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STANDARDISATION AND SOCIAL ORDERING:

A change of perspective

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This article examines standardisation in synthetic biology as a form of social coordination and ordering. I discuss standardisation by exploring what makes standards possible, and offer an understanding based on infrastructures: technical and social systems that support the existence and operation of accepted standards. By exploring the role of social infrastructures, I contend that standards depend upon social ordering: ways of arranging people in particular positions, relations, and hierarchies. I suggest that synthetic biologists ought to develop an awareness of these social orders, take responsibility for their creation, and accept accountability for their consequences, both technical and social.

Keywords: synthetic biology, standards, infrastructures, social orders, responsibility.

This monograph concerns itself with standardisation, with a special focus on synthetic biology. Like many who have written on the topic, I am interested in what constitutes a standard in synthetic biology. But rather than define the term *standard* (e.g., Arkin, 2008; Sauro, 2008) or discuss the challenges faced by those leading the standardisation charge (e.g., Canton et al., 2008; Frow, 2013) or compare different approaches (e.g., Anderson et al., 2010) I ask here: what makes standardisation possible? The question matters because knowing what makes something possible is often necessary for making it real. The question also offers an insightful perspective from which to evaluate otherwise hidden facets of standardisation. Thus, the question is useful both practically and critically.

I discuss standards and standardisation using the notion of *infrastructures*. In the literal sense, these include technological systems, practices, and functions. In a figurative sense, the term *infrastructures* enlightens us to the roles played by things seemingly irrelevant or tangential, such as trust and social hierarchies. A figurative understanding also supports a different way to view and carry out standardisation.

«Because of their immediate influence on our everyday activities and their ever-present character, infrastructures shape our experience of the world»

First, I present and explain my social scientific understanding of infrastructures. I point out basic characteristics of all infrastructures and describe their relevance and importance. I then use infrastructures to develop a different understanding of standards and standardisation. To do so, I introduce the notion of *social infrastructures*, which reveals standardisation to be a particular form of ordering people and arranging their behaviour. I explain how this viewpoint enables awareness, responsibility and accountability for choices made in establishing standards, and the ramifications of those choices. I finish by considering the potential for critical self-reflection made possible by a commitment to awareness, responsibility, and accountability.

INFRASTRUCTURES

Infrastructures are *enablers*: their function is to enable and sustain other functions. For example, as I write this the electrical grid that distributes power across Edinburgh enables my computer's operations. Put differently, infrastructures are never ends themselves. Motorways and streets exist only to make certain forms of modern transportation possible.

Absent what it makes possible, infrastructure loses all meaning.

Though simple, this description offers insights. First, one cannot understand infrastructures as isolated systems. With no understanding of electrical technologies, one can make no sense of electrical power plants or distribution grids. What is infrastructure, and to what end does it exist, if it enables nothing?

Second, infrastructures are *situated* and characterised by that which they enable. They exist where and how they do because of the specific functions they are meant to make possible. A region's demand for electricity will set requirements for its power plants. A small plant cannot power a metropolis and a massive plant would be an absurd choice to serve a tiny hamlet. Infrastructures exist if there exists a demand for what they enable, and they look as they do because of local contingencies.

Johanna Montoya

Infrastructures facilitate and enable other functions, but they are never an end in and of themselves. The electrical grids that supply towns and cities around the world are a good example of this, and include many elements, from the plant where energy is generated, to the transmission towers, to the sockets that allow us to power our homes. Without the need for this energy, the structures that provide us with it would have no reason to exist.

Finally, as enablers infrastructures establish *new affordances*. A system that creates and conveys electrical power supplies users with new capacities. Where previously those people could not operate electrical devices, the infrastructure provides them with the ability to do so. Extending a system of roads enables new opportunities for motorised travel (namely, the ability to reach more places). Nonetheless, making possible is not unbridled. Constraints accompany affordances. Just as important to understanding infrastructures as enablers is to understand them as constrained and constraining enablers.

«Building infrastructures is a type of grudge work not normally celebrated, but vital if standardisation is to succeed»

Infrastructures are *ubiquitous*. They are ever-present or ever-ready because without being so they cannot satisfy their function as reliable enablers. Because of their immediate influence on our everyday activities and their ever-present character, infrastructures also shape our experience of the world. Moreover, because we rely on them and because they affect so much of what we do, infrastructures become fixed and long-lasting. Their ubiquity and longevity suggest their importance and worth. Most obviously, infrastructures are *important* and *valuable* because we value what they enable. For instance, many people enjoy or depend upon the ability to contact others in far-away places. Communication infrastructures enable such contact, and so we appreciate them. More importantly, we come to depend on them. International research projects rely on e-mail exchanges and videoconferencing, both made possible by communication infrastructures. We arrange our behaviour in accordance with those capacities and come to depend on their uninterrupted availability and functionality. In general, we depend on different forms of stability that infrastructures provide. We also depend on the stability of infrastructures' capacities and constraints: certainty over what we can and cannot do.

