Dynamics of problem setting and framing in citizen discussions on synthetic biology

Afke Wieke Betten, Jacqueline E.W. Broerse and Frank Kupper
VU University Amsterdam, The Netherlands

Abstract
Synthetic biology is an emerging scientific field where engineers and biologists design and build biological systems for various applications. Developing synthetic biology responsibly in the public interest necessitates a meaningful societal dialogue. In this article, we argue that facilitating such a dialogue requires an understanding of how people make sense of synthetic biology. We performed qualitative research to unravel the underlying dynamics of problem setting and framing in citizen discussions on synthetic biology. We found that most people are not inherently for or against synthetic biology as a technology or development in itself, but that their perspectives are framed by core values about our relationships with science and technology and that sensemaking is much dependent on the context and general feelings of (dis)content. Given that there are many assumptions focused on a more binary idea of the public’s view, we emphasize the need for frame awareness and understanding in a meaningful dialogue.

Keywords
complex problems, focus group methodology, framing, problem setting, public engagement, responsible research and innovation, synthetic biology

1. Introduction
Synthetic biology (SB) is an emerging scientific field where engineers and biologists design and build biological systems (Khalil and Collins, 2010). The aim is to introduce a computational design approach in biology that leads to rapid delivery of useful applications (Singh and Vaidya, 2015). Yet, it is challenging to find ways to develop SB robustly and responsibly in the public interest. Many scholars and policy-makers mark the importance of a societal dialogue to guide developments in the right direction (Marris C and Rose N, 2010; Seitz S, 2016).

However, it is difficult to organize a meaningful dialogue because there are many different perspectives on the opportunities and problems around SB. Smith (2003) argues that conflicts and...
dilemmas resulting from this diversity of perspectives are not pathological. They are an integral part of our moral life. The question remains how to deal with this diversity.

Perspectives can be described as a combination of values, beliefs, interests, experiences and knowledge (see, for example, Benard, 2014; Cuppen et al., 2010). We use these combinations to make sense of things; they are shaped by our worldviews and are also context dependent and dynamic (see, for example, Te Velde et al., 2002). Confronted with an indeterminate situation, these perspectives result in various ‘problem-setting stories’ (Kupper and De Cock Buning, 2011; Schön and Rein, 1994). When people discuss these complex situations, they make a selection of features and relations that are considered important in relation to their perspectives (Benard, 2014; Kupper and Krijgsman, 2007; Schön and Rein, 1994). Conflicting perspectives are therefore an important reason that discussions about complex situations arising from emerging technologies such as SB seem intractable controversies.

If we (aim to) engage in discussions about the future trajectories of research and innovation in society, it is important to look into the underlying dynamics of problem setting and framing, that is, the ways in which we set problems and frame opportunities because that shapes how we desire to see these trajectories (see, for example, Hisschemöller et al., 2001).

This study aims to explore the perspectives of Dutch citizens on SB and gain insights into dynamics of problem setting and framing. This aim is connected to our broader goal of improving science society dialogues on the topic of SB.

2. Theories on perspectives of science and technology developments

The different ways in which people perceive and evaluate SB developments are grounded in basic perspectives on the relationship between humans and technology. These perspectives have been elaborately described and scrutinized in fields like philosophy of technology and science and technology (S&T) studies. Three distinctive views are characterized: the instrumentalist, determinist and social constructivist view (Boerwinkel et al., 2014). As we will argue here, understanding the socio-scientific issues surrounding SB might require dividing the social constructivist view into two separate views, highlighting the problematic aspects of agency, design and language in the development of SB in society.

**Instrumentalism**

In the instrumentalist view, scientific knowledge and technological artefacts are seen as neutral means or tools to realize human goals. Knowledge and artefacts can be used for good or bad and do not have any kind of agency or structuring effects on society themselves (Boerwinkel et al., 2014; Keulartz et al., 2004). The underlying assumption is that it is possible to dissociate ourselves from the world, eliminating the influence of human values and inclinations, and by that becoming able to arrive at objective and distanced conclusions about things. The instrumentalist view reflects the idea that more objective knowledge, as in independent and value-free knowledge, would result in better understanding, prediction and control of the world. Although many times refuted by scholars in S&T studies, technology ethics and related disciplines, the instrumentalist view still is rather abundant in the common understanding of S&T development (Boerwinkel et al., 2014).

**Determinism**

According to the determinist view, S&T are not by all a neutral means to realize human goals but a window that structures our perception of and interaction with the world. Historically, the determinist
view has been based on the assumption that S&T develop autonomously: they have their own momentum, control themselves and their trajectory follows a techno-scientific logic that is unfolding itself (Boerwinkel et al., 2014). The determinist view often results in a pessimistic idea about S&T developments where humanity is perceived as powerless: humans as ‘slaves of technology’ (Ellul, 1964). The determinist view of SB would result in a rather concerned and critical perspective, for example, highlighting the political economic dimensions with their complex power dynamics and a lack of influence for human actors, especially non-scientific, on the developments that take place.

