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Is it possible to give scientific solutions to Grand Challenges? On the idea of Grand Challenges for life science research

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Abstract:

This paper argues that challenges that are grand in scope such as "lifelong health and wellbeing", "climate action", or "food security" cannot be addressed through scientific research only. Indeed scientific research could inhibit addressing such challenges if scientific analysis constrains the multiple possible understandings of these challenges into already available scientific categories and concepts without translating between these and everyday concerns. This argument builds on work in philosophy of science and race to postulate a process through which non-scientific notions become part of science. My aim is to make this process available to scrutiny: what I call *founding* everyday ideas in science is both culturally and epistemologically conditioned. Founding transforms a common idea into one or more scientifically relevant ones, which can be articulated into descriptively thicker and evaluatively deflated terms and enable operationalisation and measurement. The risk of founding however is that it can invisibilise or exclude from realms of scientific scrutiny interpretations that are deemed irrelevant, uninteresting or nonsensical in the domain in question –but which may remain salient for addressing grand-in-scope challenges. The paper considers concepts of "wellbeing" in development economics versus in gerontology to illustrate this process.

Keywords: grand challenges, transdisciplinarity, everyday concepts, thick concepts, founding, wellbeing

Highlights

- Grand Challenges are divided into grand-in-difficulty and grand-in-scope challenges.
- There is a process of fitting or *founding* everyday ideas into scientific contexts.
- Founding makes evaluatively thick everyday ideas descriptively thicker.

- Founded concepts offer a middle-level theory between constructs and everyday ideas.

If the function of writing is to "express the world." My father withheld child support, forcing my mother to live with her parents, my brother and I to be raised together in a small room. Grandfather called them niggers. I can't afford an automobile. Far across the calm bay stood a complex of long yellow buildings, a prison. A line is the distance between.

From Ron Silliman's "Albany", *ABC*, Tuumba Press: Berkeley, 1983

1. Introduction

"Lifelong health and wellbeing", "climate action", or "food security" are some examples of so-called "grand challenges" which are posed for multi-sector, multi-disciplinary research including the life and health sciences. Funding schemes addressing "grand", "societal", or "big" challenges indeed emerged initially in the biological and health sciences. The Bill and Melinda Gates Foundation (BMGF) Challenges for Global Health is one of the first institutional instances of research oriented around the trope of Grand Challenges, set up in 2000, and inspired in part by the United Nations Millennium Development Goals.

Already in the late 2000s and following the end of the Human Genome Project, what was envisioned to be a 21st century of biology[1] came with new mandates for research and policy agendas to begin to orient themselves towards addressing grand and societal challenges, doing not only excellent scientific research but also orienting this work to achieve "the right" impacts (Stilgoe et al. 2013; von Schomberg, 2013; Owen et al., 2013). Currently the European Union's 7-year funding scheme, Horizon 2020, and the Research Councils of the UK cross-council research areas (cf. Table 1) have adopted such funding schemes, and correspondingly these policies are setting a trend in academic research: a *Google Scholar* search for the phrase "grand challenges" in the title of articles returns 1130 results, with half of these published since 2010 and 80% of these since 2000 (06.07.2015).

[1] Cf. for instance "The Century of Biology" by Venter and Cohen (2004) written in 1997, Wake´s (2008) discussion of integrative biology as integrating knowledge from social science and humanities and Dyson Freeman (2007) imagining the 21st century domesticating biotechnology to the extent that we have domesticated physics-based computer technology. These, like other millenial visions, are provocative and speculative but they acknowledge that biological research and innovation raise issues that beg for philosophical, ethical and societal deliberation.

In this context of increasing orientation towards addressing societal challenges, also through scientific work, this paper offers an argument for why scientific research alone cannot provide full solutions to grand challenges. This conclusion may sound trivial. After all, current research policies consider grand challenges to be in need of multi-disciplinary and multi-sector, including non-scientific, expertise. Policy-relevant problems are understood to be "wicked", resisting full, certain and permanent solutions, while it is fully recognised that societal values have and should have key roles in guiding policy-relevant science (cf. Rittel and Webber, 1973; Kincaid et al., 2007). Concerted study and effort are increasingly put into developing interdisciplinary work and institutional models to reflect on socially relevant choices made during scientific and technological innovation (Klein, 2001; Frodeman et al., 2010; Crow and Dabars, 2015; van den Hoven et al., 2014).

This paper argues that scientific research can be distracting when coming to address some of the problems that have come to be referred to as Grand Challenges. I distinguish between two uses of the trope of "grand challenges": first, to refer to challenges that are of great difficulty but that may be characterised as technical goals, and second to refer to challenges that are also grand in their scope and that involve societal stakeholders and successful uptake of innovation. I point out that some of the ideas used to express the latter could have different meaning for policy makers formulating research calls and for scientists addressing them. The paper opens up to scrutiny what I think is a process whereby some everyday concepts that are used to express broad research aims can become concepts that can guide scientific measurement and research. I propose that challenges that are grand in their scope cannot be addressed scientifically unless key everyday ideas used to express them can get *founded* into scientific contexts. Founded concepts develop from everyday concepts that get fitted to what is deemed relevant and rigorous within a particular scientific domain and epistemic culture. However founded concepts will (at best) only address particular aspects of a grand-in-scope challenge. In order to illustrate this thesis, I examine concepts of "wellbeing" that might help to tackle grand challenges such as global and lifelong health and wellbeing, scientifically, and point out that they can leave out of the picture relevant aspects of being well[2]. Articulating these gaps between everyday ideas and founded concepts is one way to evidence that extra, transdisciplinary work needs to complement scientific expertise and methods when tackling a societal challenge.

Is it possible to give scientific solutions to 'grand' challenges? In short, my answer is *No* – science alone cannot solve grand challenges and it could be distracting. This answer is based on three main premises pursued in different sections of the paper. Section 2 argues that we can distinguish two uses for the trope

[2] I use the terms "concept", "notion" and "idea" interchangeably. I use no quotes to refer to things, single quotes to refer to 'concepts' and double quotes to specify "words".

of “grand challenges”, one to specify grand-in-difficulty challenges, and a second to specify grand-in-scope challenges. Challenges that are great in their scope cut across different domains of expertise and both expert and lay domains. These challenges are often expressed using thick everyday concepts: for example, ‘wellbeing’, ‘security’, ‘health’. Section 3 proposes that social and natural science can address problems expressed in everyday ideas but only by *founding* everyday ideas into scientific contexts and transfiguring these into scientific, founded concepts which may be operationalized into relevant constructs. Section 4 argues that founded concepts are not ordinary and that they vary across scientific disciplines using the example of concepts of wellbeing. Given these premises, it follows that existing scientific work alone cannot solve challenges of a grand scope: science may help specify and address related scientific questions, however, addressing grand-in-scope challenges calls for work to bridge concepts founded in different scientific domains with each other, and with everyday ideas, which currently escapes well-delineated scientific research. The final section examines some questions for further research, relating these ideas to work in transdisciplinarity studies. I suggest that a process of *founding* both articulates the central paradox of the effort to meet grand societal challenges scientifically, namely the fact that looking for a scientific solution means reshaping a given everyday problem as only ‘scientific’ questions can have scientific answers, *and* it could help such challenges to begin to be responded to. The very process of *founding* describes here how grand-in-scope challenges are narrowed in focus in order to enable research pursued in a scientifically viable fashion. Yet those seeking to meet 'grand challenges' must also gather knowledge about and reflect on the gap and relation between everyday concepts such as 'health' and 'wellbeing,' and what founded concepts allow these to be operationalized into constructs such as “75 disease- and disability-free years” or “private consumption per head”.

Ron Silliman’s prose poem “Albany” gives an evocative account of the poet’s upbringing despite, or precisely because of, its grammatical incoherencies. Scientific work also attempts to “express the world”, and to “address” it: and it does so in an idiomatic and seemingly eccentric fashion. If we take scientific creativity seriously we should allow for its extraordinary, dappled and plural thinking on everyday issues to be expressed through various concepts and constructs. However, if scientific notions and results are to be integrated across perspectives of different scientific disciplines and to include non-scientific forms of knowledge and understanding, new forums and forms of analysis must become available for scientific knowledge to be appreciated and fruitful beyond specific scientific or technocratic elites.

