Reconciling the logic of the social sciences with the logic of particle physics through the universal concept of causality – An ontological reductionist approach

With this essay, I argue that causality does not operate fundamentally differently in different fields of science. Although the arguments are rooted in positivism, scientific realism and ontological reductionism, I aim to show that socially constructed concepts are ontologically not different to particles in physics.

This first requires a definition of ontology in contrast to epistemology. Ontology is the study of being. When we ask about the ontology with regards to a phenomenon, we ask how it manifests itself in the world and what that phenomenon is in its essence. Epistemology is the study of the nature of knowledge and describes the means we have to investigate (the presence of) the phenomenon in question. First, we must have an idea about a phenomenon's ontology, before we can engage in questions about epistemology. Ontological reductionism is the metaphysical doctrine which claims that all phenomena are in reality aggregations or combinations of simpler and more basic entities. This is what makes concepts, which we use to capture phenomena, ontologically equivalent. If one holds an epistemological reductionist account in addition, one believes that all phenomena can be completely understood and explained in terms of the behaviour of their fundamental parts. This essay however, roots in ontological reductionism, acknowledging that it is not always possible to reduce complex systems to their micro-physical entities.

Based on Comte's positivism and reductionism, according to Oppenheim & Putnam (1958), the different sciences can be ranked in the following order: mathematics[1] can be found at the bottom, followed by physics (particles, atoms, fundamental forces), chemistry (molecules), biology (from cells to animals), neuroscience (cognitive functions), (social) psychology and finally, social sciences. *Figure 1*[2] portrays this bottom-up model.

This ranking symbolizes a decreasing range of research and complexity of (methodological) instruments, but a growing complexity of the phenomena under investigation. Accounting for the latter, I will thereafter denote this bottom-up hierarchy of the sciences as the reverse-pyramid model, which widens at the top instead of tapering. Each scientific field in this ranking depends upon those below it; for instance, our understanding of chemistry depends upon our understanding of physics, as all chemical phenomena are more complex than the physics that underpin them, and although the laws of chemistry are affected by the laws of physics, the opposite is not true. Similarly, sciences that appear earlier in Comte's hierarchy are considered older and more advanced than those which come later.

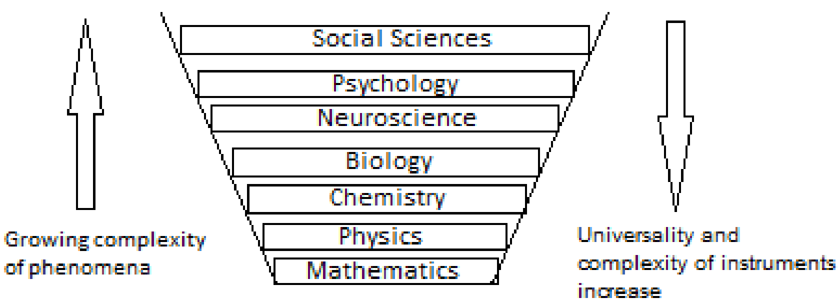

Figure 1: The bottom-up model of the sciences

[1] Mathematics provides a framework and language to describe the phenomena of the physical (world). Because this essay is about ontology, hereafter physics is considered to be at the bottom of the bottom-up model.
[2] Figure adapted by the author (Source: https://en.wikipedia.org/wiki/Auguste_Comte#Comte's_positivism)

Since the model is based on (ontological) reductionism, it has the following implications for the relationships between higher and lower level phenomena:

1) Upper-layer concepts consist of phenomena rooted in lower-level sciences and hence can be *in principle*[3] reduced to them.
2) Social phenomena can *in principle* be reduced all the way down to fundamental particle physics.
3) The higher ranked the individual science, the higher the complexity of the phenomena it seeks to describe.
4) Due to the growing complexity with higher rank, generality of theories becomes more difficult to obtain. Precision of measurements becomes less important and so the complexity of (methodological) instruments grow smaller.

This model is realist insofar as it entails the *realism of the reduced phenomena*. The model implies that the science at the top is the most complex and the one at the bottom is the most fundamental of all, as its goal is to find the universal laws of the universe, which govern all processes. Comte and Oppenheim & Putman (1958) follow these implications radically.