**Social constructivism**

The above two views have in common that S&T, on one hand, and society, on the other hand, are perceived as separate entities. The neutral world of S&T is seen as opposing the cultural world of human values and beliefs. As mentioned, scholars in various fields have criticized this view and replaced it by a view that emphasizes the interaction between science and culture. According to the social constructivist view, scientific knowledge and technological artefacts are human products, shaped by the socio-cultural context in which they are constructed. Knowledge and technology are developed through endless actions, decisions, negotiations and interactions involving a diverse range of actors (Bijker et al., 2012; Latour, 1992). Consequently, the social constructivist view departs from the idea of S&T development as an autonomous process. Instead, these developments are perceived as co-evolutionary.

**SB: Agency and language**

If we examine the three views outlined above, we see two dimensions that distinguish between those views. First, there is the question of whether S&T and society are seen as separate or as transgressive domains. This dimension clearly distinguishes the instrumentalist and determinist view, portraying S&T and society as opposing each other from the social constructivist view, emphasizing the interactive nature of their relationship. Second, there is the notion of agency. This dimension clearly distinguishes the instrumental view, perceiving S&T as passive and neutral from the determinist view, highlighting the agency and structuring effects of S&T. In the social constructivist view, agency is attributed to both S&T and society. Social constructivists recognize that science, technology and society mutually shape each other. Despite this fluid notion of agency and its underlying idea of an interactive relationship, in the context of SB, it makes sense to distinguish between a social constructivist perspective that highlights the dominance of human agency and a social constructivist perspective that highlights the dominance of technological agency. SB is directly concerned with creating new life forms and life worlds. Matters of agency and the notion of *creation* have regained attention in discussions about the governance of this emerging technology (see, for example, Dabrock, 2009). Second, in the SB, common language of designing, building and creating life requires rethinking of human and technological (moral) agency. Attributing agency to technology is of course not something new (see Swierstra and Rip, 2007). However, as they write, technological advances today result already in active systems that carry agency within them. These systems have been created to be active, but often work in relation with other (human) actors. De Lorenzo and Danchin (2008) compare SB to machines, consisting of parts that we can assemble and re-assemble to perform certain functions. In this comparison, the language of creation and the notion of an active system come together. In these developments, we could also speak of blurred agency (Haraway, 1991). This complexity of blurred lines between S&T and society is especially true for SB. As Van den Belt (2009) writes, ‘synthetic biology is challenging entrenched distinctions between, amongst others, life and non-life, the natural and the artificial, the evolved and the designed, and even the material and the informational’ (p. 257).
Therefore, in order to understand emerging societal perspectives on SB developments, we propose a model that is based on the two dimensions of agency and interaction and distinguishes between four different views (see Figure 1). The first two views (instrumentalist and determinist) are derived from the abovementioned discussions in S&T studies and philosophy of technology. The third and fourth views differentiate between two social constructivist views. The first could be best described as the creative designer view. This view builds upon the interaction and mutual shaping of society and technology. At the same time, it highlights the opportunity for humans to create not only new technical but also new moral worlds – in other words, to benefit from the structuring effects of technology on society. Dominant agency in this view is therefore attributed to humans. The second social constructivist view also builds upon the central notion of co-evolution but attributes more agency to the developments in technology. We describe this view as ‘adaptivist’ because it highlights the importance of flexibly adapting our ways of thinking and doing to the new order of life and technomoral worlds that are emerging in the development of SB.

3. Methods

In order to gain more insights into dynamics of problem setting and framing of SB among the public, we conducted eight focus groups (FGs) with Dutch citizens in three different cities (four in Amsterdam, two in Den Bosch and two in Zwolle) in the Netherlands. Involvement of the public in S&T issues is often investigated through the use of FGs (e.g. Rowe and Frewer, 2000), like the investigation of the public perceptions of biotechnology (Barns et al., 2000). FGs are used to generate a group process that helps the participants to explore and clarify their own views, in relation to others, which would not have been possible in an interview (Sim and Snell, 1996).

Participants
All FGs consisted of five or six participants. These participants were selected by a recruitment agency that specializes in the selection of participants for FGs. They were given a small fee (€35) for their participation. They did not know the topic of the FG before joining the discussions in order to prevent them from looking up information online. All participants were asked their permission to
be recorded in advance. In each group, we brought together a similar balanced selection of participants based on gender, educational level, age and living environment (village or city). There were no other criteria than for each group to have a similar balanced distribution. In four occasions, a participant cancelled on the day of the FG: in two cases a replacement with similar characteristics was found, and in two cases this was so last-minute that the FG was held with five participants instead of six.

**FGs outline**

In all eight FGs, two or three facilitators were present. Author A.W.B. was the main facilitator in four FGs and guided the facilitators in the other four FGs. The FGs followed the same 2-hour structure. The FGs began with an introduction round in which we also asked whether participants were familiar with the topic and what their (first) impressions were. Then we gave a short 5-minute introduction presentation that focused on the technique (the basics of DNA, also showing how organisms can be altered or created) and the fields of application and mentioned that there were opportunities and concerns to be discussed – which was thus the theme of the FG. The core of the FGs centred around three main fields of application (health, environment and food) that were discussed after the participants were presented with these themes through short vignettes. An example is shown in Box 1. All vignettes showed both positive and negative ethical, legal and social aspects of potential SB developments. After these thematic discussions, there was a more creative and open exercise in which participants were asked to divide their own research money over future newspaper headlines. The FGs ended with a reflection round using a word spider mapping the most important concepts and an evaluation.