2. Grand-in-scope challenges are expressed using thick everyday concepts

Fields of the life sciences dealing with issues of health and sustainability were some of the first to take up the notion of Grand Challenges. In an early attempt to characterise these problems, Reid and colleagues propose four characteristics of grand challenges in earth system science, which may apply more broadly: 1) their scientific importance, 2) the need for global coordination to address them, 3) their relevance to "decision-makers", and 4) their "leverage", or contribution towards addressing other problems (Reid et al., 2010, p. 916). Though grand challenges may indeed share scientific and practical importance, and societal and policy relevance, the expression of Grand Challenges by various funding calls ranges significantly in its specificity and its use of technical language. We can see this in the table below.

Table 1. Selected Grand Challenges as presented by research funding bodies

Bill and Melinda Gates Foundation Grand Challenges for Global Health[3]	**Research Councils UK Big Research Challenges**[4]	**EU Horizon 2020 Societal Challenges**[5]
1. Create Effective Single Dose Vaccines That Can Be Used Soon After Birth	1. Digital economy	1. Health, demographic change and wellbeing;
2. Prepare Vaccines that Do Not Require Refrigeration	2. Energy	2. Food security, sustainable agriculture and forestry, marine and maritime and inland water research, and the Bioeconomy;
3. Develop Needle-Free Delivery Systems	3. Global Food Security	3. Secure, clean and efficient energy;
4. Devise Reliable Tests in Model Systems to Evaluate Live Attenuated Vaccines	4. Global uncertainties; security for all in a changing world	4. Smart, green and integrated transport;
5. Solve How to Design Antigens for Effective, Protective Immunity	5. Living with environmental change (LWEC)	5. Climate action, environment, resource efficiency and raw materials;
6. Learn Which Immunological Responses Provide Protective Immunity	6. Lifelong health and wellbeing	6. Europe in a changing world - inclusive, innovative and reflective societies;
7. Develop a Biological Strategy to Deplete or Incapacitate a Disease-transmitting Insect Population		7. Secure societies - protecting freedom and security of Europe and its citizens.
8. Develop a Chemical Strategy to Deplete or Incapacitate a Disease-transmitting Insect Population		
9. Create a Full Range of Optimal, Bioavailable Nutrients in a Single Staple Plant Species		
10. Discover Drugs and Delivery Systems that Minimize the Likelihood of Drug Resistant Micro-organisms		
11. Create Therapies that Can Cure Latent Infection		
12. Create Immunological Methods that can Cure Chronic Infections		
13. Develop Technologies that Permit Quantitative Assessment of Population Health Status		
14. Develop Technologies that Allow Assessment of Multiple Conditions and Pathogens at Point-of-Care		
15. Discover Biomarkers of Health and Disease		
16. Discover New Ways to Achieve Healthy Birth, Growth, and Development		

The scope of specified challenges ranges from broad expressions such as "Lifelong health and wellbeing" (RCUK) to tasks like "Develop a Chemical Strategy to Deplete or Incapacitate a Disease-transmitting Insect Population" (BMGF). The particular expression and pursuit of often technical goals as "grand" ones has raised concerns (Brooks et al., 2009; Edwards, 2008; Calvert, 2013) and flagged the need to keep calls open to multi-scale approaches (Kuhlman and Rip, 2014)[6].

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[3] *http://www.grandchallenges.org/Pages/BrowseByGoal.aspx*. Last accessed: 10.06.15
[4] http://www.rcuk.ac.uk/research/xrcprogrammes/ Last accessed: 10.06.15
[5] http://ec.europa.eu/programmes/horizon2020/en/h2020-section/societal-challenges Last accessed: 10.06.15

[6] Horizon 2020 lists increasingly specific areas under each grand societal challenge.

In this section I propose to distinguish between two main uses of the trope of "grand challenges" by funding organisations: First, to specify challenges that are grand but primarily because of their difficulty and importance rather than their scope. Call these "grand-in-difficulty" challenges. Typical examples of grand-in-difficulty challenges are these posed by the BMGF for global health (cf. Table 1). A second use of "grand challenges" specifies instead challenges that are complex, but also grand in scope, involving multiple levels of action from research to public policy. Call these "grand-in-scope" challenges. Horizon 2020 and RCUK challenges exemplify these.

2.1 Two tropes: Grand-in-difficulty challenges

Let me exemplify "grand-in-difficulty" challenges with The Bill & Melinda Gates Foundation (BMGF) programme "Grand Challenges for Global Health" established in 2000. BMGF grand challenges express difficult and important but concrete problems. For example, "Prepare Vaccines that Do Not Require Refrigeration" is Grand Challenge #2 on their current list (Table 1). Indeed, BMGF "grand challenges" for global health mostly include grand-in-difficulty problems that are amenable to a technical "fix".

Edwards (2008) proposes that BMGF philanthropy belongs to a tradition of "philanthrocapitalism" (a term introduced by Bishop, 2006), which has vested interests in tackling specific, "urgent" problems "now" via technical solutions rather than providing systemic, cultural or structural interventions (Brooks et al., 2009, p. 4). BMGF strategy relies on two assumptions: 1. Targeted, technically supported outputs are optimal ways to address global health problems, and 2. People with experience in the business world are well positioned to guide the development of these solutions (Brooks et al., 2009; Edwards, 2008, pp. 7-8). These assumptions can be questioned, as can be the selection criteria for BMGF challenges.

For my argument, however, I focus on grand-in-scope challenges.

2.2. Grand-in-scope challenges

Several public funding calls, national and European, have adopted a "challenge-based approach" to organise research capacity across academia and industry (European Commission, 2013). The challenges dubbed here "big research challenges" or "societal challenges" differ from BMGF challenges, as they appear to be grand not only in difficulty, but also in their scope. For instance, both Horizon 2020 and RCUK cross-council research areas include "lifelong health and wellbeing" as a grand challenge, as well as issues around "security for all": (RCUK), "protecting freedom and security of Europe and its citizens" (Horizon 2020), and "energy": (RCUK), "secure, clean and efficient energy" (Horizon 2020) (cf. Table 1). Such challenges are generally recognisable as important by multiple, lay and expert, audiences. In this sense grand-in-scope challenges seem to be "everybody's problems".

Indeed “multi-disciplinary” or “cross-disciplinary” work is said to be key for tackling these challenges. The Research Councils of the UK (RCUK) claim that “novel, multidisciplinary approaches are needed to solve many, if not all, of the big research challenges over the next 10 to 20 years” (RCUK 2014). The European Commission’s Horizon 2020 research programme “will bring together resources and knowledge across different fields, technologies and disciplines, including social sciences and the humanities” as part of addressing Societal Challenges (Horizon 2020). These calls and statements can be questioned from different perspectives. For instance, using critical theoretical tools to consider whether concepts such as ‘sustainability’, ‘wellbeing’ or ‘innovation’ function as “ideographs” (McGee, 1980) or as “empty signifiers” (Laclau and Mouffe, 2001 [1985]), that is, as building blocks for political ideology that may facilitate or sustain established hegemony[7].

Instead let us consider how these concepts may come to function as scientific ones. My hypothesis is that there is a process which also occurs in the context of everyday life, but that aims to produce concepts relevant and appropriate for doing science: this process I call *founding* concepts in science. However in order to articulate this process, it is important to characterise the concepts which I think it operates on.

2.3 Types of Concepts: Everyday, Thick and Founded

This section proposes that grand-in-scope challenges are often expressed using thick, everyday concepts that are descriptively thin. I specify how I think of “everyday ideas” and why I call these both “thick” and “thin”.