Oppenheim & Putnam (1958) go as far as to view the unification of sciences – in terms of physics as the science that can explain everything – as the goal of science. However, for ontological reductionists this is merely an ideal that can never be reached by human science, due to our bounded rationality and limited epistemology. We shall see below why the ontological ideal matters nevertheless.

According to Comte, the lower ranked sciences had to arrive first, before efforts could be directed to work on an upper layer. In this ideal case, physics will have understood all fundamental laws, before chemistry starts to explain how molecules form, before biology tries to find out how cells occur, how they need to be structured to form consciousness and how animals come into being. Finally, humans can do sociology and find out how social behaviour works on the basis of all that formerly acquired knowledge. This is why Comte calls sociology the "Queen Science".

However, historically all sciences evolved in parallel to each other. Biologists conceptualised animals long before we knew about the structure of atoms. Psychology developed theories of human behaviour long before neuroscience came into existence. Upper layer sciences may work with phenomena of emergence, where the sum of all parts appear to inhibit characteristics the individual parts do not seem to have. As we will see, however, it can be argued that, emergence does not mean that the phenomena do not in principle consist of lower-level concepts, but it rather hints at gaps in the underlying sciences.

Hence, one may criticises the utopian visions of a unified science and that in practise higher ranked sciences are not directly built upon lower-level ones. However, this finding does not undermine the bottom-up model with respect to its ontological implications. In this view, all sciences are equal ontologically. It is this essay's aim to show how and why, by raising five arguments:

First, all sciences attempt to conceptualise phenomena which they regard as belonging to their field. Like Goertz (2006) points out, the chemical element "copper" isn't an irreducible atom. In fact, no atom is. Each chemical element represents a different atom, which itself consist of a particular structure of protons, neutrons and electrons. The protons and neutrons themselves are further made up of quarks. Hence, copper is a concept, which refers to a particular structure of

[3] from an ontological standpoint

the components of an atom, which gives rise to its physical and chemical properties such as its reddish colour and its electric charge. Even the most fundamental particles that we know, such as quarks and electrons might consist of strings: according to string theory, all matter can be reduced down to strings, which constitute the elementary particles by their different vibrations. Hence, in string theory, different vibrations give rise to certain characteristics, which physicists conceptualise as quarks and electrons. These examples from physics shall show that even the most fundamental particles are concepts. We might never know how they look like in reality (Kant's "Ding an sich"; the "Thing-in-itself"), we can only conceptualise them on the basis of their physical characteristics.

Second, in all sciences, good concepts are about ontology. Kant distinguishes between the world as we can observe it, taking into account our (epistemological) limitations (for example our senses, brains and methods), which he calls the "phenomenal world" and the world like it really is, independently of our perception, with direct access to the "things-in-themselves". As scientists we strive to develop methods to overcome these limitations, for example developing telescopes which can detect different wavelengths than our eyes or using satellites to enable real-time communication with people far away. Scientists do that to find out *what is (happening)*, even if our concepts will only ever remain an approximation, because of epistemological limitations and/or the phenomenon's complexity, which needs to be substituted to make sense of.

When conceptualising a phenomenon, one doesn't merely provide a definition, but also makes a decision about "what is important about an entity" (Goertz, 2006). This may sound like a purely constructivist argument at first, but is however in agreement with the reverse-pyramid model of the sciences, where precision decreases as complexity rises, leading to the next aspect of why sciences aren't ontologically different from each other:

Third, across all sciences, the degree of abstraction is related to the complexity of the arrangement of the phenomenon's constituents. The higher ranked the science in the reverse-pyramid model, the higher is the degree of abstraction. Probably more people would accept the existence of a quark as a "thing-in-itself" than a society. This is because the criterion for the position of the sciences on the reverse-pyramid is the degree to which respective phenomena can be determined exactly. This degree, which Comte called *positivity*, is higher the closer the conceptualisation gets to the "thing-in-itself". Hence, the degree of positivity is also a measure of the science's "relative complexity, since the exactness of a science is in inverse proportion to its complexity" (Ward, 1898). This implies that the process of abstraction is also a move away from the "thing-in-itself". Society doesn't exist as an entity one can find floating in space, independently on our existence. Indeed, it would be an ontological fallacy to assume that it really exists that way. Instead, it is an extremely abstract concept, which high complexity arises from the association of other complex concepts, not only of individual human beings, but also organisations, institutions, etcetera and their inter-dependent dynamics. However, this level of abstraction, doesn't mean that there is a fundamental difference in the ontology of social sciences and physics, only that the social sciences deal with dramatically complex phenomena.

