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The Bio:Fiction film festival: Sensing how a debate about synthetic biology might evolve

Markus Schmidt
Organisation for International Dialogue and Conflict Management IDC, Austria;
Biofaction KG, Austria

Angela Meyer
Organisation for International Dialogue and Conflict Management IDC, Austria

Amelie Cserer
Organisation for International Dialogue and Conflict Management IDC, Austria;
Technische Universität Wien, Austria

Abstract

Synthetic biology (SB) is a new techno-scientific field surrounded by an aura of hope, hype and fear. Currently it is difficult to predict which way the public debate – and thus the social shaping of technology – is heading. With limited hard evidence at hand, we resort to a strategy that takes into account speculative design and diegetic prototyping, accessing the Bio:Fiction science film festival, and its 52 short films from international independent filmmakers. Our first hypothesis was that these films could be used as an indicator of a public debate to come. The second hypothesis was that SB would most likely not follow the debate around genetic engineering (framing technology as conflict) as assumed by many observers. Instead, we found good evidence for two alternative comparators, namely nanotechnology (technology as progress) and information technology (technology as gadget) as stronger attractors for an upcoming public debate on SB.

Keywords

art-science, film analysis, film festival, public engagement, science fiction, synthetic biology

1. Introduction

> But if there is a sense of reality […] then there must also be something we can call a sense of possibility. (Robert Musil[1])

Corresponding author:
Markus Schmidt, Organisation for International Dialogue and Conflict Management IDC, Kaiserstrasse 50/6, 1070 Vienna, Austria; Biofaction KG, Kundmanngasse 39/12, 1030 Vienna, Austria.
Email: schmidt@biofaction.com

Synthetic biology

Synthetic biology (SB) presents a new and dynamic emerging field of science and engineering. Its aim is to apply tools and methods of engineering disciplines to biology. Although SB was already mentioned 100 years ago by the French scientist Stéphane Leduc, the term was "re-invented" about a decade ago by MIT engineers who wanted to make biology easier to engineer (Campos, 2009, 2012). The most commonly used definition describes SB as the design and construction of new biological parts, devices, and systems, and the re-design of existing, natural biological systems for useful purposes. SB as an interdisciplinary field brings together experts – and their scientific cultures – from a number of different areas, most notably biology, biotechnology, genetic engineering, chemistry, nanotechnology, engineering, and information technology (IT).

Within SB a number of subfields have been identified that focus on different levels of complexity (O'Malley et al., 2008; Schmidt and Pei, 2011). Applying the toolbox of engineering disciplines to biology, SB engineers attempt to realise a whole set of potential applications such as novel chemicals, pharmaceuticals, and biofuels (Schmidt, 2012).

An evolving debate about synthetic biology

Many scientists and engineers as well as funding agencies across Europe have in the past expressed the assumption that SB might follow the same "fate" as genetic engineering in the 1980s and 1990s, when, in the eyes of these stakeholders, a promising and safe technology came to a standstill due to largely irrational fears by the public. They came to the conclusion that something has to be done to prevent that from happening. The fear over a re-enactment of the genetic engineering debate was so great that similar conclusions were also drawn in other technology areas, especially nanotechnology.

Different reactions as to how to avoid such a debate were put forward, ranging from trying to avoid a public debate altogether, to provide "improved" information for the public (following the deficit model), to more timely interventions such as upstream engagement, public engagement, or embedding of social scientists in SB research projects. As a result of the upstream engagement and embedding, societal concerns have been taken into account at a very early R&D stage (Schmidt et al., 2008; Tait, 2009; Pei et al., 2012).

Public debates need frames and comparators in order to be meaningful. Scholars of science and technology studies, for example, have attempted to learn from past emerging technologies to define the governance needs of nanotechnology by comparing it to biotechnology, identifying similarities and differences (Kuzma and Priest, 2010).

While it seems "clear" to most stakeholders that the (public) debate about SB will be framed predominantly by genetic engineering, some scholars have suggested alternative comparators (Torgersen and Schmidt, 2013). In particular, careful analysis found three alternative frames with which to talk about SB: 1) biotechnology/genetic engineering; 2) nanotechnology; and 3) information technology.

According to Torgersen and Schmidt (2013) each of these comparators entails a unique way to understand and interpret the technology at stake. For biotechnology, the comparator stands for "technology as conflict", in the case of nanotechnology it is "technology as progress", and for information technology it is "technology as gadget".[2] They conclude:

> If a comparator becomes dominant, i.e. obvious to many experts, stakeholders and members of the public it might influence the course of a debate "out there" through suggesting one or more dominant frames. They will reflect the encompassing nature of the debate through their implicit conceptualisation of the public: "technology as conflict" goes along with the public to be taken seriously; seen through the glasses of "technology as progress", the public appears as an entity to be mastered through appropriate means; and

> with "technology as gadget" the public is seen as a player in the technology's own team, so to say. (Torgersen and Schmidt, 2013: 52)

Although the authors were able to lay out three options on how the future debate in SB might develop, there is, however, little indication at the time of writing which one (or any combination of them) will be most likely to be the guiding framework.