**Box 1. Example vignette.**

| Synthetic biology would allow us to create cells that can grow into body parts, for example, skin tissue or new kidneys. Eventually, it might be possible to develop combinations of organs. This application could be a solution to organ shortage. This case is about organs that are artificially created instead of naturally grown. |

**Analysis**

All FGs were transcribed and both hand coded and coded using MAXQDA 11 software. We included everything that was said during the FGs in our analysis, including the introduction rounds and the concluding exercises. Data were analysed by authors A.W.B. and F.K. We performed inductive thematic labelling and coding (see, for example, Braun and Clarke, 2006) and then organized our data into three main themes: framing of artefacts and practices, societal desirability and ethical acceptability, and governance. In our analysis, we focused on dominant frames of participants (see Figure 1) and how these themes are approached from these dominant frames.

**4. Results**

**Representation of archetypical views**

Analysis of the eight FG discussions shows that although all four archetypical views of SB were apparent in the discussions, the majority of the participants argued from a dominant determinist or instrumentalist view. At the same time, we saw that although most participants have a dominant view, they do shift to other views under certain circumstances.
The ‘determinists’ mostly express concerns about the kind of impact SB might have on their lives, and the world, and the lack of influence they (or we as humanity) have on those developments in return. Confronted with concrete advantages of SB, they are inclined to acknowledge them but not without posing counterquestions. The advantages are not embraced but rather ‘not negated’. This observation fits the determinist assumption that technology development is inevitable and out of control. In the words of participant IM (FG8),

Yeah, I am saying, you can do little about it because development … 10 years ago, the mobile phone, it wasn’t much so to say, and now in daily life, if you don’t have one you’re not part of it, if you know what I mean, so, diseases, you used to die from the flu, and now? The flu is nothing. It’s just very hard to stop

Participants with a dominant instrumentalist view certainly embraced the advantages of SB. They found it reassuring that S&T form a solution to many of our problems, and improve our lives and health, from a generally optimistic standpoint regarding technology and its use:

Ah well, an advantage, I’m just making something up, food. If you make plants, you make new kinds of food that are very nutritional, for example many proteins. Many good carbs for example. You could probably do a lot with that. There’s a lot of scarcity in the world. And that you could solve quite a bit with this. […] The advantages are mostly for poor countries, in Africa for example. (JW, FG2)

Concerns are also expressed, but not as a counterargument. Concerns are viewed as a requirement for further research – as something we can take into account. Also, concerns are mostly raised about so-called ‘hard impacts’, questions of, for example, safety and security. More fundamental issues about the way technology structures our lives, often found in the determinists’ discourse, were not observed in the worries expressed by ‘instrumentalists’. An example of this difference was seen in a discussion about the synthetic creation of organs. Many participants raised issues regarding the quality of these organs and chances of rejection. For ‘determinists’, these unknowns oppose the lifesaving promises; for the ‘instrumentalists’, they merely show that research should be done into these matters.

Most participants in the FG discussions adopted an instrumentalist or a determinist view. As a result, probably, the discussions exhibited a clear risk versus opportunity discourse. At the same time, in all sessions we encountered participants with co-evolutionary views. Despite their minority, their contributions stood out. Their contributions were different in nature from those of others, and they continued to add to the discussion when others were finished. Also, they did often not take part in coalition forming but continued reasoning in their own different way. One of the aspects that were different, for example, was the openness towards new and creative possibilities:

Then we need to make a little hop skip jump into the future. If we as humans can become independent from fossil fuels and not only from fuel but from the earth in itself for food and whatnot, we are not restrained by it. And then, many nice things could happen … (KL, FG1)

Rather than concrete applications or risks, the argument focuses on what a possible future world could look like. This participant would often contribute in this particular manner, after other participants agreed on an argument or when no new discussion points were raised.

Another reason why their contributions stood out was their language. The ‘creative designers’ and ‘adaptivists’ in our FGs used different language in their arguments, trying to describe either the mutual influencing of S&T and society or the open-endedness of technological development. An
example of this was seen in a discussion about rules on food labelling, in which LH (FG7) was not actively participating until the end stating,

That might be all true, but in the end we also buy what we buy and feel about it the way we feel about it, it’s not that simple, we are all in this system.

In many discussions, it became visible that the contributions from this perspective did not always resound with ‘determinists’ or ‘instrumentalists’. This resulted often in situations of silence, after which new topics were started.

Within the group of ‘co-evolutionists’, we observed several differences in view. The framework of archetypical views outlined above was helpful to interpret those differences. Perhaps because of the dominant risk versus opportunity discourse, the question on who or what is leading (in) the developments of SB was a central and recurring theme in many discussions. The basic assumption of agency gives a completely different meaning not only to notions of risks and opportunities but also to the role of society, the future, education, and so on. This opposition was also recognized in the different contributions of co-evolutionists. In line with the framework, we distinguished creative design view and adaptivist views among the participants. Observations in the dialogues supported our understanding of the different frames, showing a frequently recurring distinction between creating developments and continuously adapting to them:

It should just be adjusted per stage, see how it goes, you can’t say beforehand we will go this far, that should be done in the process, and then continuously ask, and ‘what now’? (YP, FG6)

This contrasts the ‘instrumentalist’ view that SB can be valued and judged by its products and services regardless of their context. It is also essentially different from the ‘determinist’s’ focus on the impact of technology on us.