The more complex the phenomenon, the bigger the need to substitute its complexity by making the right choices when deciding "what is important" (Goertz, 2006) about it. It is common to say that concepts "reduce" complexity of a phenomenon in order to make sense of it. However, that may be misleading as it could give the impression that the phenomenon is less complex after conceptualisation, when instead the concept is a substitute for the complex phenomenon. Furthermore, it may be mixed up with reducing according to reductionism. The latter means to investigate a phenomenon's lower level processes, which might involve travelling down the reverse-pyramid. The former happens on the same level as the science operates; When conceptualising a complex phenomenon, an individual science generally strips away those complex parts of the phenomenon whose conceptualisations belong to a lower ranked science. That is to account for the level of abstraction. For example, when a social scientist concept is about how social norms developed, that concept rarely needs to account for the biological or psychological processes of every individual involved in the process, let alone a description of the movement of all molecules involved. However, just because complexity is substituted it doesn't mean that the phenomenon itself is not based on those lower-level processes. This means that according to ontological reductionism, the phenomenon could, *in principle*, be reduced to phenomena explained by lower-level sciences, but isn't for the sake of simplicity, pragmatic reasons or for epistemological reasons. Abstraction then means not having to go the long path of reduction and making sense of complex phenomena for advancing science and our daily lives.

The following example of a concept we use in our daily lives should illustrate this point. Imagine the following: When you drink water out of a glass that you hold in your hand, in fact you hold a specifically arranged structure of molecules (mainly silicon dioxide), which constitutes the glass. You "drink" (the process of drinking is naturally also one that can be broken down into biological processes) H2O molecules (for the sake of simplicity, we assume you are drinking distilled water). The glass doesn't exist as such, but only its molecular structure which itself can be reduced to its fundamental particles. The glass is a concept to construct meaning of this arrangement of molecules for our daily usage.

A very important point here is that being aware that the glass as a "thing-in-itself" doesn't exist (and hence avoiding the ontological fallacy) doesn't mean to reject the ontological idea that *in principle* it can be reduced to its fundamental constituents. That is what all sciences have in common, while operating on their individual level of abstraction. Differing from that basic ontological idea would mean to deny that phenomena consist of constituents described by lower ranked sciences. An equality in ontology doesn't mean to commit the ontological fallacy to assume that the phenomena the science conceptualises exist as such, it means to recognise, that they are abstract concepts of complex phenomena which *in principle* can be tracked down to the basic laws of our universe. Recognising this is important because it demonstrates the limits and dependencies of upper-level sciences. When conceptualising an upper level phenomenon it might make sense to consult the at least the adjacent lower-level science in order to find out what is essential about this phenomenon. For example, when a social scientist concept researches a phenomenon that involves rage, it makes sense to consult neuro-psychology to get an idea of what is happening in people's brain when they experience rage. If insights from lower level sciences aren't recognised, the upper level science is at the risk to run into contradictions, since its concepts don't recognise the foundations of the phenomena they seek to describe. Hence, at the border to the lower-level science, lie the respective science's foundations. That is why the reverse-pyramid model is so consistent in its logic and why the ontology doesn't differ across the sciences, only the abstraction level. Goertz (2006) describes this by drawing an analogy again between copper and social scientist concepts:

> "There are two issues in discussing chemical elements. The first is the substantive component parts, such as electrons, protons, neutrons, etc. The second is the geometric structure [an arrangement, comparable to a social scientist network] of these elements. The same is true of most important social science concepts. We need a good analysis of the substantive dimensions of the concept along with how these secondary-level dimensions are structured."

Fourth, in the ontological reductionist approach to concepts, ontology is related to causation. Hence every phenomenon has causes. The complexity of these causes generally rise with the complexity of the science. Goertz (2006) suggests thinking of concepts as having three levels: the abstract concept[4], secondary dimensions, and the indicator level. "The secondary level provides theoretical linkage between the abstract [concept] and the concrete indicator/data level" which "is where the concept gets specific enough to guide the acquisition of empirical data". The linking can be described by logical AND/ OR operations. The indicator level often consists of indicators which are themselves concepts on the level of abstraction of the respective science. For example, if the concept is a social scientist one, let's say "democracy", the indicator level consists of social scientist concepts such as "executive turnover" (see *Figure 2*[5]).