2.3.1 Everyday Concepts: Ready for use

By “everyday” concepts I refer to ideas that are used and understood by the majority of users of a language, irrespective of their professional background(s) or expertise. If you came across an everyday idea in text or heard it in speech, you would not need to look into a dictionary, or ask for a clarification. Reversely, ideas that are *not* everyday are either not used very much by anyone, or they are used and quite a lot but by specific communities, or for specific audiences. This can happen respectively when a term becomes rare, or when an idea is a technical concept. For example, scientific ideas, financial ideas, or sports ideas will often not be everyday ideas. I say “often” because there is neither strict insularity in language

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[7] Geuss (1981) identifies three ways for a form of consciousness to be ideological in a pejorative sense: 1. if it is mistaken, 2. if it can be used to exert unjustifiable, excess oppression, 3. if it is motivated by goals that agents pursuing the ideology would not embrace, were they conscious of them. Geuss calls these 1. epistemic, 2. functional and 3. genetic “properties” of an ideology. A critical theoretical analysis of challenge-based research calls could examine their epistemic, functional and genetic properties. For critical theoretical discussion of recent research policies, which adopt disparate analytic tools, see Åm (2011), Sullivan (2012) and Bos et al. (2014).

use, nor among language users. Specialists share in an everyday discourse, while many non-specialists come to acquire specialist concepts as part of a general education or through popular media.

This analysis juxtaposes everyday ideas with a specific type of technical concept: scientific concepts that will be defined in Section 3 as *founded* concepts. The boundaries between folk and scientific discourse are porous: science experts are increasingly funded and able to do their work because they can mobilise public or private funding, while there is significant and developing research on what is involved in communicating across scientific and policy domains (cf. Collins and Evans, 2007) and developing approaches for integrating scientific knowledge and sociohumanist/ethical research (Fisher et al., 2015). Still, though one might have a common understanding of say "electron" or "GNP", more fleshed-out conceptions and sophisticated usages of these terms will be found in scientific domains, say in a physics class or in an economics paper[8].

But for now consider the ideas used to express grand-in-scope challenges. Recall Horizon 2020 Societal Challenges (Table 1.) These are expressed through ideas like 'health', 'security', 'sustainability', 'inclusion' or 'wellbeing'. The successful pursuit of these research topics partly relies on different audiences being able to comprehend these ideas without specialised training. But these ideas have another important feature related to why they might compel research: Several of these concepts are *thick*.

2.3.2 Thick Concepts: Evaluatively but not descriptively rich

As understood in ethics, "thick" concepts have both a descriptive and an evaluative dimension (Anscombe, 1958; Williams, 1985; Scheffler, 1987). Most ideas have some descriptive content or use[9]: They are used to say something about how the (or a) world is. So for instance concepts such as 'healthy', 'sustainable', 'secure' describe some characteristic or behaviour, a state of affairs or a state of thinking, an object or person, and say *this* is healthy, sustainable, or secure respectively. At the same time, calling a situation or behaviour thus also comes with some evaluative import: We usually seek health, recommend sustainability and value security. Thick concepts have both descriptive and evaluative dimensions, which ethicists find useful to pick out, in order to make visible the potential moral import of using certain concepts.

Philosophers of science also talk of thick concepts, but in this case referring to how descriptively rich and specific these concepts are. So for instance when Cartwright (2003, p. 13) refers to "thick causal concepts" like 'compress', 'attract', and 'smother', she is referring to the richness of the *descriptive* content or uses of

[8] The creation of a Professorship in the Public Understanding of Science is perhaps an example of the institutional recognition of the need to make scientific ideas accessible to the public –however scientists may not have the skills for broader reflection that could be needed in such positions.

[9] Different conceptions of 'concept' are discussed by Kindi (2012) but outside the scope of this paper.

these notions[10]. Thick concepts in this case help guide judgements in an epistemic context: Saying that "the sun attracts the earth" is saying a lot more than "the sun is causally connected to the earth". For instance, it can help infer whether the earth would tend to move toward or away from the sun. So philosophers of science call some concepts "thick" because the descriptions they afford are rich enough to guide epistemic judgements[11].

Ideas used to express grand-in-scope challenges are thick everyday ideas –but "thick" as used in ethics, rather than in the philosophy-of-science sense. Key concepts used to express grand-in-scope societal challenges have a distinctive evaluative dimension: for instance 'sustainability', 'health', 'security', or 'wellbeing' specify goods or ideals that we would hope to establish. As such, these thick everyday ideas work to engage both specialists and non-specialists, while their evaluative content offers avenues to link research to political and policy aims arguing for its political or societal value. They can inspire people to step outside their professional boundaries, talk to each other and to lay stakeholders and bring their expertise to the service of "society" – they operate as "boundary objects" collecting interest and structuring work from multiple actors in different fields while retaining some common identity (Star and Griesemer, 1989).

Thick everyday notions work really well to motivate research precisely because of their evaluative content. However, ideas used to express grand-in-scope challenges have rather poor descriptive content. For instance 'wellbeing' says less than earning minimal wage, living a long healthy life, or being literate, and yet 'wellbeing' could involve all of these. To become integrated and mobilised into scientific research descriptively thin everyday ideas often need to become descriptively thicker, more specific and also perhaps possible to measure empirically. Once it comes to ideas used in grand challenge calls, this process often results in concepts that appear to be evaluatively more neutral, but that retain links to everyday concepts. For example, a "healthy" life may become understood as a life with "75 disease- and disability-free years" –a concept which seems possible to associate more directly with a measure– even if a notion of health ordinarily valued and understood is driving this research[12]. The transformation of evaluatively

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[10] In fact thick concepts are also contrasted to thin ones in ethics on the matter of their specificity, for instance "adulterous" is a thick concept whereas "bad" is a thin concept (cf. Williams, 1985, p. 152; Scheffler, 1987, p. 411). Still, the thickness of ethics concepts is traditionally scrutinised as relevant for ethics rather than epistemology. As such it is usually the dual evaluative and descriptive nature of thick concepts rather than their descriptive richness that is put forth as their defining characteristic.

[11] Whether the thickness of concepts is an absolute or a relative property is a matter of discussion, but not a concern here.

[12] We may consider the function of everyday notions that are thick in an ethics sense in orienting the selection of research targets and questions as a case of what Max Weber called the "value-relevance" of science.

charged, but descriptively generic everyday ideas into descriptively specified but evaluatively deflated scientific ones is an outcome of the process I call *founding* everyday concepts in science.

3. The need to found everyday concepts in science

The second premise of my argument is that social and natural science can address problems expressed in everyday ideas only by transfiguring these ideas through a process of founding. The following section outlines what is involved in *founding* everyday ideas in scientific contexts. Conceptual change has been of interest to historians and philosophers of science mainly as a diachronic phenomenon, occurring in cases of scientific discovery or during intra-theoretical revisions following paradigm shifts (cf. Andersen, 2000, 2012a, 2012b; Nersessian, 2010). This account is also speculative and it regards the possibility of synchronic conceptual change across multiple scientific domains. I posit that there is a process through which everyday ideas can become *transfigured* into multiple scientific notions, and that this process is influenced not only by questions regarding epistemic adequacy regulated by norms internal to a scientific epistemic culture but also subject to influences of actors influencing science policy such as funding-bodies, science communication media, and governmental and non-governmental institutions. This account was developed in connection to the use of non-scientific race concepts in population genetics and social epidemiology (Efstathiou 2009), and it found inspiration in early Vienna Circle discussions on everyday ideas and in modern art[13].