Science, fiction and science fiction

What the Austrian writer Robert Musil (1880–1942) has described as a sense of reality and a sense of possibility, can be encountered in the contemporary debate about SB. In addition to the more realistic characterisations of SB (de Lorenzo and Danchin, 2008), a number of scientists-promoters also dwell in the realm of possibilities. One of the founding fathers of SB, Drew Endy has repeatedly predicted that one day SB will allow us to genetically programme a gourd to grow into a full blown house.[3] In George Church's vision, SB will technically allow us to resurrect the Neanderthal and mammoths.[4] Several SB related companies use future scenarios bordering science fiction, to successfully attract large amounts of cash from venture capital.[5]

In a way, SB is not only a field at the intersection of biology, chemistry and engineering, it is also one where a seamless integration of science, fiction and science fiction is taking place. Whereas scientists are normally very alert to draw the line between fiction and facts, cutting edge techno-science – more often than not – relies on imagination and the imaginary. For example, when the team around Craig Venter published their groundbreaking SB work on a "synthetic organism" (Gibson et al., 2010), they added three quotes into the DNA, one of which (ascribed to Robert Oppenheimer) said "See things not as they are, but as they might be". Also, several observers have noted that the debate about SB is merely about its possibilities, rather than about its reality, since hardly any SB product is on the market or close to it.

Given the intimate relationship between SB and "professional speculation" (Kirby, 2011) we suggest that, in order to anticipate the future debate on SB, the realm of possibilities has as much – if not more – to offer as reality. In other words, if the vision of a resurrected Neanderthal living in a reprogrammed gourd with his pet mammoth is not met with overwhelming scepticism, but as an indicator for things to come, why can't we use such speculations to decide which kind of public debate is ahead of us?

That is to say, what if the best indicator for the upcoming public debate about SB is not grounded in reality, but in its possibilities? In the words of science fiction scholar Csicsery-Ronay (2008: ix), we may "understand *science fictionality* [*sic*] as a way of thinking about the world, made concrete in many different media and styles" (italic in original).

Bio:Fiction film festival

Based on the assumption that "[f]iction provides an open 'free' space to put forward speculative conceptualizations" we agree with Kirby that "[c]inematic depiction has an […] advantage over written fiction" due to "[c]inema's perceptual realism" (Kirby, 2011: 142).

In the past, blockbuster movies have been analysed to explore their ramifications for public perceptions of science and engineering (Jörg, 2003; Weingart et al., 2003; Meulenberg et al., 2004; Csicsery-Ronay, 2008; Kirby, 2011; Bould, 2012). But instead of relying on Hollywood blockbuster movies, with their narrative limitations due to the fact that these films are primarily produced to make money, we focused on (short) films from independent filmmakers as presented at the first science film festival on SB, called "Bio:Fiction". The festival took place at the Museum of Natural History in Vienna, Austria, on 13 and 14 May 2011. (See: www.bio-fiction.com and "Material and methods" section for further details.)

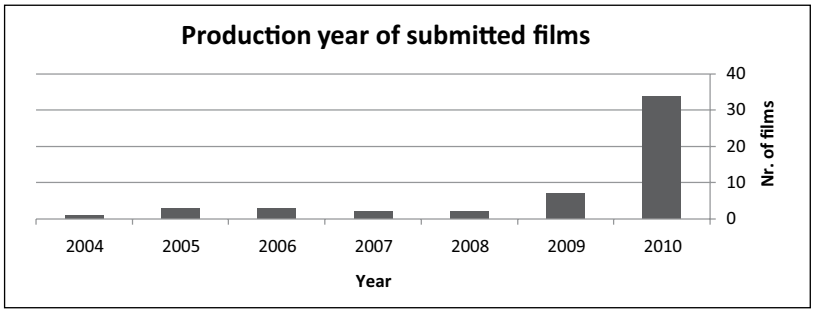

Figure 1. Most films were produced shortly before the submission deadline (n = 52). The oldest film was from 2004, the same year that the first international synthetic biology conference Synthetic Biology 1.0 took place (http://syntheticbiology.org/Synthetic_Biology_1.0.html).

Paving the way for things to come

Our research approach was based on two hypotheses. Firstly we started from the assumption that the Bio:Fiction short films can be understood as indicators for a debate to come. In other words, we don't see the audiovisual narratives as mere symbolic or iconic signs, but understand them with respect to their indexicality. If this holds true, our second hypothesis states that the Bio:Fiction short films can help us to sense *which way* an upcoming debate about SB might develop. In particular, we suggest that SB will not automatically follow the example of biotechnology/genetic engineering (as assumed by many observers), but will rather be coined by the nanotechnology or IT comparator.

In order to test our hypotheses we asked questions with respect to the representation of SB and its societal ramifications in films, its motivations, applications described, and the relation between SB and humans as producers, users and products. By doing so, we hope to shed some light on to the uncertain nature of the upcoming debate on SB.

2. Material and methods

The Bio:Fiction international call for short films in 2010 (final deadline 1 December 2010, see Appendix A at http://pus.sagepub.com/) yielded 130 film entries from 25 countries, of which 52 films were selected for the two-day festival (see Appendix B at http://pus.sagepub.com/). The selection was made based on the thematic connection of the films. Most films were produced in the year of the deadline (see Figure 1).

Of these 52 films, a total of five received awards (best fiction, best animation, best documentary, public online award and special prize of the jury) from the film festival jury.[6] The 52 films selected for the Bio:Fiction film festival formed the basis of our analysis. A short description of each film is available at http://www.bio-fiction.com/pdf/biofiction_programm_web.pdf and the films can be watched at www.bio-fiction.com/videos. See Appendix B (available at http://pus.sagepub.com) for an overview of the films.