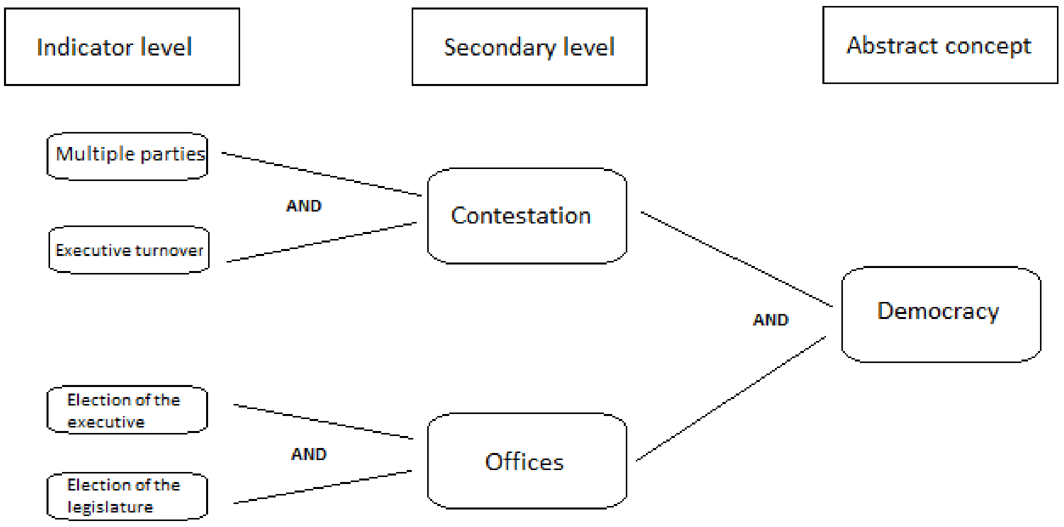

Figure 2: An example for a three-level concept from Goertz (2006): „Alvarez et al. (see also Przeworski et al. 2000) conceive of democracy as a three-level concept with AND at both levels. They propose two secondary-level dimensions for democracy of 'contestation' and 'offices' where contestation has indicator-level variables of multiple parties and executive turnover, while offices involves the election of the executive and the election of the legislature. If any of the indicator level variables has value zero then its secondary-level dimension is zero, which then implies a basic-level democracy value of zero."

Indicators may be effects of the concept, they may be causes or they may have no causal relationship with the concept. In the first case, the abstract concept is on an ontologically lower level and causes the indicator level phenomena. In the third case the indicator defines what the concept is, and hence there is a non-causal relationship, but rather one of identity. The second case, where the concept is on an ontologically higher level than the other two, is what I will discuss here further to demonstrate that there is also no difference in the ontology of causation, regardless of the ranking of the science on the reverse-pyramid.

As pointed out above, conceptualisation is a process where a decision needs to be made about what is important with respect to its theoretical context. For example, copper could be conceptualised differently, like on basis of its reddish colour. However, the fact that copper appears red is due to the chemical and physical properties that this structure evokes. Hence, "the redness of copper is an effect (symptom) of more basic aspects of copper's defining characteristics" (Goertz, 2006). In this case, these are the "secondary level dimensions" – the dimensions that appear when looking below the (literal) surface. It makes sense to conceptualise

[4] He denotes the abstract concept as "basic level", but I think that is misleading, because it suggests that the concept is ontologically on a more fundamental level than the other two levels, which is not necessarily the case as we will see.
[5] Figure created by the author on basis of the referenced text in Goertz (2006)

on basis of the lower level dimensions and not the phenomenon's effects, since the ontological theory of a phenomenon focuses on the root and only secondarily on its symptoms. If copper had been conceptualised on basis of its red colour, scientists could run into troubles[6] trying to explain how other things can be red which don't consist of copper or why copper is such a good electric conductor. The reason why the theoretical ontology of concepts is important is because it infers to the fact that a concept is constituted by the causal powers of its lower level dimensions which themselves can be further reduced to their causal lower dimensions.