3.1 Background: From ordinary to scientific concepts

The notion of founded concepts and founding everyday ideas in science was developed in an attempt to understand how non-scientific race concepts can be used in scientific research. Specifically, it was developed to analyse multi-disciplinary work in population genetics and social epidemiology aimed to address the challenge of racial health disparities in the United States. It became apparent that when social epidemiologists wrote of “race” and when population geneticists wrote of “race” and when one ordinarily spoke of “race” different aspects of what one might think of as an ordinary idea of race (Hardimon 2003) were being fleshed out, differently but not arbitrarily: a concept was articulated and connected to notions

[13] A philosophical account that prompts me here Martin Heidegger´s (2002 [1938]) understanding of 20th century science. In *Science in the Age of the World Picture*, Heidegger argues that science-as-research sees as being only what it can represent as being, thereby turning the world into (a) picture. Heidegger is pessimistic about the possibilities that modern science affords for seeing or recognising what is not within its *Grundriss* (its Ground-plan). Flagging that it is possible to *find* non-science within a scientific context and to *found* it there as/in science aims to counteract the insularity that Heidegger paints for science, though it acknowledges the limits and situated-ness of scientific visions.

and constructs already accepted as scientific or scientifically meaningful in each domain. According to this analysis, one could thus distinguish between two types of race concepts that were used in science: *biorace* concepts of race and *sociorace* concepts of race. These concepts were understood to be second-order concepts of a first-order everyday concept of race, which articulated the concept as respectively, biologically or social-scientifically meaningful, for instance by relating elements in the everyday concept, such as "visible physical features of the relevant kind", to (biological) notions like "phenotype", or (social) notions such as "stigma" (Efstathiou, 2012).

Starting from this example, I postulated that there is a general process through which some everyday, non-scientific concepts may become articulated and transfigured into scientific concepts: the process of *finding* and *founding* everyday concepts in science was understood to result in a type of science dubbed "found science" by analogy to "found art" –this is the type of modern/provocative art which purports to transform everyday, non-artistic objects into artworks.

This account of how everyday and scientific concepts are related may appear somewhat eccentric but it addresses an issue that has long interested philosophers of science. Bridging everyday ideas and scientific concepts was one of the key concerns of the Vienna Circle, whose members are also known as neo-positivists or logical empiricists[14]. A central project of logical empiricism was the attempt to connect, using the tools of logic, ordinary experience, expressed in statements taken to document particular observations, with scientific, theoretical concepts. Some everyday ideas appeared to be easy to specify descriptively and to relate to theoretical concepts through mathematically formulated laws, however others were more visibly a problem for the neo-positivists. The case was more pressing for concepts in the social sciences. Ideas like 'happiness', 'inclusion' or 'equality' were legitimate objects for (social) scientific research, yet these ideas were hard to logically connect to specific observations and to abstract theoretical concepts. One response to this problem was that of the philosopher and social scientist Otto Neurath. Neurath called these ideas *Ballungen* –what in German means "congestions" or "agglomerations" (cf. Cartwright et al., 1996, p. 190). The term has been translated as "cluster concepts" and used by Neurath to describe concepts that are imprecise and complex, unlike concepts used in the natural sciences. Talking about *Ballungen* Neurath said "... we are not dealing with clearly outlined concepts as in mathematics, these concepts are barely defined in their internal parts; hazy edges are essential to them" (quoted in Uebel, 2007, p. 116). Neurath challenged the mainstream Vienna Circle view that scientific concepts should capture such ideas via precise definitions that would be possible to verify empirically through observation.

[14] This is a simplified overview. The Stanford Encyclopedia of Philosophy offers a relatively accessible and nuanced overview of logical empiricism –cf. Creath (2014). For a deeper analysis consider Uebel (2007). Cartwright et al. (1996) discuss the work of Otto Neurath while Kindi & Arabatzis (2008) offer a historical account of how concepts were conceived to matter in early 20th century philosophy of science and language.

Instead he claimed that social science cannot reduce but rather has to deal with these ideas whose boundaries are not so well defined.

This view is reflected in current practice in the social sciences, but also in epidemiological and public health domains. Instead of defining scientific concepts of/for a phenomenon of study through empirical research, social scientists instead develop "constructs" to approximate these complex ideas, and further "measures" or "indices" to measure constructs empirically. A rationale for this practice seems to be: We want to study a complex social phenomenon scientifically. We cannot really, as it is so hard to pin down and subject to differences of interpretation and experience. So we shall approximate it through a "construct" and devise a way to measure *that*. The result is often a range of constructs and measures, and very little theoretical justification regarding how these constructs are developed. For instance, attempts to measure 'wellbeing' were affected by the availability, starting from the 1940s, of national statistics that could give economists some concrete, quantifiable variables for measurement, such as measures of national income – even though such constructs neglected other aspects that were relevant to assessing 'wellbeing' such as what those incomes were used for (Gasper, 2004, p. 1).

Further, *Ballungen* everyday concepts seem to be an intrinsic part of not only social scientific, but increasingly of socially relevant scientific research. Scientists across the natural and social sciences are called to work together and address challenges expressed in everyday *Ballungen*. However, working across disciplines on such seemingly common challenges involves unpacking what is understood to be at stake across domains. This work includes scrutinising how everyday ideas get founded into different scientific contexts.

3.2 Founding concepts and found science

As understood here, founded concepts are scientific concepts that mediate between everyday ideas and scientific constructs. Founded concepts result from a recursive process of: 1. Finding a concept as available but non-scientific in a scientific domain, and 2. Founding a concept in a scientific domain as scientific (Efstathiou, 2012: 705). Founding involves *transfiguring* everyday concepts by emphasizing and developing certain aspects of an idea while dropping or numbing other aspects, in accordance with norms and concepts already accepted within a particular scientific discursive practice[15]. Such transfigurative work includes:

- Focusing the concept on the ontological domain of scientific interest

[15] Calling this a process of "transfiguration" emphasises that the effect of these articulations can go against ordinary understandings. Transfiguration can be contrasted with a process of homeomorphic representation or mirroring. The term is borrowed from Danto's (1981).

- Articulating the concept isolating, emphasizing, or developing aspects taken to be relevant and interesting in this scientific domain, while ignoring or dropping elements deemed irrelevant
- Re-expressing the concept using accepted scientific terms
- Using the concept to make what would pass as a scientific claim
- Discussing and debating this idea with science colleagues
- Standardising, operationalising or devising ways to measure the concept through scientific tools and rules
- Presenting work on the idea in scientific conferences
- Publishing a scientific paper on this idea
- Getting funding to do further scientific work on it.

The process of founding culminates in changing an everyday idea to make it fit for, and in, science: This sort of 'fitting' involves both a justification of the concept as epistemologically relevant and an adjustment to norms operating in, and on, a scientific epistemic culture (Knorr-Cetina, 1999). One may posit different degrees to which a concept can be founded in a particular discursive practice, depending on its perceived legitimacy and use in this domain. In principle, it would be possible for historians and philosophers of science, but also for social anthropologists or science studies scholars to study a 'trajectory of founding': that is how and when a quotidian (everyday) idea gets brought into scientific practice, and made into a relevant scientific concept. Whether a concept is founded in a particular discursive practice will be a matter of case-by-case, context-specific, partly empirical (historical or ethnographic) and partly analytic research.

Founded concepts often keep some original, everyday names, words like "sustainability", "security", or "wellbeing". But once founded in a scientific context, these concepts no longer operate as ordinary ideas. That is why, when reading an economics article measuring "wellbeing" one might stop and wonder: what notion of wellbeing are these scholars using? One could certainly learn something about what is involved in being well, but likely not why playing with a dog makes one feel well. Indeed if one inquires further one can discover that the economics concept is aimed to perform a much more specific role and it is bound to strict methodological requirements, like validity, reliability and responsiveness—that is, it is articulated in specific ways to relate to accepted technical notions at the expense of its general meaning. At the end of this inquiry what sounded like a familiar term turns out to operate as a sophisticated tool designed to perform specific work[16], for instance to measure developing nations' quality of life or to assess a health initiative — but unable to convey how much fun having a dog can be.

[16] Indeed if we follow Hoel and van der Tuin (2013) we might think of such concepts as technologies.

As mentioned, doing science by founding everyday ideas in scientific contexts may be thought of as *found science*, by analogy to found art: art made of everyday objects, *objects trouvées* or *readymades*. Found art was a radical art movement of the early 20th century. It questioned what art is and what it means to be an artist. A paradigmatic example of found art is the upturned and inscribed upon urinal *Fountain*, submitted for exhibition in a 1917 New York show (unsuccessfully) by Marcel Duchamp[17]. Found art posits that any found object can be art, extending the limits of art to include items that are *prima facie* non-artistic and extending the skill-set of the artist to include new approaches to doing art. So, why think that there is something like *found science*, by analogy to found art?

