the question arises whether it is still open to any sort of public participation. According to Weingart (2005, 28) this becomes doubtful, once such a stage of complexity is reached. Thus it is questionable whether the public is or will be able to "construe" systems biology as a science or define its expectations towards it. Here, further research could help to understand the influence of media coverage and the way it is done on such a complex scientific development. In that sense, systems biology could be a possible example for an "autonomy of science" that was introduced by Rödder (2011, 838), an autonomy that surfaces as a "mode of communication" (ibid.) and that allows scientists to drive a (relatively) autonomous discourse beyond discursive interventions by the public.

6.5.3 *Third, the Distance Between Science and Public Might Be Increasing*

Following Weingart (2005, 21), the complexity and current absence of concrete applications[34] and corresponding personal stories of scientists, physicians, or even patients increase the distance between science and the public. However, in the case of systems biology it is questionable whether the public actually expresses a "claim to participation, control, and usefulness"[35] (ibid). Systems biology seems to be complex enough and so hard to understand for the public that it is seldom discussed and if it is, then often a flowery and inexact language is used. Hence, for now, the application of systems biology is not linked to social and cultural experiences. This may be another reason why systems biology and even more, its possible applications, are difficult to grasp for the media in both Germany and Austria. Perhaps caused by the embedded nature of systems biology which is always deeply integrated with other, more easily understandable disciplines, there is an apparent lack of personal "stories": it is unclear how systems biology can be applied, for instance, in medicine, biotechnology, or agriculture in order to create practical value. Again, this is not very different between Germany and Austria. Although systems biology has produced results that are accepted by the scientific community, its consequences for everyday life are far less evident; it application possibilities remain vague and without clear examples for the public.

[34] One field currently emerging is systems medicine; see Chaps. 1 and 7.

[35] German original: "Anspruch auf Teilhabe, Kontrolle und Nützlichkeit."

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