**Guiding themes in citizen discussions on SB**

The themes and narratives discussed here are strongly interconnected. They are also reflective of the current societal context in which this study took place.

**Framing of artefacts and practices**

*Malleability, natural and normal.* Within the group that had a dominant determinist view, we often heard the argument that these developments are unnatural or ‘not natural’ – and therefore not wished for. Here, the term ‘unnatural’ was not used to describe things that are ‘not organic’, but more ‘as opposed to the normal course of action’. It seems that the famous playing god argument, even expressed in statements such as ‘We shouldn’t play God’ and ‘you’re in the Maker’s chair then’, was often not used as a religious argument but as a metaphor for not letting things run their course.

As participant MT (FG8) says,

I work with the elderly and I always have the strong feeling that people aren’t allowed to die anymore, and I really get that feeling with this.

A related argument revolved around the idea that you should not interfere in the current state of affairs because that is good as it is, often out of concern for uncontrollable effects:

but you are messing with a balanced ecosystem yet again. (ME, FG5)
Finally, there were many participants with a determinist view who aim to illustrate that we as human beings are just trying to exploit and take control, making things more malleable for the sake of having and taking control. In the words of JM (FG3),

You are intervening in nature; we can’t make everything malleable in life, that’s what I’m thinking. basically that making things malleable, wanting to play God, to have complete control over everything.

Reasoning from this determinist view, some participants argued that it was ‘arrogant’ to organize control over nature. ‘Instrumentalists’, however, saw it as ‘the logical next step’ and necessary ‘to make progress’ and sometimes even arrogant not to want it. The participants in our FGs with a dominant adaptivist view did acknowledge this idea of arrogance – the possibility of ‘going too far in control of nature’ – and emphasized that we should not forget to be considerate.

Who benefits? The question of who benefits from SB was very prominent. Questions such as ‘Who will own the technology’ and ‘can everyone afford it’ were important to many participants for different reasons:

But what you have already is companies who own the DNA of a specific type of rice, or a specific tree, some tree from India, the nema-tree, they patented it, they figured that out. And then they bring, sell it, back to the people in India. And if by accident a seedling blows over the border they have to pay because it accidently came on their land. (PJB, FG4)

Another argument expressed frequently in the FG discussions, mostly from a determinist view, was the following:

There’s a large chance that the technology is only being developed to make money, by companies that are already making money, so that inequality will only increase. (RD, FG6)

This remark is illustrative of the argument that technological development cannot be disconnected from who will benefit from it up to the likelihood that technologies are only developed to make money.

Participants with an instrumentalist view, however, would argue that it is inherent to technology that not all outcomes are beneficial to all, and they emphasize how SB might solve issues (of inequality), for example, by addressing food security. This difference in argumentation is characteristic of the discussion dynamic between ‘instrumentalists’ and ‘determinists’. Participants with a creative design view or adaptivist view often tried to step away from this binary, arguing that ‘there are more sides to the story’ in order to emphasize value plurality.

Societal desirability and ethical acceptability

Framing of problems and opportunities. Participants frame problems and opportunities differently because they (a) have a different perspective on the problem, resulting in a different problem definition, or (b) reframe the problem strategically in order to protect a particular value they hold. An example of the first phenomenon is the discussion about food security in FG5. Participant MD, who adopted an instrumentalist perspective, recognizes potential:

That’s where the necessity lays, in the development of bananas that can grow under water, for example, to solve the food shortage in the world.
Two participants with a dominant determinist view, however, respond almost simultaneously: ‘but there is not food shortage’ (KF) and ‘there is no such thing’ (ME).

With respect to all three SB cases, we saw that participants would debate on the urgency of what developments in SB could offer. Similar to the dynamic of ‘we can solve problem x’ → ‘there is no problem x’, this was often in response to possible positive applications or effects. These were strategically marked as either too expensive or not linked to the societal issues they feel are most important.

Another reframing dynamic that occurred in the discussions was what can be seen as a discussion stopper: diverting off topic with a non-disputable statement. An example of this is the conversation between RP and IM (FG8) about superhumans. RP hesitantly says, ‘I don’t know, this sort of feels like, towards, during the second world war, when they started these experiments’, and IM responds quickly, ‘that holds for everything, misuse can happen anywhere, and when you’re scientist or something, you just try to make the most of it, but there will always be people, dictators, who want to do wrong …’.

**On limits and boundaries.** The issue of control was in most discussions introduced by participants with a dominant determinist view, predominantly framing it as a matter of setting boundaries. The often-heard statement ‘We shouldn’t do or want everything we [technically] can’ captures that core idea. For ‘determinists’, boundaries related to an intuitive judgement that was difficult to explain.