It doesn't matter how individual sciences call causation, whether they talk about "understanding", "(in)dependent variables", "pathways", "mechanisms", "a/e-ffects", "consequences", "explanations", "laws", "tendencies" or ask "how"-questions – all of these terms refer to an attempt to describe what is (happening) and why. There is no science, which is purely descriptive, as they all seek to explain, and hence at least implicitly, ask "why" questions. There is no science that can reason without using the preposition "be*cause*". That is why a discourse about causation is unavoidable when talking about the ontology of science.

When entering such a discourse we first need to define what causality is, i.e. we need to look at the ontology of causality. In simple terms of physics, a cause is any kind of information that travels from its source and is received by a (one or more) sink, leading to one or more effects on the sink side. The space of possible causes for each (and any kind of) event (*E*) is called the *light cone* (*Figure 3*[7]). The light cone classifies all events in spacetime into 3 categories with respect to the event *E*:

1) Events *inside the future light cone* of *E* are those possibly affected by *E*.
2) Events *inside the past light cone* of *E* are those that can affect what is happening at *E*.
3) All other events are in the (*absolute) elsewhere* of *E* and are those that cannot affect or be affected by *E*.

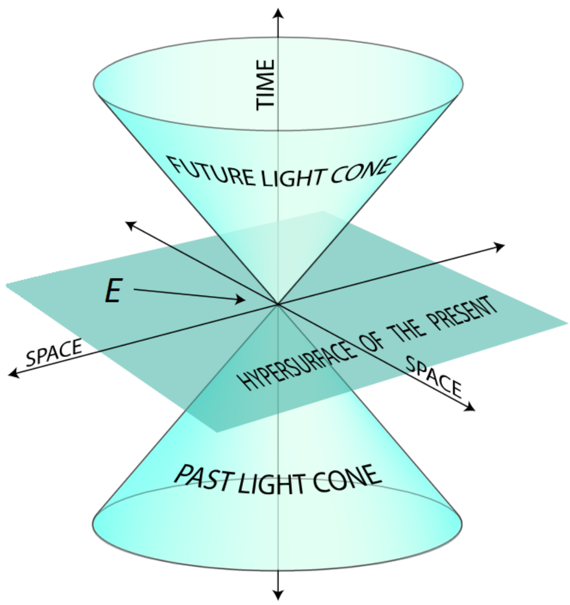

Figure 3: The light cone (a concept from physics) visualises the space of possible causes for each (and any kind of) event (E).

[6] The process of scientific endeavour includes „misconceptualisation" where „what is important" is misjudged or effects are mistaken for causes. An example is the classification of natural substances into 5 elements (wood, fire, water, metal and earth), which each contain specific characteristics and properties. Because these "misconcepts" strike scientists to be inconsistent with new findings however, they may get reconceptualised for a more complete and consistent understanding of the phenomenal world.

[7] Figure adapted by the author (Source: https://en.wikipedia.org/wiki/Light_cone)

As the name suggests, the light cone's borders are defined by the speed of light. As, according to Einstein's theory of relativity, nothing can travel quicker than light, information can only travel with this maximum speed. Hence, events that are outside of the light cone of *E* are too far away from *E* so that no information could possibly be sent (/ received) by *E* in time to have an effect on the other event (/ on *E*).

If *E* is affected by or affects another event there is a causal connection. According to Glennan (1996; in Brady, 2008) "two events are causally connected when and only when there is a mechanism connecting them" and "the necessity that distinguishes connections from accidental conjunctions is to be understood as deriving from a underlying mechanism" which "can be empirically investigated" according to Brady (2008). This requires a definition of the term *mechanism*.

Mechanisms "are entities and activities organized such that they are productive of regular changes from start or setup to finish or termination conditions" (Machamber et al., 2ooo; in Brady, 2008). Brady (2008) points out that the crucial terms here are "entities and activities", indicating that "mechanisms have pieces". It should be possible to take a piece (or part) "out of the mechanism and consider its properties in another context" Glennan (1996; in Brady, 2008). Change can be produced by "the interaction of a number of parts according to direct causal laws" Glennan (1996; in Brady, 2008). This means that mechanisms typically explain observed regularities in terms of lower-level processes.