Found science can be similarly controversial, as founding an everyday idea in *scientific* contexts focuses, re-frames and fleshes out particular elements of a given concept in a different context, creating a new thought for that concept. Importantly, *found science* seems to be a science of the given or found, but it relies on founding: transfiguring what is found to fit with already available scientific practices, interests or metaphysics. The creativity that can be productively unleashed during *founding* is checked by accepted scientific norms and interests and broader agendas and policies regulating these, besides the affordances of material referred to, or by the epistemic practices in place.

The process of *founding* can help transform concepts that are thick in the ethical sense but descriptively thin into concepts that are thick in the philosophy of science sense, that is, descriptively thicker. The process of founding will often result in specifications geared to fit an everyday notion within available scientific frames, using already accepted scientific concepts that may for instance enable empirical measurement or theoretical justification. Founded concepts may thus often come to seem what one might call more “objective” or “stabilised”, and evaluatively thinner in an ethical sense. However they are no less normative. Instead of thinking of the evaluative dimension as thinning out in quantity, one should rather see it as transformed in texture to fit with evaluative standards within science. At the same time, the possibility that the relevance of a *founded* concept is not lost in an everyday domain (where after all the concept was found in the first place) often gets mobilised to justify further scientific work on a problem, thus mobilising the dual scientific and societal or ethical relevance of the idea.

The descriptive-normative transformation which is needed to bring some everyday ideas into the realm of scientific measurement is also a modification of concepts’ ordinary extensionality to the effect that some phenomena that would be ordinarily included within the extension of the everyday concept (and awarded attention and action) get excluded from the extension of the founded concept. At the same time as a

[17] Cf. Cross (2006), Hopkins (2004). It has been suggested that Baroness Elsa von Freytag Loringhoven submitted *Fountain* for exhibition.

Ballung can get honed into some of its ordinary referents as especially scientifically interesting, the intention of such founded concepts shifts and opens up to include scientific entities (things, concepts, measures, indices, risk factors or constructs) that would not be ordinarily available with the everyday idea. Though they are founded these scientific concepts never lose their connection to everyday realms. This is partly because their names remain ordinary words thus always evoking everyday experiences, but also because these notions can relate to (specific) everyday goals or everyday phenomena in specific manners. Correspondingly the use of founded concepts to refer to everyday experience may have the effect of streamlining or rationalising but making these notions visible as founded concepts shows that they are no less normative than thick everyday ideas; it is just that their normativity has become partly outsourced into that of a given scientific domain and culture.

The next section brings these considerations together with our discussion of grand-in-scope challenges through the example of founded concepts of wellbeing. I discuss the process of founding in relation to 'grand challenges' because it strikes me as particularly descriptive of the particular relations between researchers, and funding-bodies, governments or non-governmental institutions which may utilise everyday vocabularies.

4. The case of being well: Towards different founded concepts of wellbeing

“Health, demographic change and wellbeing”, “Lifelong health and wellbeing”: these grand-in-scope challenges are raised in Horizon 2020 and RCUK respectively. This section examines how “wellbeing” is understood in development economics and gerontology research to clarify the third premise of this argument: Founded concepts are not ordinary and they differ across scientific domains. These are just two examples among the many scientific uses of the term and they are selectively presented. My point here is not a full discussion of the scientific treatment of wellbeing but simply an illustration of the process of founding[18]. The section explores how and why what appears to be a common concept gets articulated very differently across domains using the case of wellbeing. Similarly, there is scope to disagree on my definition for an everyday idea of wellbeing, but I propose this as a starting point for the purposes of this paper. Pointing to this process aims to show that scientific conceptions of everyday phenomena like “being well” have a specialised scope, thus one might expect there to be limitations in the range of scientific claims´ validity and/or relevance once it comes to such phenomena. It is precisely at this point that one might raise the question of whether a founded scientific concept is, besides scientifically relevant, still suitable and

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[18] For an accessible glimpse of the vast diversity of scientific approaches here see Carlisle and Hanlon (2007).

relevant to an everyday problem. The need for transdisciplinary collaborations on grand-in-scope challenges could then be justified from a philosophical basis.

4.1 Constructs of wellbeing: development economics vs. gerontology

Discussions of wellbeing are quite prominent in economics, as wellbeing is commonly used to establish whether policy interventions are achieving the hoped-for results. Development economists interested in "wellbeing" are specifically interested in assessing a nation's, usually a developing nation's, wellbeing. There are several approaches to specifying and measuring wellbeing in development economics. A popular approach to conceptualising wellbeing involves thinking about it as a multi-dimensional concept: with dimensions including knowledge, friendship, economic security, health, leisure, affection, freedom, self-expression (McGillivray, 2007, p. 4). One such concept proposed to capture the current wellbeing of a nation is offered by development economist Partha Dasgupta in his book *Human Well-being and The Natural Environment* (2001). Dasgupta proposes a way of specifying how well a nation is currently doing through a measure for *aggregate quality of life*: what would be obtained by aggregating indicators for quality of life for individuals living in a nation.

> To sum up, a minimal set of indices for spanning a reasonable conception of current wellbeing in a poor country includes private consumption per head, life expectancy at birth, literacy, and civil and political liberties (Dasgupta, 2001, p. 54).

Unlike other accounts, this construct does not focus on a nation's Gross National Product (GNP) but rather measures wellbeing in terms of a nation's "human capital", understanding quality of life as equivalent to wellbeing[19]. Dasgupta clarifies in a footnote to this claim that there are alternatives for all suggested indices, for example, indices for infant survival rate instead of life-expectancy at birth, or refinements such as focusing on healthy years of life lived as opposed to including years lived in bad health conditions.

Gerontology is another scientific context where notions of wellbeing are utilised. Gerontologists interested in wellbeing are particularly interested in individual older persons' wellbeing, understood as related to but independent from health (Staehelin, 2005, p. 166). Most constructs for wellbeing in gerontology thus specify wellbeing as a combination of a. subjective satisfaction with one's life, and b. objective functioning, usually appraised by considering one's ability to go through everyday life activities without help.

Within gerontology, we find further particularized constructs of wellbeing and associated measures for them. For example, gerontologists and health professionals interested in the wellbeing of elderly sufferers

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[19] Gasper (2004) offers an accessible overview of measures of wellbeing in development economics.

of osteoporosis may use the measure currently recommended by the International Foundation for Osteoporosis QUALEFFO-41.

> This measure uses 41 questions on issues such as back pain, sleep, or daily activities, such as bathing, dressing and toilet abilities, as well as questions on leisure and social activities[20].

What can RCUK and Horizon 2020 learn from these domains, and from the many other research domains interested in wellbeing? What, if anything, *is* wellbeing?

4.2 An everyday idea

Attempts to conceptualize wellbeing in the social sciences seem lacking, with practices characterised by "measurement without theory" (Gasper, 2004, p. 1). Discussing the variation of constructs of wellbeing among the social sciences Anna Alexandrova challenges philosophical accounts that define wellbeing very broadly, as what is good for a person *in general*, "all-things-considered" (Alexandrova, 2013): Under such generalist understandings the particular constructs that scientists develop to measure wellbeing lose relevance and legitimacy (Alexandrova, 2012). Rather than adopting a strict, stipulative and generalist view about wellbeing, she argues that we should go for a contextualist approach to defining wellbeing, acknowledging that there may be a substantial but broad theoretical understanding of the notion but that the precise semantic content of "wellbeing" can vary according to the multiple contexts of the concept's application (Alexandrova 2013, 2014).

In agreement with Alexandrova's contextualist approach to defining wellbeing, one may still consider some *Ballung* guiding everyday and scientific usages which could be further specified. The previous section introduced two scientific constructs of wellbeing (one from developmental economics and one from gerontology). Let us now consider a common or everyday definition of wellbeing, derived from an English dictionary[21].