Most of these ‘determinists’ felt that the limits of technologies such as SB are being stretched by others, crossing their own boundaries. Moreover, they expressed to have little influence on setting these boundaries. Also when potential benefits were recognized, exploring boundaries as we go was deemed dangerous or unwise:

I mean, it sounds very Dutch, pointing a finger and wanting control, but these things come with unlimited possibilities for terrorists, for example. (ME, FG5)

Setting boundaries is also an important theme for the ‘instrumentalists’. In their opinion, setting boundaries is about systematically evaluating the limits. It is not something that should be exploratory in nature; boundaries are not so much emotional or contextual – they are and should be measurable. Consequently, they regard both setting and safeguarding boundaries a task for experts. They are the ones with scientific, factual knowledge: ‘they know best’ and ‘they can predict how things will go’. Interestingly, both ‘instrumentalists’ and ‘determinists’ only see a small role for themselves or society, in general, when it comes to setting or protecting boundaries.

The discussion of limits revealed a difference among the participants in how the meaning of boundaries was approached. Boundaries can be seen as an end point and a starting point. From a creative design perspective, the (freedom of) exploration of boundaries is key in its meaning:

I also find it interesting to see what the limits are and to mess about with those limits. (KL, FG1)

In this sense, boundaries become spaces of action, instead of brick walls or red flags.

The fourth view on setting and protecting limits of SB can be summarized as a continuous adaptive learning process. In this, similar to the ‘freedom approach’, society plays an important role in making sure this process goes well. If we are to enter new worlds in which technology and humans are fundamentally connected and part of the same, we need to be careful and alert in our responses. JS (FG5) explores the idea of connections between the worlds, the impact that has and what this requires in terms of dealing with it.
JS first argues,

Because, everything will get shuffled around, not just, uhm, and this sounds corny, norms and values, but everything, the whole of humanity will probably run the risk to fall or crumble.

He later continues on how to deal with all this:

Perhaps a pilot phase first, you know, like that at a given moment a certain development came into being, and then a pilot, or how would you call that, a trial, and based on that trial, and what comes out of it, developments can continue to develop [...] but in the pilot phase [...] the possibilities will be looked at carefully, and thought about [...] coming back to those target groups, for who this would be important, and they can then indicate, this is or is not applicable to us, or perhaps applicable, or the options that come out of it …

**Governance**

**Matters of trust.** Trust was mostly discussed in interactions between participants holding a determinist view and participants holding an instrumentalist view. Doubts from a determinist perspective about the intentions of the major stakeholder groups in the field of SB, science, industry or government were predominantly raised in discussions about the responsibility for making decisions about the future of SB. For example, when a participant suggested an important role for independent scientists, the validity of that contribution was questioned either out of a lack of trust in the scientist’s integrity or referring to the uncertain nature of scientific work:

> Even in science they contradict each other, one says it is good, and the other says that it isn’t, and the other says it’s not harmful, and as long as they are not sure about it, we just have to … (PL, FG7)

Industry was trusted even less. Many participants reasoning from a determinist perspective believed that in the end ‘it’s always all about the money’. For example, in a discussion about the contribution of SB companies to public health, a participant argued,

> Well, I don’t believe they’re in it to make me healthier, more to become a lot richer themselves. (DV, FG6)

Also the government could not count on a lot of faith among participants holding a determinist perspective.

‘Instrumentalists’, on the other hand, looked differently at these major stakeholder groups and granted the highest credibility to scientists. Firmly believing in (their) objectivity, they trust predications of scientists. Scientists were viewed as independent, and the scientists’ integrity was valued and appreciated. In conversation with participants with a determinist view, they did acknowledge cases in which the integrity of scientists could be disputed, but regarded them as incidents rather than a structural phenomenon. A solution is sought in clear limits and control procedures and the involvement of objective expertise:

> Well, I think that people should think about this really well with real experts, if you are really making this because it can also go the wrong way, creating an Ubermensch, or a sort of robot, so you need to stay within certain limits I think, you know, is it safe and useful. (JF, FG6)

Participants with an instrumentalist view often felt that decisions should be made by experts, not politicians. They did acknowledge the need for a government to issue legislation and rules to prevent and control negative impacts:
But well, if the government just says like we’re choosing for the new synthetically made fuel and the environment will be less damaged, that everyone just has to deal with that. I think that’ll be a good solution in the long run. People will get used to those really high prices then. (JK, FG1)

Participants holding a creative design perspective or adaptivist perspective were generally less outspoken about the issue of trust, especially in relation to concrete stakeholder groups. Sometimes, they were able to shift the discussion towards a new solution, for example, by suggesting collaboration between different stakeholders as a way to organize trust.

**Dealing with uncertainties.** Participants of the FGs differed in the extent to which they were willing to accept the uncertainties associated with SB developments. We found this difference could be explained by a difference in underlying assumptions. Participants with a creative design or instrumentalist perspectives, for example, viewed uncertainty as an integral part of the process of discovery. ‘Creative design thinkers’ felt that you cannot foresee important discoveries – and that they happen due to a surprising combination of factors. For these participants, this assumption would be a reason to accept the uncertainty associated with discovery.