In turn, these mechanisms can be explained by causal laws, but following Brady (2008) "there is nothing circular in this because these causal laws refer to how the *parts* of the mechanism are connected. The operation of these parts, in turn, can be explained by lower-level mechanisms. Eventually the process gets to a bedrock of fundamental physical laws." Causes can be understood as "atom variables" that can be reduced further to their lower-level mechanisms.

Naturally, mechanisms "'bottom out' relatively quickly" (Brady, 2008), which means that for example "molecular biologists do not seek quantum mechanical explanations and social scientists do not seek chemical explanations of the phenomena they study" (Brady, 2008). This is because these kind of explanations do not belong to the abstraction level of the respective science, but to a lower-level science. Hence, even by adopting ontological reductionism we don't seek explanations whose degree of abstraction is far lower than the one of the science trying to conceptualise the phenomenon. Instead, concepts can be reduced down to their lower-level processes only as far as to the border to a lower-level, which poses the natural limit for the upper-level science. As outlined above, at this border, it isn't the task of the upper-level science to conceptualise those phenomena, but to consult the respective lower-level science and adopt their concepts as foundations of the upper-level science.

An example is the periodic table of chemical elements. In fact, as demonstrated with the example of copper, those elements are concepts from physics, not chemistry, as atoms belong to the realm of physics. However, because atoms are the foundation of chemistry – they represent the border between physics and chemistry – the set of the variety of atoms we know of is called periodic table of chemical elements.

"The atomic structure of copper explains how it acts in many situations, social science concepts are no different." (Goertz, 2006). This is because "the core attributes of a concept constitute a theory of the ontology of the phenomenon under consideration. Concepts are about ontology" (Goertz, 2006). As shown above, the ontology of every kind of phenomenon is entangled with the mechanisms that bring the respective phenomenon into being. This principle holds across all sciences, which is why they are all ontologically equal.

Fifth, since all phenomena come into being because of their causal mechanisms, all sciences share an *ontological determinism*. I am aware that some scientists refrain from using the term mechanism, as it may sound too “mechanic”, too rigid to be useful in explaining abstract concepts. However, it should have become obvious by now that “mechanisms are not exclusively mechanical, and their activating principles can range from physical and chemical processes to psychological and social processes” (Brady, 2008). A mechanism, according to a definition in the context of scientific concepts, as outlined above, is one part of a causal chain leading to the phenomenon under consideration. Critique against this reductionist mechanism approach to scientific concepts might concern the determinism that it involves. Abstract concepts (such as in social sciences) are often claimed to be emergent phenomena, which may be too complex or too non-quantifiable as to be rooted in deterministic processes. How can we speak about a mechanism when there is only a likelihood that it causes the phenomenon? However, as John Stuart Mill said “Whoever makes use of an argument of this kind, not intending to deceive, should be sent back to learn the elements of some of the more easy physical sciences.” (Mill, 1872; in Sekhon, 2004). This hints at the fact that more abstract sciences are more complex, however not ontologically different from “easier” lower-level sciences.

Accepting an ontologically deterministic world with causal mechanisms “in no way implies that researchers will successfully analyze causal processes in this world. But it does mean that randomness and chance appear only because of limitations in theories, models, measurement, and data” (Mahoney, 2008). In other words, ontologically, there is no such thing as a *probabilistic cause*. Causes merely appear probabilistic when their mechanisms aren’t fully accounted for due to our limited knowledge and/or epistemological limitations. “A case with multiple causes and complex interactions among deterministic associations would, to us, look probabilistic in the absence of a theory (and measurements) that accurately accounted for the complicated causal mechanisms” (Sekhon, 2004).

Mahoney (2008) shows how this reductionist model of an ontologically deterministic world brings unification of case-oriented and population-oriented approaches to causality: “[The reductionist theory for unification of causality] assumes that causal effects at the population level manifest themselves only insofar as causal processes are operating in the individual cases. The population level does not exhibit any ‘emergent properties’ that cannot be reduced to (i.e., explained in terms of) processes that occur in the individual cases. Causation at the population level is thus epiphenomenal; case-level causation is ontologically prior to population-level causation.” Thus, the concept of *emergence*, where the sum of all parts appears to exhibit characteristics the individual parts do not seem to have, is merely a stopgap, representing our lack of knowledge on certain characteristics about the individual parts, which give rise to the dynamics we can observe.