Markus Spiske

Jan Kaluza

Infrastructures are *heterogeneous assemblies* of very different components. For example, electrical infrastructures include: objects such as generators, power lines, wiring, sockets, and metres; places such as plants, distribution centres, and end-points; practices such as planning, fabrication, installation, repair, use, oversight, and regulation; knowledge such as electromagnetism laws, engineering skills, mundane user knowledge, and regulatory expertise; and organisations such as power companies, national regulators, and technology suppliers. Those parts depend on each other and must work together in order for the infrastructure to operate successfully. Infrastructures' heterogeneity supports a united outcome. The many parts of an electrical infrastructure enable one capacity: electrical power. If they do so successfully, then the complexity is hidden and I see only what is made possible. I see the socket and the reaction of my computer to being plugged in; I do not see what made either possible.

As a result, infrastructures are *difficult to see*. We engage with the farthest tips of their longest extremities, such as the wall socket or the water tap. In fact, we only engage with what they enable, such as the devices that run on electrical current. There are many reasons for this invisibility. Some infrastructures (like the electrical power grid) are so expansive that one cannot view them in their entirety. Others are physically isolated, such as water piping, and so are not easily accessible. Most importantly, there is no need to be aware of infrastructures so long as they remain functional. I do not need to see electrical infrastructure if my access to power goes undisturbed. That changes once functionality fails and our regular behaviour runs into problems, such as our lights being cut. Infrastructures are also visible when they are still being built, such as are synthetic biology standards. During that time, infrastructures are accessible and open to change.

STANDARDS AND SOCIAL INFRASTRUCTURES

The concept of an infrastructure is relevant to standards and standardisation in many ways. Most obviously, one cannot have a universal, reliable, and easily adoptable system of standards without those things that make it possible. For example, synthetic biology standardisation requires systems that make assembly, storage, and distribution of genetic parts possible (e.g., Anderson et al., 2010; Endy & Arkin, 1999). They require tools for compiling, storing, and sharing data that characterise those parts (e.g., Mutalik et al., 2013). At the same time, infrastructures rely on standards. Shared parameters, units, parts, and procedures make it possible to build infrastructures and to deliver products that depend on them. What binds the two forms of dependence is their shared need for social ordering.

«Like all infrastructures, social orders are neither static nor ends in themselves; they are dynamic and support other things»

Building infrastructures is a type of grudge work not normally celebrated, but vital if standardisation is to succeed. Less obvious, but even more important, is «social infrastructure»: forms of social coordination without which standardisation cannot come to be. Simply put, a social infrastructure is a particular ordering of people in a community. Ordering involves the ways that a given community is divided into sub-groups and the ways in which its members are sorted among them. It constitutes how the groups relate to each other, how people inside of them are assigned roles, responsibilities, allowances, and restrictions. Orders also include how people are arranged into hierarchies and how social power is distributed in different ways to different persons.

Societies are more than just collections of people; they are collections of people who interact with each other in certain ways (Barnes, 2001; Wenger, 1998). Social ordering enables those interactions. Like all infrastructures, social orders are neither static nor ends in themselves; they are dynamic and support other things. The most important is to enable people to participate in shared activities. For example, language (an infrastructure) makes interpersonal communication (a shared practice) possible. Social orders enable diverse populations to produce shared constructs. For example, social ordering enables groups of people to plan, build, and maintain an operational power grid.

Blaz Erzetic

Standards are successful when a given community embraces and implements them collectively. Otherwise, their existence would be impossible. The metric system, for example, is an example of a worldwide standard.

Collectives, orders, and standards

Many social orders develop without intention or director. Others are planned and installed intentionally. Standards in synthetic biology are not a happenstance development. Instead, groups of people have produced them deliberately, or are working intentionally to create new ones (Frow, 2013). If standards are successful, colleagues coordinate their behaviour accordingly and intentionally. That is, the community plans, establishes, and follows a specific social order (a particular social infrastructure).

We often perceive standards in terms of such things as specified parameters, guidelines for practice, configurations of data, blueprints to follow, and diagrams to reference. All of these exist and all are relevant to standardisation. However, not one of them accomplishes anything by itself. If no people subscribe to parameters and guidelines, they are just lists. If nobody makes use of blueprints and diagrams, they are just images. Data not put to work are meaningless information. Only when people enrol these many things into some kind of practice do they accomplish something (Schaffer, 1999). Nonetheless, only some kinds of practice will do.

«If by *standard*, we mean same, shared, or synchronised, then multiple coordinated people are necessary»

Standards become possible, gain meaning and operate successfully only when practice is collective. It makes no sense to talk about standards that only one person follows, since standards are supposed to be used uniformly by all (or at least, most) members of a community. If by *standard*, we mean same, shared, or synchronised, then multiple coordinated people are necessary. While standards are built by people, only when the group coordinates its actions appropriately (adopts the right social order) do those standards exist and they operate only once a specific social order exists and operates (Barnes, 2001; Schyfter, 2015). Working standards depend on working social infrastructures.