For ‘instrumentalists’, the intrinsic value of knowledge was more important and led them to accept the associated uncertainties. Participants with a determinist perspective, on the contrary, often highlighted that ‘you can never be sure if something is safe’. Even though these participants did recognize the advantages of SB, they opted for a precautionary approach. Rather than by the value of progress, they were guided by the value of security.

Departing from different core ideas and values, different participants adhered to different forms of governance to deal with the uncertainties involved. Participants attributed different meanings to concepts, such as responsibility and control, as is illustrated by the example of nuclear energy developments as a comparative technology to SB. There were quite a few moments where participants used the analogy of nuclear energy, weapons or disasters in discussions. In most cases, the central points were about lack of control, dual use and terrorism. Here, the comparison was made either to illustrate dramatic outcomes of uncertain technologies or to show that with any technology there are people out there who want to do harm with them:

And is it possible to sustain? I don’t think we can sustain it. Just like nuclear technology, if you want the information you can get it (VL, FG4)

The argument is made that no matter how hard you try to develop or use a technology safely, you can never be sure. MD (FG5) – someone with a dominant ‘instrumentalist’ view – uses the comparison to illustrate that you can contain (even the most dangerous) things:

Look, i can imagine that if you would make a power station according to this idea, then you could make, just like a nuclear power plant, a contained area, so that way you basically have everything under control.

ME (FG5), a determinist, responds quickly,

Just look at Fukushima.

In a different FG, DK (FG6), whose contributions seem to be anchored in a ‘creative design’ view, acknowledges the same but concludes differently:

Well yes, but the atom bomb was also an innovation, not a good one, but it was part of it, of nuclear energy.
Another example in which these notions of temporality and context come into the discussion comes from PJ (FG4), who is also an ‘adaptivist’:

I think that the reality is always very temporary, I mean the knowledge about what is good and what isn’t and which nutrients are needed, that is based on the knowledge. And the reality of that knowledge just changes. So, I don’t really think there is food that is precisely right, it changes all the time, so I think I wouldn’t expect too much from that.

5. Discussion

Archetypes, views and frames

In this article, we have described how four fundamental views of S&T are connected to dynamics of problem setting and framing when discussing SB. We have argued that while all four archetypical frames emerged during our discussions, most participants seem to reason within a dominant determinist or instrumentalist frame. This resulted in a risk versus opportunity discourse in which it was difficult for participants with ‘creative design’ and ‘adaptivist’ views to find their way. Participants with similar archetypical views easily found each other and harmony between those participants often grew quite strong over the course of the discussions. The outcome that most people deploy a determinist or instrumentalist framing is in contrast with the Science and Technology Studies (STS) consensus that S&T are developed in co-production or co-evolution with society. These results are similar to those of Boerwinkel et al. (2014), where participating students also expressed mainly determinist and instrumentalist attitudes towards SB.

We argue that even if perspectives clash with the STS accord that ‘the way that we know the world is inseparable of the way we choose how to live it’ (Jasanoff, 2004: 2), it is important to acknowledge and explore these existing views. We observed how participants frame problems and opportunities differently because of their different core values on S&T or because they strategically reframe them to protect their core beliefs. Because of this, some conversations had the tendency to turn into a dialogue of the deaf – being unresponsive to what the other is saying and resulting in only superficial exchange of thoughts.

People who problematize technology are often labelled as ‘against’ or ‘in fear of’ technology. Besides the point that this is a superficial reading of someone’s argument, it should also be noted that problematization is a common part of sensemaking. As Bogner and Torgersen (2015) describe, ‘problematizing does not mean deciphering a problem that exists ex ante; in fact, it is a way of giving technology a meaning that is not random’ (p. 519). We saw exactly that participants tried to make sense of the cases that they were presented with by expressing concerns about existing policies, the trustworthiness of governments and their experiences with other technologies – not automatically leading to a definite or exclusive ‘no’ to ‘the technology’. Problematization of topics around SB formed a large part of the conversations, with participants being mostly concerned about or interested in ethical issues such as equality, distribution of and access to benefits, and power. Interestingly, Torgersen and Schmidt (2013) concluded in their study that ethics does not seem to play a dominant role in the biotechnology analogy of SB. They argue that references to one of the strongest possible ethical challenges, the ‘playing God’ metaphor, seem to be less attractive to the press and to members of the public than expert discourse sometimes suggests. In contrast, our study suggests that members of the public do actively engage in ethical enquiry within a dominant risk versus opportunity discourse and that they do use the ‘playing God’ metaphor very often, mostly as a way to bring the argument that ‘we shouldn’t do everything we technically can’ to life.

The ethical discussions that the participants engaged in resonate well with what Swierstra and Rip (2007) call NEST-ethics: an ethics of new and emerging technologies that have characteristic
patterns of moral argumentation. We would like to make the remark here that while they argue that with nanotechnology there is little about the ‘nano’ of the technology that sets it apart from general NEST-ethics and that ‘this is different from the case of bio-ethics, where aspects and issues derived from living creatures are a shared starting point’ (Swierstra and Rip, 2007: 3), by far most ethical reflections by participants in our FGs were also general NEST instead of bio. Even though discussions, primarily following the case about artificial organs, revolved around the creation of life and participants did comment on notions of naturalness and origins of life, it became clear that often-times these remarks had different meanings: they were more about letting things run their course or about issues of money and power. Of course, this is not to say that we should revisit the idea of a bio-ethics, but more to add to what we know about how lay people engage in ethics when they take part in discussions on emerging technologies.