The Oxford English Dictionary (OED) defines wellbeing as:

> The state of being or doing well in life; happy, healthy, or prosperous condition; moral or physical welfare (of a person or community)
>
> Satisfactory condition (of a thing).

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[20] The questionnaire is available online: http://www.iofbonehealth.org/quality-life-questionnaires-qualeffo-41 Last accessed: 10.06.15. Developing measures of quality of life and validating these is extensively debated by scientists and by philosophers.

[21] Available online at: http://www.oed.com/view/Entry/227050?redirectedFrom=wellbeing#eid

Using the OED as a guide one might identify an everyday concept of wellbeing as a concept of, first, a personal or communal state of "being or doing well", assessed along material, psychological, physical, or moral dimensions and secondly, as a condition or state deemed satisfactory by some external judge.

These two points refer to two main uses of the word "wellbeing" in the English language, but they seem to indicate an ordinary idea of wellbeing. This could be specified as follows:

> An ordinary idea of wellbeing is a concept that distinguishes states of being of what can be thought of as an agent (e.g. a person, an animal, a community, a nation,...) in terms of two criteria, dubbed the Ordinary Wellbeing (OW) criteria:
>
> OW(1) a state that **accommodates or furthers** current and envisioned (social, material, psychological or other) needs and/or goals of the agent
>
> OW(2) a state that is **adequate to** the demands placed on the agent by the current and envisioned (social, material, psychological or other) milieus that the agent is in.

This concept is articulated using philosophical expertise, but it is not a philosophical account of wellbeing. Even though I specified a candidate everyday idea following the OED, my account does not assume that there is only one way to specify an everyday idea. Arguably philosophical investigation may shine a light to a folk idea of wellbeing, though it also often leads to particularised understandings[22]. For instance, if one articulates OW(1) as more important for wellbeing than OW(2), a range of "subjectivist" as opposed to "objectivist" accounts of wellbeing are on offer. Or one might articulate the idea further by examining which kinds of needs or conditions, for instance, material, psychological, or social, matter more for establishing wellbeing, developing different normative accounts of wellbeing.

4.3 Founded concepts of wellbeing

Founded concepts articulate everyday concepts as relevant and interesting for science. Everyday ideas of wellbeing can get articulated differently following epistemological, as well as historical and cultural demands placed on working scientists. We may below start to consider how such discipline-specific scientific articulation could happen, though for a thorough investigation further historical and empirical research would be in order.

Development economics is a field of the social sciences that focuses on economics of/in the developing world. In development economics the ordinary concept of wellbeing is founded to focus it into one interesting and relevant to studying the economics of developing nations:

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[22] Philosophers who define what appear to be folk concepts of wellbeing include Darwall (2002) and Kraut (2007).

A <u>development economics concept of wellbeing</u> is a concept that distinguishes between states of being of what can be thought of as an agent in development economics, for example a **developing nation**, in terms of two criteria dubbed the Development Economics Wellbeing criteria (or DEW for short):

DEW(1) a state that **accommodates or furthers** the current and envisioned needs and/or goals of **a nation: e.g. economy, health, birth rate, security and self-government, cultural development, etc.**

DEW(2) a state that is **adequate to** the **demands** placed on **a nation** by the current and envisioned social, material or other milieus that the nation is in: e.g. **human, social or economic capital in the context of a globalised society and economy**

This founded concept is descriptively more precise than everyday wellbeing, but it is still open to interpretation. The specification narrows down the extensionality of the everyday concept but it also shifts it to relate to new ideas, such as 'national birth rate', which would not be ordinarily available with the concept. Working with this founded concept, development economists might devise different constructs to operationalise it and related measures and indices to approximate these; for example as proposed by Dasgupta:

> a minimal set of indices for spanning a reasonable conception of current wellbeing in a poor country includes private consumption per head, life expectancy at birth, literacy, and civil and political liberties (Dasgupta, 2001, p. 54).

To see how different disciplinary cultures may mandate different founded concepts, consider how an everyday idea of wellbeing can be understood as relevant for gerontology. A concept founded in gerontology may be specified as follows:

A <u>gerontological concept of wellbeing</u> will be a concept that distinguishes between states of being of what can be thought of as an agent in gerontology, for example, an **older person**, in terms of two criteria articulated for the domain of Gerontology (call these the GErontological Wellbeing criteria or GEW for short):

GEW(1) a state that **accommodates or furthers** an older person's current and envisioned needs and/or goals: **productivity, mobility, health, mental ability, social life, family life,...**

GEW(2) a state that is **adequate to** the **demands** placed on an older person by the current and envisioned social, material or other milieus that an older person is in: **care-taking (themselves and others), dealing with injury, ability to communicate with care-takers and family, financial independence,...**

Working with this founded concept of wellbeing gerontologists might devise different constructs to define wellbeing in different domains, and different measures for these; for example the

QUALEFFO-41, a measure designed by the European Foundation for Osteoporosis which includes 41 questions on issues such as pain, mental function, sleep, and daily jobs around the house, bath and toilet abilities, dressing and mobility.

I do not propose that founded concepts following criteria such as DEW and GEW are explicitly articulated in the process of thinking scientifically about wellbeing. Indeed it seems to me that founding everyday ideas into scientific contexts happens mostly tacitly and 'naturally', as part of already established epistemic cultures that help sort some elements of the ordinary notion as relevant and others as noise when deciding what "being well" should mean in each scientific context. Still such founded concepts help understand why handling a grand-in-scope challenge through scientific work alone is hard.

The process of founding an everyday concept shifts its referents, to the effect that some phenomena that could be included (and thought to deserve attention and action) within the extension of a thick, everyday concept get excluded from the extension of the founded concept in favour of new, descriptively specific and scientifically relevant content. As a result, the transition from everyday to scientific concepts can invisibilise considerations which might turn out to be relevant to addressing everyday problems. Thus, when dealing with everyday challenges scientifically, it is important to include mechanisms to encourage self-reflection and discussion across scientific and lay domains, and across different scientific domains. This work is not easy, and it is often uncomfortable. Founding processes follow the standards, interests and current practices of each scientific context in question, so making their contingency visible and open to negotiation can challenge professional expertise, identities, and ethos. This poses extra challenges for how to synthesise perspectives across disciplinary domains as synthesis involves cultural and ethical besides epistemic dimensions (De Grandis, this issue; Efstathiou and Mirmalek, 2014).

4.4 Founded concepts: Helping bridge everyday ideas and scientific constructs

Studying everyday problems in science can result in multiple founded concepts, which need to be negotiated, along with multiple constructs of each founded concept, and multiple measures for each one of those constructs. Could this multiplication be at all helpful?

Making founded concepts visible could help study, structure and bridge some of the gaps between everyday ideas and scientific constructs. For example, scientists hoping to enhance the wellbeing of an older person in a developing country, could explicitly consider and decide which founded concept(s) of wellbeing are relevant to the situation at hand, before deciding how to operationalise those ideas and measure them. And reversely, no economist should be expected to say what wellbeing 'really' is. The empirical or theoretical adequacy of a scientific construct to an everyday issue or phenomenon, would not need to pass the impossible test of capturing some vague, thick everyday idea, but rather of articulating a still broad but specialised founded concept. Economists should strive to develop a suite of founded concepts of wellbeing that would work for the range of objects and purposes that economics research and policies have, specifying and measuring how wellbeing can be dependent on economic factors[23]. At the same time, founded concepts would be possible to relate to a 'parent concept cluster'; become specific in one context, and unspecific in another; from research proposal to actual research; from research to a published paper; from research to a presentation; from presentation to informing policy-making. They would be thick enough in an evaluative sense and thick enough in a descriptive sense to be able to go back and forth across scientific and lay domains, acting as if they were boundary objects (Star and Griesemer, 1989; see also section 5.2, this paper).