The films that won awards received a total of €9000 in prize money. Over the course of the two days, a total of about 800 people visited the Bio:Fiction festival. Of these, roughly 50% were people interested in science, 30% were interested in art and film, and 20% represented the broader public. A total of 1500 printed Bio:Fiction festival programme folders were distributed for free before and during the event. Between 15 April and 15 June 2011, approximately 15,000 visitors came to the Bio:Fiction website, requesting over 29,000 individual sites. Website visits peaked in the 3 weeks prior to the event. Country-wise, the majority of web visitors came from Austria (>3100), the US (>2700), Germany (>1900), and the UK (>1900).

Table 1. Overview of SB subfields and related keywords.

Subfield	Keywords
Constructing (natural) DNA	Synthetic DNA, constructing viruses in the lab, resurrecting extinct animals (e.g. mammoth) by reconstructing their DNA
Reconstructing organisms using natural bio-parts	Reprogramming life, tuning life, biological parts, biobricks, engineering life, designing and constructing life
Minimising natural organisms (top-down)	Reduced life, minimal life, simple life, minimal genome
Constructing whole cells or parts thereof	Creating life from scratch, artificial life, synthetic life, protocells, vesicles
Creating alternative/unnatural life forms	Alien life forms, unnatural life forms, weird life, shadow life, completely new life, unknown life, artificial life, second life

Table 2. Ethical, legal and social aspects (ELSA) or issues (ELSI) subfields in SB, and related keywords.

ELSI field	Keywords
Biosafety	Risk, exposure, release, toxin, disease, virus, strain, containment, biosafety, error, accident, mistake, biohazard
Biosecurity	Terror, evil, killer, war, bio-weapons, weapons of mass destruction, remedy, cure, government programme, secret facility, military, police, mercenary
Ethics	Playing god, ethics, religion, human enhancement, eugenics, gene therapy, superhuman, trans-humanism, post-humanism, applying SB to humans, responsibility, unfair distribution, unequal distribution of benefit and harm (risk), exploitation
Intellectual property rights	Monopoly, owning life, company, business, bio-economy, poor, rich, wealth, money, biotech industry, greed, manifestation against company, corruption, law
Philosophy	What is life?, Different definitions of life, status of synthetic vs. natural life

We analysed the films by asking a number of questions (see "Results" section). In order to assess whether the films made reference to real-world SB, we used five categories for classifications (see Table 1) (O'Malley et al., 2008; Deplazes, 2009; Schmidt et al., 2009; Schmidt and Pei, 2011; Pei et al., 2012).

We also used a similar scheme to identify links to real-world societal issues related to SB (Table 2) to identify the most relevant ELSA areas related to SB, based on Schmidt et al. (2009) and Schmidt and Pei (2011).

3. Results

The following section summarises the most important findings.

To what extent did the films deal with SB?

Although all of the films selected for Bio:Fiction were related to SB, not all explicitly mentioned the term "synthetic biology". While most films made a direct connection to SB (34 films or 65.4%), about one third (18 or 34.6%) depicted procedures, mechanisms or concerns that can be assigned to an attempt to engineer life or nature.

For example, while films such as *Synthetic biology: a new pathway for evolution* (U. Sleytr et al., 2010) or *Patents and synbio* (P. Muir, 2010) even mentioned SB in their titles, other films such as *Cinderella 3.0* (S. Harrer, 2010) or *OCCUPATION: movement II & III* (E. Schockmel, 2010) approached the topic in a more general way. In *Cinderella 3.0*, two people were depicted who uploaded a computer program to their body, which resulted in a transformation into more desirable, and more beautiful persons, representing the wish to use rational engineering to improve the human body and at the same time entertaining a strong analogy to IT applications.

To what extent did films try to link to real-world SB science?

Based on the classification shown in Table 1, we found that the most frequent type of SB alluded to was the reconstruction of organisms using bio-parts (48.1%), followed by the (re)construction of DNA (25.0%). Whole cell construction (19.2%) and minimal life forms (11.5%) ranked 3rd and 4th, respectively. Only one film, *We need a biological existentialism* (R.M. Matysik, 2008), mentioned alternative and unnatural life forms as a fictional category. In 14 films, no reference to real-world SB could be found.

Were societal consequences of SB discussed in films; if yes, which ones?

Guided by the categories in Table 2, we sought those societal issues discussed among ethics and governance scholars, policy makers, non-governmental organisations and funding agencies. Many films alluded to more than one societal issue. We found that ethical topics were most relevant in the films (59.6%), followed by fundamental philosophical questions about what is life (46.2%). Ownership and Intellectual Property Rights (IPR) related issues on life (25.0%) were also frequently mentioned, ranking 3rd, whereas biosafety (11.5%) and biosecurity (9.6%) were only mentioned a few times.

Twelve films (23.1%) did not allude to any of our societal categories. Within the category ethics the most popular theme was the moral challenge of applying SB to humans. The film *All American Hero* (C. Jarvis, 2009) tells the story of a participant in a reality TV show, who lets doctors and engineers transform his body so that he would become the ultimate soldier for the US army. *Recobrain* (K. Sengstaken, 2010) presents a medical/human enhancement procedure: a simple injection into the brain enables people to become more productive and thus have more time for the things they really want to do. The video also comments on the various side effects of the procedure. Another example of the pressure of societal desirability is the ironic *Perfect Body* (M. Burghardt, 2010), in which female consumers can purchase different types of sexy buttocks, each catering to different masculine tastes and preferences.