This realisation provides a different understanding of standards. Standardisation involves making choices about how to sort people out. That is, it consists of arranging people into particular configurations and then enrolling them in specific types of practices. Most simply, one must create a group of people that are jointly committed to the standards, and that together design, install, use, and maintain those standards. Arranging people into particular orders also involves distributing responsibilities for different tasks, setting people's privileges and constraints, defining criteria to evaluate people's behaviours, and creating ways to make sure that people stay «in line» with the standards (Barnes, 2001; Wenger, 1998).

As a result, we are posed with an important question: as a group develops and establishes standards, what form of social orders do they create? As I noted above, infrastructures are visible when being put together. The same is true of *social* infrastructures like social orders. Once established, social orders are difficult to see; while still in the making, they are less opaque. Synthetic biologists are still putting their standards together, which means that they are still constructing the relevant social orders.

Awareness, responsibility, and accountability

As they make technical choices about things like design, functionality, assembly, use, storage, metrology, and terminology, synthetic biologists are making choices about how to sort out their people.

Those making the social orders cannot circumvent those choices. Instead, the decision is between making the choices actively, or accepting whatever results come to pass. Synthetic biologists should ask themselves if surrendering control to chance is the best way to arrange their community. I believe that synthetic biologists ought to establish their social infrastructure actively. I also believe that three principles can guide their efforts: awareness, responsibility, and accountability.

Awareness consists of replacing assumptions and commonplace beliefs with more accurate understanding. In this case, awareness involves questioning what a standard is, what it requires, how it exists and what it causes. Put differently, replacing a view of standards as static guidelines or rules with an understanding of standards as active social coordination. Awareness consists of realising that making sense of what standards are requires thinking about how people in a collective are arranged and how they behave. Finally, awareness requires being cognizant of what occurs during the process of developing and establishing standards, even if it is not something strictly technical.

Awareness is supplemented with responsibility. People must acknowledge that not just their standards, but also that which they establish to make those standards possible, belongs to them. Scientists and technologists routinely take ownership of their accomplishments. The community also expects people to accept responsibility when practices have negative consequences. Responsibility acknowledges persons' intentional involvement in the making of things, such as standards. It also transforms awareness into something with material consequences. That is, responsibility brings awareness out of abstraction and into the grounded world of synthetic biology practice.

«Awareness consists of replacing assumptions and commonplace beliefs with more accurate understanding»

Finally, responsibility demands accountability. Once persons accept that certain accomplishments belong

to them, they must also be answerable for their consequences. Otherwise, responsibility is empty. Those responsible for making standards and for supporting standardisation are accountable for the effects of what they produce or endorse. They are also accountable for addressing faults, problems, and harm done. Just as responsibility transforms awareness into something grounded, accountability transforms responsibility into something with ramifications. It also sets down ethical expectations, commitments, and duties.

SHIFTING PERSPECTIVES, ENABLING REFLECTIONS

The social sciences offer different ways to think about standardisation. Understanding standardisation as a form of social ordering makes visible aspects of standards that are otherwise obscure. It allows us to move past the immediately accessible at the bench, on the screen, and in text and talk. Each of these offers a restricted perspective on what constitutes standardisation. Moreover, because so many of these things have become rigidly established, they offer little in terms of critical thought. A perspective that supports awareness, responsibility and accountability makes possible critical self-reflection.

Technologists are no strangers to certain forms of reflection. Even if only implicitly, technologists reflect on and evaluate their technical choices in order to ensure technological success. Following major malfunctions, such as the Space Shuttle Challenger disaster and recent accidents involving Boeing 737 MAX aircraft, procedure calls for evaluation of technological choices made (Vaughan, 1996).

Self-reflection based on a social scientific perspective expands technical reflection in order to incorporate thinking about what technical choices impose on those carrying out the work. For example, it requires people to consider how technical choices establish particular social orders, and how those orders shape experiences. Because technical choices cannot be rid of their social ramifications, this type of reflection fits effectively into technological development efforts. More importantly, this type of reflection enables active, aware decision-making. It makes explicit developments that would otherwise «just happen».

Crucially, such self-reflection becomes handicapped, if not prevented, by the institutionalisation

iGEM Foundation / Justin Knight

«Those responsible for making standards and for supporting standardisation are accountable for the effects of what they produce or endorse»

Standards need infrastructures to be consolidated, but these need to be not only physical, but also social. A social infrastructure is a particular way of ordering people in a community, in which each subgroup will be organised in a specific way that distributes the roles, responsibilities, benefits, and restrictions that must be followed by the individuals of that group. In the picture, an aerial photograph of the groups participating in iGEM 2014, an annual international synthetic biology competition that brings together about 300 participating groups, including university students of different levels, but also high school and laboratory groups. The aim of the competition is for each group to be able to build new biological systems using the same set of genetic components.

«Self-reflection based on a social science requires people to consider how technical choices establish particular social orders»

of standards. Once standards become established and operational, they hide their heritage and their inner workings. Successful standardised parts work as reliable black-boxes. Users need not know from where they come nor how they work to employ standard parts well. Once operational, standards become distant; the same is true of social orders. The most effective time to reflect on these issues is before standardisation has become shared practice, before new standards have been fixed in place, and before the community has ordered itself accordingly. The most effective time is when awareness, responsibility, and accountability remain viable.

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