To be sure, these examples seem to proceed quite "sensibly" by focusing an ordinary idea on a select set of objects or questions. But there is no one, "logical" relationship between everyday ideas and founded concepts, nor is there one recipe for deriving constructs from founded concepts. As discussed, founding depends on a range of factors from material, procedural and conceptual tools available to scientists to various cultural, societal and historical factors modulating scientific interests and capabilities.

In sum, founded concepts do not eliminate the gap between everyday ideas and scientific constructs. Indeed, they challenge the possibility of doing so in any one way, as multiple founded concepts will in principle be available for articulating an everyday idea scientifically. This undermines attempts to address grand-in-scope challenges scientifically, as further work is needed to relate founded concepts to each other, to everyday ideas, and to scientific constructs and measures. Yet not all is fragmented: the account points to a "middle level" of concepts that are more precise and suitable for scientific work than everyday ideas but not yet collapsed into any one measurable construct. As such founded concepts may offer some fertile loci for the interdisciplinary and transdisciplinary discussions needed to address grand-in-scope challenges.

Let us consider that prospect in the concluding section of this paper.

5. Scientific work alone cannot solve grand (in-scope) challenges

This paper argued that a challenge with addressing grand-in-scope challenges scientifically is dealing with everyday ideas scientifically. This section specifies the challenge of bridging founded concepts as especially

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[23] Thus, if we follow this account, questions of realism or nominalism about for instance economic measurement would target founded concepts as opposed to everyday ideas: cf. Cartwright and Bradburn (2011) who argue a similar point.

relevant to transdisciplinary work and it explores Clifford Geertz's incitement towards "ethnography of thought" (Geertz, 1982).

5.1 Science needs non-science: Background for transdisciplinary work

It is commonly emphasized that meeting Grand Challenges requires research and innovation across disciplines and sectors (academic, public, private or non-governmental). Research on how to organise knowledge-production activities into new supra-disciplinary forms preceded (and possibly prepared) the emergence of "Grand Challenge" funding schemes. Studies on "interdisciplinarity" and "transdisciplinarity" date back to the second half of the twentieth century (cf. Jantsch, 1972) though the fields of interdisciplinarity and transdisciplinarity studies took shape in the 1990s and early 2000s with the first *Handbook of Interdisciplinarity* (Frodeman et al., 2010) currently undergoing its second edition.

There are three main recognised models for collaboration among disciplines, what are dubbed "multi-disciplinary", "interdisciplinary", or "transdisciplinary" approaches (cf. Klein, 1990, pp. 55-73). "Multi-disciplinary" research is understood to combine research from different disciplines additively, dividing labour along accepted lines of expertise but without challenging or transforming these. "Interdisciplinarity" instead specifies a work model that merges disciplines more strongly, possibly changing the participating disciplines, or creating new, intermediate or mediating spaces for questions and answers transcending prior expertise to be formulated. Finally "transdisciplinary" work merges not only different disciplines but also non-academic, lay, policy or other stakeholder knowledge and values as part of a relevant research framework[24].

Transdisciplinary approaches seem to recommend themselves for tackling grand-in-scope challenges. Transdisciplinarity research is mainly influenced by two theoretical perspectives: First, the work of Funtowicz and Ravetz (1993, 1994) on *post-normal science*, and secondly the work of Gibbons and colleagues (1994) on *Mode 2 knowledge production* (cf. Klein, 2004, p. 517; for an assessment of the latter influence see Thorén and Breian, this issue). Both accounts were developed at the end of the 20th century and both specify a shift in research practices, in the first case from "normal" to "post-normal" science, and in the second case from "Mode 1" to "Mode 2" knowledge production. Funtowicz and Ravetz dub "post-normal" the science operating under conditions of high epistemic uncertainty and high decision-stakes. For instance, assessing the impact of industrial and other human activities on the environment is both uncertain epistemically and controversial for policy-makers to regulate. In a similar vein, though independently, Gibbons and colleagues (1994) observe a mode of knowledge production which challenges established divisions of intellectual and practical labour by bringing research closer to the (social) context of

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[24] The grounds for these distinctions are subject to discussion: see O'Rourke et al., this issue, Holbrook (2013).

its application. Both accounts portray science as breaking with insular, disciplinary forms, becoming an integral part of social life and decision-making, and partly because of its success, scale, and power, getting held up to societal demands, and priorities[25].

Consider how some of this work relates to founding everyday concepts in scientific contexts.

5.2 Founded concepts: Implications for transdisciplinary work

To understand relationships between founded concepts and work in transdisciplinarity studies let us examine a "conceptual model" representing an ideal-typical transdisciplinary research process developed at the Institute for Social Ecological Research (ISOE) in Germany (Bergmann et al., 2005, p. 19; Jahn et al., 2012, p. 5; Lang et al., 2012, p. 28)[26]. This model conveys transdisciplinary research processes as mediating between "societal practice", and "scientific practice". The model is addressed to practitioners in ecology and sustainability science and can be further developed philosophically.

Transdisciplinary work is depicted as proceeding in three phases: a. problem transformation, b. interdisciplinary integration, and c. transdisciplinary integration (Jahn et al., 2012a, p. 5). Phase one of transdisciplinary research identified as "problem transformation" starts by taking up "problems from everyday life" to develop further research and strategies for addressing these (Bergmann et al., 2005, p. 15). In this phase a societal problem is understood to become transformed into a "boundary object", i.e. a concept or a material object that can admit multiple interpretations while retaining an identity recognised by participants (Star and Griesemer, 1989). This boundary object is then transformed into an "epistemic object" "by means of developing or applying theories or concepts" (Jahn et al, 2012a, p. 5): "these epistemic objects are, in turn, the basis from which research questions are derived" (Jahn et al., 2012, p. 5). Jahn and colleagues emphasise that this first phase of transdisciplinary work is one of "transforming" as opposed to "framing" or "structuring" a problem:

> what happens in this process is, in most cases, not a unique mapping of a societal onto a corresponding scientific problem; instead as knowledge itself changes (both as regards structure and meaning) when transferred from one context to another, so too does a problem when displaced from the world of needs, interests, and values into the realm of the scientific rigor and objectiveness; in other words, a solution to the identified scientific problem is not imperatively a possible solution to the original societal problem (Jahn et al., 2012, p. 5).

[25] Philosophers of science also examine these issues: see Longino (1990) on "contextual" values, Douglas (2000, 2009) on "value-laden" science, Kitcher (2001), on "well-ordered" science.
[26] See Lang et al. (2012), p.28 for models conveying transdisciplinary research process in a similar manner.

Considering processes of founding everyday concepts in scientific contexts helps complement this ideal-typical model especially as regards a) the notions of boundary and epistemic objects utilised here and b) the scope of research questions possible to address. Founded concepts help explain why for an everyday issue to become a candidate object of scientific inquiry a process of transformation, rather than framing, is needed. The process involves transfiguring everyday concepts' evaluative and descriptive content and uses to fit within accepted scientific norms: founded concepts can seem descriptively thicker and evaluatively deflated, though retaining ordinary names.

Jahn and colleagues juxtapose a "world of needs, interests, and values" with the realm of "scientific rigor and objectiveness". These two worlds of course are not so easy to separate: I argued that founding has epistemic and cultural dimensions, that is, it is a process depending on practices and norms regarding what is known, what is knowable, and what is *worth* knowing and why. Interestingly the phase of problem transformation is here depicted as rather unitary: transforming one problem into one boundary object and one epistemic object. My account proposes that some thick, everyday notions can act as boundary objects but they can drive research only if it is possible to found these into relevant scientific discourses and practices, thereby potentially culminating in *multiple* "epistemic" objects. This suggests that there is work involved in coming to agree on *one* boundary object and to form *one* epistemic object, instead of multiple ones, already during the phase of problem transformation, which founded concepts could help explicate and account for. In my view, there is an intermediate step, whereby a boundary object gets founded differently across participating science domains, thereby producing several founded concepts that then need to be negotiated and transformed further into some one epistemic object, or objective (Figure 1).