IPR issues mainly appear in the form of various open source/open access interpretations. In *Bruce* (T. Judd, 2009) a person at home downloads the source code of a small mammal superhero (resembling a mini version of Bruce Willis) and then uploads it to a piece of meat, which is then transformed into the superhero. In addition to the fictional films, one – *Patents and synbio* (P. Muir, 2010) – tackles the real-world problem of patents and open access head on, with a number of serious expert interviews.

Did filmmakers use fact-based documentary style or (science) fictional stories?

While 26 films (50%) could be described as fictional, science fiction[7] or fantasy, 21 films (40.4%) were either documentaries or primarily fact based. The remaining 5 films (9.6%) presented a combination of factual and fictional elements.

The film *Transformation of competent cells* (Y. Guri, 2010) for example was clearly a representative of the fact-based film section, explaining lab work and methodology to modify living cells. The film *E. chromi* (D. Ginsberg, 2010) also fell under the category of documentary film as it documented a student team that went on to win the annual iGEM[8] competition (although the applications presented in *E. chromi* were science fictional). Half of the films, however, were regarded as fictional, among them *Aphasia mechanica* (D. Warner, 2010), a black and white study that shows moving body elements and joints through X-ray vision, revealing mechanical components such as cogwheels within the human body. In the last category, combining fact and fiction, we find films like *Protocells* (R. Armstrong and M.S. Toon, 2010). It shows real artificial vesicles made in the lab by the filmmaker, but adds an additional narrative layer by adding a fictional dialogue between the microscopic protocells. The otherwise lifeless chemical entities thus become anthropomorphic and appear alive with an individual will and feelings.

Which explanations on the motivation to do SB were given in films?

The motivational analysis of the short films revealed a rather benevolent cause behind SB. Films provided, on average, more than one motivation. Clearly the most frequent theme was "to create a perfect world" (42.3%). SB was deployed mainly pro bono for a generally accepted good cause. The second most frequent motivation was pure scientific interest (23.1%). Economic interest (19.2%) and human enhancement (15.4%) (separated here from the first category owing to its ambiguous ethical problems) came in third and fourth, respectively. Neither personal nor entertainment interest (5.8%), nor playing god (3.8%), however, were provided frequently to justify the use of SB. Interestingly, no film described political or power-related motivations. In a total of 15 films (28.8%), no motivation for carrying out SB could be identified.

An example of the aim to create a perfect world is the film *Smell Triggers* (S. Cámara Leret, 2010). It is a fictional story about a new type of biosensor, namely mosquitoes that incorporate synthetic bacteria, enabling an environment with an embedded diagnostic function for human diseases. The film about the International Genetically Engineered Machine competition iGEM, namely *igem EPFL Movie: Asaia, the pink force against Malaria* (EPFL iGem Team, 2010) also presents SB as a neat tool to provide a remedy for a human disease. Another iGEM film, *igem 2010 Team Slovenia project* (N. Tomsic, 2010), underlines the scientific interest and the contribution of SB to research progress.

Which specific applications of SB were mentioned?

The most frequent type of applications shown (13 films or 25%), were smart pharmaceutical products (e.g. intelligent drugs). The second most popular application category was also human centred, namely human enhancement (17.3%). Other applications, in particular biosensors (9.6%) and biofuels (7.7%), were mentioned only a few times. In 20 films (38.5%), however, no utilitarian application was shown.

An example for a medical product is seen in *Die Schneider Krankheit* (J. Chillon, 2008). A rare disease from outer space terrifies humans and turns into a pandemic. Scientists eventually develop a hybrid organism – a crossover between a turtle, a worm and a lizard – that can be applied to patients as a treatment. Although the treatment removes the disease from the human body, all humans still need to wear gasmasks to avoid a second infection by the same disease.

Which type of synthetic organism was used in the film?

Most films depicted synthetic organisms that could only be categorised as fictional in the sense that no real-world counterpart could be identified, and/or the organism was unspecified (42.3%). In those films containing organisms that could be related (somehow) to the real world, we found hybrids as the most prominent group (19.2%), followed by bacteria (15.4%), plants (13.5%), human organs and animals (both 11.5%). Humanoids (7.7%) and viruses (1.9%) were hardly mentioned. In six films (11.5%) no organism was shown.

Where did the production of synthetic organisms take place?

The place of production was predominantly (63.5%) some type of laboratory. In the remaining 19 films (36.5%) the place was not specified. Every time a place of production was mentioned, it was a laboratory. Most of the time the laboratory was at a university (28.8%). Company labs (19.2%) were the second most likely place, followed by home labs (15.4%). The military was never mentioned, neither was nature. While university and company labs are self-explanatory, the home labs described do-it-yourself (DIY) biologists who engineered living organisms in their own household. For example, the film *Grow Your Own* (T. Thwaites, 2010) is a fictional documentary in which a police officer describes his everyday work with special police bees. These bees do not need any search warrant to enter windows of houses to collect pollen from plants grown on private property. With genetic analysis of pollen and the bees' waggle dance, the police can determine whether citizens are growing genetically modified plants (e.g. tomatoes) that produce illicit substances, like THC normally found in marihuana plants. Although no home lab is shown, the secrecy of production suggests that such engineered plants were made in home labs.

Who was shown as using SB applications in the films?