Meaningful dialogue

The observation that underlying dynamics in making sense of SB have a layered pattern could be seen as a point of action in our quest to make science society dialogues more meaningful or impactful.

From the analysis of our citizen discussions, we argue that this means the notion of having frames should be a topic of dialogue in itself. We see that insights into how everyone’s perceptions of problems and solutions are being shaped by our individual and collective framing processes are essential for meaningful conversations. We should pay attention to frame awareness and opportunities of reframing (allowing for shifts in perceptions).

What we pose is in line with the account of frames as put forward by Dorst (2011) that frames are

very complex sets of statements that include the specific perception of a problem situation, the (implicit) adoption of certain concepts to describe the situation, a ‘working principle’ that underpins a solution and the key thesis: if we look at the problem situation from this viewpoint, and adopt the working principle associated with that position, then we will create the value we are striving for. (p. 525)

In line with this, we argue that the untangling of frame dynamics should be a core feature of our societal dialogue on SB.

Limitations of this study

It is hard, if not impossible, to start a discussion about SB without framing it already. Throughout the FG process, we therefore strived for a balanced representation of a diversity of application fields and argumentation lines.

The literature on public engagement in biotechnology discusses three interconnected issues that we address here. First, as described by Bogner (2012), small-scale participation experiments are prone to having a paradoxical effect because of their retraction from society. Second, despite its scale, these experiments do actively shape imaginaries of the future (e.g. Borup et al., 2006), not only in the minds of participants but also by writing them down in this article. And third (because of these two points), in organizing these experiments (STS), scholars are ‘divided between the aim of maintaining a critical and reflexive approach based on theoretical ideals and a social commitment to engaging in action’ (Delgado et al., 2010: 840).

Our setup was carefully designed and by that carried out under controlled conditions. We highlight our openness about this and about our rationales for this project: getting a feeling for
underlying frame dynamics in conversations between citizens. In this sense, it was more to see what participation would look like or to inform future large-scale and/or ongoing participation experiments.

Another issue concerns the notion that SB is ‘a global endeavor’ with research and development programmes in many countries having the potential to improve global health in the area of vaccine development and drug synthesis (Douglas and Stemerding, 2013). Because of this, as they argue, SB requires a global governance strategy. This raises questions about the meaning of our study in other parts of the world and emphasizes the importance of focusing on cultural aspects of sense-making and framing. In this article, we have explored connections between implicit layers of sensemaking and explicit meanings, and it would be interesting to see how cultural and societal differences play a role in these dynamics.

**Conclusion**

We began this research project with a dialogue perspective: How to deal with differences in sense-making of SB in a meaningful dialogue? From this perspective, we found that citizens are very well capable of discussing and making sense of SB. Our results suggest that how people feel about SB is grounded in core value systems, much dependent on the context and general feelings of (dis)content, and support the idea that most people are not inherently against or for SB, as a technology or development in itself. Given that there are many assumptions focused on this binary idea of the public’s view, this study emphasizes the need for frame awareness and understanding.

**Funding**

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This work was carried out within the BE-Basic R&D Program, which was granted a FES subsidy from the Dutch Ministry of Economic affairs, agriculture and innovation (EL&I), and was also supported by the Centre for Society and the Life Sciences (CSG).

**References**

Barns I, Schibeci R, Davison A and Shaw R (2000) ‘What do you think about genetic medicine?’ Facilitating sociable public discourse on developments in the new genetics. *Science, Technology & Human Values* 25(3): 283–308.

Benard M (2014) *Engaging society in pig research. A multi-stakeholder approach to enhance animal welfare in pig production*. PhD Thesis, VU University, Amsterdam.

Bijker W, Hughes T, Pinch T and Douglas D (2012) *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*. Cambridge: MIT Press.

Boerwinkel D, Swierstra T and Waarlo A (2014) Reframing and articulating socio-scientific classroom discourses on genetic testing from an STS perspective. *Science & Education* 23(2): 485–507.

Bogner A (2012) The paradox of participation experiments. *Science, Technology & Human Values* 37(5): 506–527.

Bogner A and Torgersen H (2015) Different ways of problematising biotechnology – And what it means for technology governance. *Public Understanding of Science* 24(5): 516–532.

Borup M, Brown N, Konrad K and van Lente H (2006) The sociology of expectations in S&T. *Technology Analysis & Strategic Management* 18(3): 285–298.

Braun V and Clarke V (2006) Using thematic analysis in psychology. *Qualitative Research in Psychology* 3(2): 77–101.

Cuppen E, Breukers S, Hischemöller M and Bergsma E (2010) Q methodology to select participants for a stakeholder dialogue on energy options from biomass in the Netherlands. *Ecological Economics* 69(3): 579–591.
Dabrock P (2009) Playing God? Synthetic biology as a theological and ethical challenge. *Systems and Synthetic Biology* 3(1–4): 47–54.