Figure 1. Transforming everyday issues into transdisciplinary research problems

Jahn et al. (2012)	*This account*
real world problem	**real world problem**
↓	↓
boundary object	everyday concept (boundary object)
↓	↙ ↓ ↘
epistemic object	founded concepts
	↘ ↓ ↙
	epistemic object

The authors do stress that "creating epistemic objects in a joint effort of the whole team is crucial in allowing for an integrative design of the research process" (ibid.). I would posit that this is because discipline-specific and other assumptions are made visible when negotiating among founded concepts. My hypothesis is that this phase involves negotiating middle-theory, involving founded concepts of selected boundary objects, rather than an arbitration between scientific constructs and measures. However these are partly empirical questions: Are founded concepts operative in the problem transformation phase, and how? Would making founded concepts explicit help or inhibit the collaboration process?

Phase two starts once a common epistemic object has been formulated. During this phase of “interdisciplinary integration” different kinds of expertise come to feed into each other and create new knowledge or strategies relevant to a problem at hand (Jahn et al., 2012, pp. 5, 7). Again here the question arises of how a common epistemic object gets addressed by different collaborating disciplines. Do further founded concepts of this object, or of related concepts, get developed? What cultural and epistemic factors matter in this context? Though a common epistemic object might have been arrived at after the problem transformation phase, there might still be further founding needed for ideas to actually facilitate measurement and scientific research.

Phase three of “transdisciplinary integration” involves integrating outcomes in respectively societal and scientific contexts. The distinction between everyday and founded concepts matters here. Especially in the case of the social sciences, founded concepts are often tagged by everyday names, such as “wellbeing”. This makes it important to be clear when sharing scientific results or approaches with lay policy-makers or publics. It is crucial to explicate the conditions under which a scientific outcome will be externally valid: That is when a result validated following a well-designed study, or deductive reasoning, or another method, will hold in contexts external to the study. Here a question might be: Are founded concepts explicated during communication with policy-makers, and should they be?

Overall, transdisciplinarity studies complement theoretical questions regarding founded concepts: they offer cases where questions might be pursued in practice, while founded concepts help investigate transdisciplinary work at an analytical level. One concern that harks back to our original question, however, is the scope of challenges that may be addressed through transdisciplinary work. A key aim of transdisciplinary (‘mode 2’ or ‘post-normal’) science is to bring societal, ethical or practical issues to the attention of researchers early on in a research process[27]. Arguably such strategies may help ensure the external validity of research, broadly conceived to include its efficacy and value. However, depending on the methods selected to “include” such concerns, this might imply that some context for the application of research outcomes should be relatively well-defined from the outset of a transdisciplinary work effort. This could be a problem for addressing grand-in-scope challenges, whose impact is hard to define. The expectation that some societal “context of application” is considered early in the research process suggests that transdisciplinary research might have to limit itself to challenges that are restricted enough in their

[27] Cf. Nydal et al. (2012); Fisher et al. (2015) who offer a map of existing approaches in the “integrative” field.

scope to enable social scientists to consider and study empirically what needs and values emerge in affected communities.

5.3 Prospective research: Taking diversity seriously

This paper argued that science alone, whether multi- or mono-disciplinary, cannot tackle grand-in-scope challenges. This is not only because we need to apply science better, but also because we need to better understand everyday issues to which scientific research is to relate. This includes work to bridge everyday ideas and scientific constructs and to spell out founded concepts in different domains. I conclude by offering some reflections for further research.

First, the dual scientific and political function of everyday terms begs further research. This analysis took Grand Challenge calls at face value, considering how thick, everyday ideas operate in scientific research, but one could argue that grand-in-scope challenges are impossible to address: Grand-in-scope challenges are ideological, and if not in the pejorative sense, in the programmatic sense. That is, they are inspirational goals as opposed to actual problems targeted for solution[28]. If so, then work should clarify how researchers are meant to orient themselves towards these directives. Alternatively, those favouring technical solutions might argue that scientific work on these grand-in-scope challenges is 'enlightening', showing that *actually*, there is no grand-in-scope challenge with, for example, wellbeing, only particular, local issues concerning the wellbeing of particular poor nations, or older people with osteoporosis that we should start addressing one by one – the mark of having succeeded being that those nations or those older persons with osteoporosis thereby do well on the specified measures of the constructs developed. Perhaps this could make the life of scientists easier but a completely fragmented incrementalism without political vision is difficult to accept by citizens who are not fully cynical, nor by foundations and NGOs who work for these directives and goals. If Grand Challenges are to be formulated and accepted across multiple fields of expertise, and by public and private stakeholders and if that common basis is not everyday discourse and experience, then what is it? And what should it be?

Secondly, in a context where the societal responsibility of science becomes ever more important it becomes important to study how specialised and everyday thinking and values relate. I suspect that to do so, we need to understand disciplinarity better. I find myself intrigued by an incitement of Clifford Geertz to his fellow academics in 1981. In a keynote celebrating 200 years of the American Academy of Arts and Sciences Geertz reflected on how assumptions and approaches in anthropology, his own discipline, have changed (from normative to more descriptive). He proposed that how academic thinking develops is itself an important research field.

[28] Geuss (1981).

> We are all natives now, and everybody else not immediately one of us is an exotic. What looked once to be a matter of finding out whether savages could distinguish fact from fancy now looks to be a matter of finding out how others, across the sea or down the corridor, organise their significative world (Geertz, 1982, p. 19).

Using Kuhn's terminology, Geertz envisioned a new "disciplinary matrix" for ethnography of thought:

> …The ethnography of thinking like any other sort of ethnography – of worship, or marriage, or government, or exchange –is an attempt not to exalt diversity but to take it seriously as itself an object of analytic description and interpretive reflection (Geertz, 1982, p. 23).

Arguably the field of Science and Technology Studies developing in that period has pursued ethnographic approaches to reflect on science and scientific thinking (cf. notably, Latour and Woolgar 1979). But perhaps these efforts can be expanded. If we take Geertz's suggestion seriously, studying how thinking develops involves mapping social, policy, epistemic or other mechanisms through which ideation, in philosophical, economics, gerontological, policy, activist, or other domains becomes shaped, inherited and enriched, from teachers to students, and so on.

Now, one does not need to know why yellow and red look like they do, to mix them into orange. Transdisciplinary efforts can be very effective despite substantial ignorance regarding participating disciplines' histories and cultures. Yet to develop principled approaches to trans- and interdisciplinary work, perhaps we should take cultures of thinking and knowing seriously, figuring out more ways to study them and to reflect on our own handicaps and strengths (Toulmin, 1970; Frodeman, 2012). Ethnographies of thinking could be one way to understand the historical, cultural and epistemic dimensions of the production of knowledge and ignorance across the sciences, arts and humanities. With an ever-increasing demand for solutions to global issues from several directions, and a need to connect everyday ideas to scientifically operative concepts, such reflections will become ever more important.

6. Conclusion

Responsible research and innovation on grand-in-scope challenges involves becoming accountable to many. Over-specific targets can become blinders for researchers and other actors involved in ministering solutions and yet specifying the scope and interests of scientific questions is crucial for achieving excellence and rigour in science. Providing resources, incentives and recognition for trans-disciplinary reflection on the potential social scale, philosophical depth and practical complexity of grand-in-scope challenges is thus key to achieving a balance between research that is excellent and societally warranted and responsible. Such work even when it is done often stays invisible, operating under the threshold of recognition and reward because its primary aim is to bridge different milieus and only occasionally and subordinately to produce academic, technical or commercial outputs.

To be sure, even when pursued through more socio-culturally sophisticated modes or innovation systems academic knowledge does not suffice to address grand-in-scope challenges. Yet research needed to unpack connections between multiple scientific or other specialised discourses and everyday ideas could help "everybody", or at least more of us, respond to and debate problems that are shared among us. And though it is natural for scientists to specialise and translate real world problems into their preferred idiom, it must also start becoming natural for us to make the journey "back", to the proverbial 'polis', or jungle, or village, or down the corridor, as it may be.

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