For the production sites, universities and companies dominated; however, the users most frequently depicted were regular citizens/consumers (44.2%). Second were scientists or medical doctors (32.7%), primarily in a research context. Companies were also mentioned sometimes (23.1%), but less often than scientists. Police and/or military were never mentioned. In 15 films (28.8%) nobody was shown using SB applications.

How many men and women were present as directors and characters?

In sum 20 women and 42 men were (co-)directors of the 52 films. Although fewer women appear among the directors, three female directors were honoured in the five prize categories of the Bio:Fiction festival.

The 52 films presented 22 men and 13 women as producers of artificial life forms, however, 27 films did not show any producer at all (see Figure 2). On the other hand, 21 men and 19 women were presented as users of SB products, whereas 30 films did not personalise the application of SB artefacts.

The importance of quantitative analysis concerning men and women working in a specific profession depends on its ability to reveal tendencies of gender (Orland and Rössler, 1995) concerning the professional field. Numerous studies in the academic research of women's studies, such as from Sandra Harding (1991) and Hilary Rose (1983), have asked why there are so few women in science and technology. The minor representation of women in science and technology leads to the

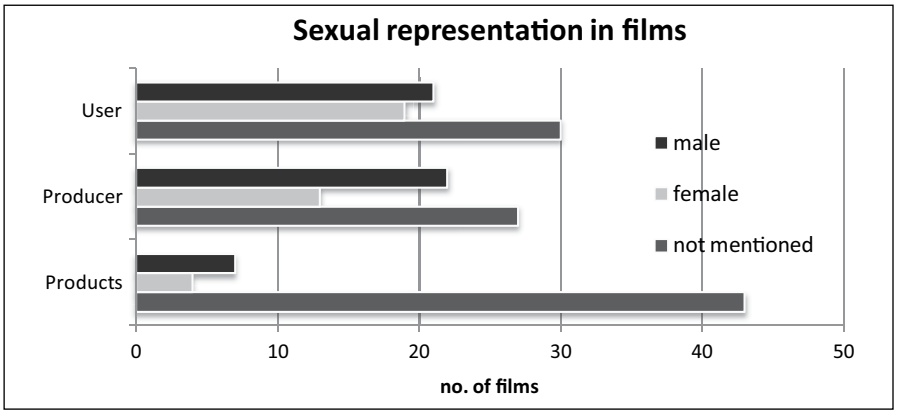

Figure 2. While products and users were more or less equally men or women, producers were more likely to be men. In most cases, however, sex was not mentioned in any of these three categories.

result that these professions have a specific culture, which suits more a life of men than that of women (Nowotny, 1986; Harding, 1991; Keller, 1992, 1995). In this sense science can be identified by a specific sexual culture called "gender" depending on cultural norms for male and female bodies.

Further science and technology studies made transparent that technological and scientific progress in modern society is dominated by men as producers/inventors and by women as users (Wajcman, 1991, 2004) of technological artefacts. Owing to these studies we analysed the representation of men and women in the films in these categories.

As the technological artefacts of SB are living entities, we tried to identify their biological sex, too. The products showed a slight majority of 7 male to 4 females, but in 43 cases no sexual identity was represented, e.g. bacteria, fantasy organisms, plants or animals with unspecified, biological sex.

4. Discussion

Most of the 52 films selected for Bio:Fiction directly referred to SB. Those films that did not directly mention SB presented ideas, ways of production or products that can be associated with SB. This shows that the festival can indeed be seen as a SB film festival and not merely a science festival in general. We suspect that the call for submissions, together with the announced prize money, motivated filmmakers to make a new film or complete an unfinished one. This conclusion is supported by the fact that on some occasions filmmakers confirmed (via personal communication) that the Bio:Fiction festival was an additional motivation to complete their film project. Moreover, a large majority of the films were produced in the year of the submission deadline (in 2010). Although filmmakers are more likely to submit their most recent film instead of one that is several years old, the actuality of the productions is another hint that filmmakers really had SB (and the festival) in mind when producing the film. Overall, we conclude that the content of the films largely matches the aim of the festival, namely to request and show films about SB. We also conclude that – instead of an undefined science fiction event – the festival may indeed be considered as a platform for filmmakers to express their views on SB and its possibilities.

The frequency (and thus relevance) with which the five main subfields identified in the literature (Table 1) were mentioned in the films matches surprisingly well with the answers of 20

leading SB scientists who were asked to lay out their view of SB (News Feature, 2009). In both cases, films and experts most often mentioned: "biological systems made of standard biological parts" and "DNA synthesis". Also in both cases the creation of alternative/unnatural life forms was the subfield least mentioned. Thus, the films were a very good representation of the relevance of the different subfields, as seen by SB experts.

In terms of representing the work of scientists in the lab, the level of detail was – unsurprisingly – limited. With the exception of certain films made by biotech students, the films transported only a very rough idea of the scientific details, processes and practices in SB. The films can help to introduce SB on a general level, but mostly fail to connect to the specific work done in labs, although some were more accurate than others. Since a public debate about SB, however, is unlikely to be based on specific technical details, rather than on a rough description of the field, we do not see this lack of detail as an argument to reject our hypothesis that the films could be seen as an indicator for an upcoming debate. On the contrary, should the films have shown an extraordinary level of detail, we would have been forced to reject our hypothesis since such level of detail is hardly ever seen in public debates.