De Lorenzo V and Danchin A (2008) Synthetic biology: Discovering new worlds and new words. *EMBO Reports* 9(9): 822–827.

Delgado A, Kjølberg K and Wickson F (2010) Public engagement coming of age: From theory to practice in STS encounters with nanotechnology. *Public Understanding of Science* 20(6): 826–845.

Dorst K (2011) The core of ‘design thinking’ and its application. *Design Studies* 32(6): 521–532.

Douglas C and Stemmer D (2013) Governing synthetic biology for global health through responsible research and innovation. *Systems and Synthetic Biology* 7(3): 139–150.

Ellul J (1964) *The Technological Society*. New York: Vintage Books.

Haraway D (1991) A cyborg manifesto: Science, technology, and socialist-feminism in the late twentieth century. In: Haraway D (ed.) *Simians, Cyborgs and Women: The Reinvention of Nature*. New York: Routledge, pp. 149–181.

Hisschemöller M, Hoppe R, Groenewegen P and Midden C (2001) Knowledge use and political choice in Dutch environmental policy: A problem structuring perspective on real life experiments in extended peer review. In: Hisschemöller M, Hoppe R, Dunn WN and Ravetz JR (eds) *Knowledge, Power and Participation in Environmental Policy Analysis* (Policy studies review annual, vol. 12). New Brunswick, NJ: Transaction Publishers, pp. 437–470.

Jasanoff S (ed.) (2004) *States of Knowledge: The Co-Production of Science and the Social Order*. New York: Routledge.

Keulartz J, Schermer M, Korthals M and Swierstra T (2004) Ethics in a technological culture. A programmatic proposal for a pragmatist approach. *Science, Technology & Human Values* 29(1): 3–29.

Khalil A and Collins J (2010) Synthetic biology: Applications come of age. *Nature Reviews Genetics* 11(5): 367–379.

Kupper F and De Cock Buning T (2011) Deliberating animal values: A pragmatic – Pluralistic approach to animal ethics. *Journal of Agricultural and Environmental Ethics* 24(5): 431–450.

Kupper F and Krijgsman L (2007) The value lab: Exploring moral frameworks in the deliberation of values in the animal biotechnology debate. *Science and Public Policy (SPP)* 34(9): 657–670.

Latour B (1992) *Where Are the Missing Masses? The Sociology of the New Mundane Artifacts* (Shaping technology, building society). Cambridge, MA: MIT Press.

Marris C and Rose N (2010) Open engagement: Exploring public participation in the biosciences. *PLoS Biology* 8(11): e1000549.

Rowe G and Frewer (2000) Public participation methods: A framework for evaluation. *Science, Technology & Human Values* 25(1): 3–29.

Schön D and Rein M (1994) *Frame Reflection: Toward the Resolution of Intractable Policy Controversies*. New York: Basic Books.

Seitz S (2016) Let’s talk about… synthetic biology—emerging technologies and the public. In: Hagen K, Engelhard M, Toepfer G (eds) *Ambivalences of Creating Life—Societal and Philosophical Dimensions of Synthetic Biology*. Berlin: Springer, pp. 157–175.

Sim J and Snell J (1996) Focus groups in physiotherapy evaluation and research. *Physiotherapy* 82(3): 189–198.

Singh M and Vaidya A (2015) Translational synthetic biology. *Systems and Synthetic Biology* 9(4): 191–195.

Smith G (2003) *Deliberative Democracy and the Environment*. New York: Psychology Press.

Swierstra T and Rip A (2007) Nano-ethics as NEST-ethics: Patterns of moral argumentation about new and emerging S&T. *Nanoethics* 1(1): 3–20.

Te Velde H, Aarts N and Van Woerkum C (2002) Dealing with ambivalence: Farmers’ and consumers’ perceptions of animal welfare in livestock breeding. *Journal of Agricultural and Environmental Ethics* 15(2): 203–219.

Torgersen H and Schmidt M (2013) Frames and comparators: How might a debate on synthetic biology evolve? *Futures* 48: 44–54.

Van den Belt H (2009) Playing God in Frankenstein’s footsteps: Synthetic biology and the meaning of life. *Nanoethics* 3(3): 257–268.
Author biographies

Afke Wieke Betten is a PhD Candidate and Lecturer at the Athena Institute for Research on Innovation and Communication in Health and Life Sciences at the VU University Amsterdam, The Netherlands. Her PhD project focuses on dynamics of sensemaking in and through deliberative processes on synthetic biology.

Jacqueline E.W. Broerse is Full Professor of Innovation and Communication in the Health and Life Sciences at the Athena Institute. Her current research is focused on methodology development for and implementation of multi-stakeholder innovation processes, reflexive monitoring and evaluation of interventions, and system innovations in order to contribute to a better embedding of new interventions in society (globally).

Frank Kupper is Assistant Professor of Science Communication and Public Engagement at the Athena Institute. His research focuses on sensemaking and framing and the development of new methodologies and tools for the design and facilitation of playful reflection and science–society dialogue.