On closer examination of the films, it was occasionally very difficult to assign them to either the fact-based or the fictional category. The difficulties lay less in the way the films presented their content, but more in that many statements by real-world scientists and other SB proponents of the future of SB also sounded rather fictional (see the gourd, Neanderthal, or mammoth examples mentioned before). Since few real success stories have materialised from SB so far (see the much cited anti-malaria artemisinin example (Ro et al., 2006) for what is practically the only example, and even that one is contested as rather belonging to metabolic engineering), most statements about SB concern the medium- to long-term future. (See Schmidt (2012) and WWCIS (2012) for an assessment of potentially upcoming SB applications.) Even in the scientific community it is less than clear which assumptions and predictions are plausible and which are not. Many of the hoped for successes in applying engineering principles to biology are still far from being a reality (Kwok, 2010). To this extent, the films conserved this "sense of possibilities" covering both "real science" as well as fictional elements.

The first and foremost outcome of the analysis of societal issues in the films was that most films did indeed touch upon the ELSA categories defined in Table 2. The analysis shows that the filmmakers did not embrace the techno-scientific utopia in an uncritical or techno-naïve way, but reflected on the various societal ramifications on several layers.

The focus filmmakers had on societal issues can be compared to the type of issues identified and discussed among ELSA scholars[9] as Schmidt et al. (2008) showed that the most intense debates circled around ethical and intellectual property (IP) issues. Biosafety and biosecurity aspects were also debated frequently, although less than ethics and IP, whereas philosophical questions (especially "what is life?") were hardly discussed. The Bio:Fiction films also showed that ethical and philosophical issues were the ones most often referred to. IP issues were frequently mentioned, confirming their relevance to experts (Rai and Boyle, 2007; Oye and Wellhausen, 2009). Biosafety and biosecurity, in contrast, seemed to have had a smaller impact on filmmakers than on the experts. Misuse of SB for illicit purposes was hardly a theme in the films, while it is a persistent topic in SB (e.g. Garfinkel et al., 2007; Kelle, 2009; Hayden, 2011). In sum, ethical issues continue to get the most attention from experts and non-experts, such as filmmakers. This explains why several National Ethics Committees have taken up the issues in recent years, e.g. in the US (PCSBI, 2010) and Europe (EGE, 2009). Despite their frequent alluding to ethics, not one film discussed a moratorium or a ban on SB. While civil society groups such as the ETC Group, Friends of the Earth or Via Campesina have frequently demanded

such drastic steps (ETC, 2008), filmmakers did not pick up this social criticism, neither supporting nor opposing it. In arguing against the deployment of SB, civil society groups like ETC or Friends of the Earth extensively use the association with genetic engineering, even calling SB "extreme genetic engineering" clearly trying to frame SB as "technology as conflict". The analysed films, however, did not support this association.

The kind of framing may also be expressed by presenting the motivation to do SB. Strikingly, the first and foremost cause for SB research was to "make the world a better place", a notion that is very much in line with "technology as progress". Thus, despite all the ethical concerns raised in the films, SB is still fundamentally seen as a potential vehicle to solve major problems of humankind. SB is primarily depicted as benevolent, finally giving us the right tools to change the world for the better. In many Hollywood films (Kirby, 2011) or (written) fiction (Schummer, 2011), the scientists/creators start out with good intentions but then their creation gets out of hand and causes harm to society. The Bio:Fiction short films surprisingly miss that narrative almost completely. The "worst" thing is that some SB products appear as somewhat ironic and perhaps provocative (especially when it comes to replacing body parts to be more beautiful or stronger), but hardly outright harmful or destructive. Rare exceptions are two films in which economic interests lead to an overexploitation (e.g. *OCCUPATION: movement II & III* by E. Schokmel, 2010) of nature or humans (e.g. *Local Unit* by T. Ermitagno, 2006). See ETC Group and Heinrich Böll Foundation (2012) for more detailed accounts of these overexploitation concerns. The notion of making the world a better place can clearly be associated with the framing of "technology as progress" and to a lesser extent "technology as gadget", but hardly at all to "technology as conflict".

Regarding applications, many films did not bother to name specific applications. Those that did dealt with next-generation pharmaceuticals or went directly into human enhancement. Altogether, the focus of the applications was primarily to immediately cure diseases or overcome the limitations of the human condition. When doing the analysis we clearly saw the use of semi-fictional applications and products, as if they were already naturalised and seen as everyday objects by the people depicted in the films. Such a "diegetic prototyping" is a well-known narrative strategy for "pre-product placement". Examples from Hollywood films such as *Destination Moon* (1950)*, The Lawnmower Man* (1992), or *Minority Report* (2002) prepared audiences for the necessity, normalcy and viability of technological products such as space travel, gesture controlled computer interfaces or virtual reality (Kirby, 2010, 2011). In diegetic prototyping the filmmakers aim to promote a certain product/technology, and take great care to paint a desirable picture of the envisioned product, avoiding malfunctions, accidents and anything else that would hamper the desire of moviegoers to use this device themselves. Maybe the most outstanding examples of diegetic prototyping were the intestinal biosensors in *E. chromi* (D. Ginsberg, 2010) and the drug producing plants in *Grow Your Own* (T. Thwaites, 2010), since they[10] established very well the necessity, normalcy, viability and harmlessness of the respective application without bothering to show the potential for malfunction or unreliability. Diegetic prototyping has mainly been described in relation to "pure" engineering applications, like computers or transport. Thus, when looking at the three frameworks of technology (conflict, progress, gadget), we see diegetic prototyping fitting best to the IT frame of "technology as gadget".

A similar effect was noticed with respect to the type of engineered organisms. Plants, among the most visible products of real-world genetic engineering, did get represented but hardly in the usual GM crop framing (as food or feed). Probably the most surprising result was the almost entire lack of viruses in the films. Viruses are much easier to synthesise than bacteria or higher organisms and they can pose a threat to human health (e.g. Cello et al., 2002). Fitting well into the logic of the diegetic prototyping, the exclusion of viruses makes sense since they are associated mainly with

diseases and death, and would thus not fit into the benign presentation of SB, aiming for necessity, normalcy and viability. This indicates a rejection of the notion of "technology as conflict".

According to the definition most commonly used, SB is the design and construction of new biological parts, devices, and systems, and the re-design of existing, natural biological systems for *useful purposes*. It seems that filmmakers do indeed conform to that definition, avoiding other than *useful* purposes. It might well be that the spirit of usefulness has also affected filmmakers when writing storyboards, as neither illicit nor useless applications were shown. This brings us back to diegetic prototyping and the IT frame of technology as gadget.

Apart from the overemphasis on home laboratories, the allocation of the production process revealed a quite realistic picture. Universities and companies were shown as the main source of synthetic life forms (Shapin, 2008). Consistent with the absence of power maniacs or evildoers, the filmmakers refrained from allocating SB labs to the military: not one film showed military or police labs. The framing of SB as a benign, user-friendly technology is continued along the lines of SB users. The most frequent type of user shown in the films was consumers/citizens (technology as gadget), followed by scientists or medical doctors (technology as progress).

In examining the depiction of men and women in the films, the slight advantage in numbers of men over women is rather insignificant in the cases of products or users. In the category of users, slightly more men than women consumed the SB artefacts. This difference in sexual representation can be further questioned by the fact that most of the films didn't show a human user at all. The SB products didn't relate to a sexual dichotomy of male or female gene expression. The biology of bacteria, viruses and artificial plants either doesn't need the sexual manifestation or overcomes the male/female expression of the human, biological sexes. In this sense the films presented SB as a new science of biology, which is able to queer the traditional, explicit distinction between conventional dichotomies of human sexuality and an average representation of gender. The tinkering with genes changes body performance. The sexual identities become fluid, as in the film *Cinderella 3.0* (S. Harrer, 2010), which shows how a transsexual change of the body also changes the possibilities of gender.

On the one hand, this presents a kind of biological essentialism, which means that a change or queering of gender performance is only possible with a change of biological sex (Hirschauer, 1993). On the other hand, the possibility of biological change of human bodies via SB, refers to the idea of the cyborg, a techno-feminist ideal, to break the naturalisation of female oppression (Wajcman, 2004) and the naturalisation of male dominance over women with the help of "biopolitics" as the science of nature and especially of biology nourished via sexist epistemologies (Haraway, 1995; Scheich, 1995; Schiebinger, 1995; Strum and Latour, 1999). The productive process of SB technology is able to change genomes and therefore impacts cultural values in the material body. In that theoretical context Haraway (1999) detected power plays and interests of profit at the heart of bodily rearrangements, which should be revealed for the sake of a "human" reality. Even in *Cinderella 3.0* (S. Harrer, 2010) the transsexual change was well integrated in an economic countdown of time and money.

The producers of SB, however, are more likely to be men. This corresponds with the image of the engineer and maker, who plays with Lego© Bricks or designs electronic circuits (Hughes, 1999), and who now has entered the world of biology with SB.

Making things seems to be the privilege of men, which somehow might reflect the attitude of the filmmakers themselves, of which two thirds were men. It might, however, also reflect the male dominance in SB science. The real sex ratio for contemporary SB is not known, but probably lies somewhere between 10% (professors) and 33% (doctoral students). The minor representation of women scientists on higher levels can be interpreted as a sign of the mechanism of the leaky pipeline, which means that there is a sexual bias between women and men the higher the steps of the scientific career that have been achieved (Nowotny, 1986; Harding, 1991), though the science of

biology in comparison to other sciences of nature is traditionally more often frequented by women (Orland and Rössler, 1995).

Although men were more frequently mentioned in films, the role of women was not that of "attractive assistants", as was the case in many blockbuster movies, see e.g. Flicker (2003) and Steinke (2005). Classic role models and stereotypes were hardly visible in the displays of female actors. On the contrary, stereotypes were sometimes used in a critical context, reflecting on the cultural usurpation of the female body. This leads us to the interpretation that independent filmmakers, although preferring men as makers, are more reflective of sexual stereotypes than Hollywood productions have been.

After a careful consideration of the analysis of sexual/gender stereotypes, we came to the conclusion that it does not lead to a conclusive hint towards one of the three frames of technology. In all three, biotech, nanotech and IT, men are more dominant than women, although biotech could be the most "woman friendly" field, and IT the one with the highest percentage of male players.

5. Conclusion

We conclude that our first hypothesis holds true insofar as the artistic artefacts presented at the Bio:Fiction film festival can indeed be used as indicators for an upcoming SB debate. The film festival did indeed target SB as a techno-scientific field, representing the most relevant scientific subfields as well as reflecting on the canonical ELSA issues. In the analysis of the Bio:Fiction short films it turned out that they covered enough "real science" to be relevant to the debate but also contained a fair amount of fictional elements in order to maintain a "sense of possibilities".

Our second hypothesis rejected the assumption of most SB observers that – in the public debate – SB will follow the example of biotechnology/genetic engineering, depicting technology as conflict. On the contrary our point of view, however, stresses the dominance of the other two comparators, namely nanotechnology (technology as progress), and IT (technology as gadget) (Torgersen and Schmidt, 2012, 2013).

Throughout our analysis we found several examples supporting the differences between genetic engineering and SB, and establishing similarities between SB and nanotechnology, and SB and IT.

While a number of environmental civil society organisations are trying to emphasise the notion of SB as "extreme genetic engineering", as an unwanted technology in need of a moratorium, the analysed films completely refrain from such an association. Not once was the idea of a moratorium, a total ban until further notice, brought up in the films. Quite the contrary, the films rather focused on the very many useful ways SB could "make the world a better place". The notion of making the world a better place can hardly be associated with "technology as conflict", but is clearly linked to the framing of "technology as progress" (to a lesser extent also to "technology as gadget"). As a dramaturgic tool, diegetic prototyping (Kirby, 2010, 2011) is deployed several times in the films to increase the plausibility of future useful SB applications. A specific feature of diegetic prototyping is the establishment of the necessity, normalcy and viability of technological products. The deliberate exclusion of misuse, malfunctions, accidents and anything else that would show the technology as conflict is typical. An almost complete lack of misuse, evildoers, mad scientists, military facilities, viruses, GM crops, or the police (as indirect evidence of breaking the law), shows clearly that the comparator "technology as conflict" is not implied here. What does fit with diegetic prototyping, that is the useful character of SB, however, is the framing of "technology as gadget" and also "technology as progress".

An additional argument for technology as gadget is the observation that the most frequent type of user shown in the films was consumers/citizens, followed by scientists or medical doctors (technology as progress).

The only ambiguous element of our analysis was the sexual/gender representation in the films. All three comparators, all three "model" technologies, seem to be dominated by male actors and honouring behaviour predominantly associated with men (designing, constructing, engineering).

We can, with some degree of certainty, conclude that representations of SB in the Bio:Fiction films confirm our hypothesis that the debate about SB is not seen as a straight continuation of the debate in biotechnology/genetic engineering. Instead, alternative narrative attractors seem to be dominant. Although we were not able to make a clear case for either technology as progress or technology as gadget, since both aspects played out more or less equally, we could clearly reject the technology as conflict frame.

As a final statement, we would like to explicitly state that we don't see our conclusions as a normative guideline, as an indicator of how the debate *should* be, but rather as an indicator of how the debate is most likely to play out. The uncertainty we found in the gender analysis is a subtle reminder that all of the comparators seem to – more or less – continue existing power structures and constraints. A debate on how a future debate *should* be framed has yet to come.

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Notes

1. See: http://www.robertmusil.net/musil/works/If%20there%20is%20a%20sense%20of%20reality.pdf
2. The denomination "technology as …" does of course not imply that conflict is confined to biotechnology, progress to nanotechnology or playfulness to information technology. It is just an attempt at catching the main "taste" of the frame in a single term.
3. See: http://www.esquire.com/features/75-most-influential/drew-endy-1008 or http://longnow.org/seminars/02008/nov/17/synthetic-biology-debate/
4. See: http://www.spiegel.de/international/zeitgeist/george-church-explains-how-dna-will-be-construction-material-of-the-future-a-877634.html or the Long Now Foundation's Revive and Restore project to bring back the woolly mammoth and the passenger pigeon: http://longnow.org/revive/
5. However, see also the history of the company Amyris that promised cheap biofuels, before deciding to quit its R&D due to lack of commercially viable results. See: http://www.fastcompany.com/3000040/rise-and-fall-company-was-going-have-us-all-using-biofuels
6. The jury consisted of a mixed group of artists, filmmakers and social scientists (Oron Catts, Huib de Vriend, Philippe Marliere, Vitor Martins dos Santos, Frans Meulenberg, Julia Stenzel, Robert Styblo, Helge Torgersen).
7. We are aware of the limitations of these categories and the difficulties in establishing clear boundaries between them. The categories were used here rather as a rough orientation.
8. International Genetically Engineered Machine competition, see: www.igem.org
9. One of the few quantitative assessments of ELSA issues can be found in Schmidt et al. (2008), which analysed an online community discussion on the societal aspects of SB.
10. Both filmmakers are, by the way, graduates from the Design Interactions MA of the Royal College of Art, which has a focus on "speculative design".

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Author biographies

Markus Schmidt (Organisation for International Dialogue and Conflict Management IDC and Biofaction) has an interdisciplinary educational background in electronic engineering, biology and risk analysis. He works in the area of technology assessment of novel bio-, nano- and converging technologies such as synthetic biology. He explores the interface between science, society and art through academic research, documentary film production, science gamification and art-science exhibitions. Schmidt was the scientific coordinator of the project "CISYNBIO: Cinema and Synthetic Biology" which analysed the representation of synthetic biology in blockbuster movies and independent short films.

Angela Meyer (IDC) has an academic background in political science. Her research interests lie in international relations and regional integration, as well as sustainable development and social conflicts related to new and emerging technologies. In the project CISYNBIO, she has conducted film analysis on how blockbuster movies represent scientists and science in the area of biotechnology.

Amelie Cserer (IDC and TU Wien) has an educational background in sociology and media studies. Her main interest lies in the area of the social shaping of technology and innovation. In the project CISYNBIO, she focused on how blockbuster movies translate scientific concepts to a lay audience.