From an epistemological perspective, the concept of emergence helps us to conceptualise phenomena even if not enough is known about the lower level mechanisms (yet), which is the case in the majority of scientific investigations. Theories that are not directly rooted in their underlying mechanisms, help make sense of the world and can be used as “probabilistic” approximations to *what is (happening)*. That is how abstract concepts (such as social science ones) or instrumentalist theories will always have their place in the scientific world. Ontologically, one should be aware however, that those are “only” approximations and ideally the limitations, arising from insufficient knowledge about the underlying mechanisms, of those concepts should be made explicit. One should remain open to the idea of "unpacking" (Brady, 2008) the phenomenon in question to study what lower level features caused what effect in order to produce more accurate theories. I would like to give a few examples to demonstrate why this attitude to ontology is important:

> The first example involves Newton's theory of gravity. When Einstein was able to unpack the concept of gravity in more detail than Newton was, due to having more knowledge about lower level processes, Einstein found that Newton's formula to determine the gravitational pull of one object to another, was a good approximation, but not the whole story. Even though technically it is wrong, Newton's law of gravity is still used, as it works as a good approximation within certain limits (such that the objects in question doesn't approximate the speed of light). Einstein's theory of relativity might also one day be replaced with a more accurate one when we understand the operations of the fundamental particles a bit better.
>
> The second example is the concept of nuts. Our culinary and perhaps even nutritionist[8] definition of a nut is different to the concept according to botany. The former classification is based on a similarity in nutrients (especially proteins, minerals and vitamins) and a similar texture. However, having a closer look at the biology of those plants that we commonly regard as nuts, reveals that for example peanuts, cashew nuts and almonds belong to different plant families. Hence, "unpacking" the phenomena in question leads to a different conceptualisation than our intuition and the science of nutrition would tell us. Nevertheless, using the concept of a "culinary nut" in our daily lives and in nutritionist terms makes sense, despite it being misleading in strict scientific terms. If, however, we need to know more plant biology and evolution, we better understand the lower level processes that lead to different plant families.
>
> Third, it is possible to lead heated debates about the existence of free will in (deterministic) physics, philosophy, psychology and the social sciences. However, as long as there is no accurate knowledge of what consciousness is, how it comes into being and how it operates, these discussions are nothing more than speculation and free will remains a pragmatic concept, which sets the basis for many of our laws and theories of action.

As demonstrated by these examples it makes sense for upper-level sciences to conceptualise phenomena, even if those cannot directly build upon lower-level concepts, for pragmatic reasons and because good concepts are approximations, considering the respective scientific context. Hence, the reverse-pyramid model doesn't suggest that, in reality, all sciences seamlessly build upon each other, but that phenomena conceptualised by upper-level sciences come into being because of lower-level processes, which *in principle* can be unpacked. In other words, the ontological roots of a phenomenon are to be found in the lower-level science. This is why interdisciplinary work in science is so important: it uncovers the connection between abstract concepts and the underlying lower level processes.

Furthermore, while the reverse-pyramid model implies ontological determinism, meaning that phenomena can *in principle* be reduced down to their lower level processes, upper-level sciences are not required to develop deterministic concepts or theories. In fact, following Comte as outlined above, the positivity of a concept decreases when the degree of abstraction rises.

[8] E.g.: https://www.health.harvard.edu/nutrition/why-nutritionists-are-crazy-about-nuts

This follows from the very nature of abstraction, which is the process of conceptualisation, where complexity is reduced and only those aspects of the phenomenon are selected which are relevant in the theoretical context under consideration. Hence, the reason why entities don't exist as the "things-in-itself" is precisely, because the abstraction process stripped off lower-level dimensions.

It follows that, by definition of the nature of social science, there cannot be a deterministic social theory or a universal social scientist concept. This is not because their logic is inherently different to physics or any other science, but because the complexity of the phenomena under consideration is infinitely higher. Sekhon (2004) asks what benefit there is then "in assuming that the underlying (but [perhaps] unobservable) causal relationship is in fact deterministic." As I am hoping it has become obvious by now, this assumption is important, because it draws back to a shared ontology. We shouldn't mix up ontology with epistemology, since this would equate and confuse what *we can* observe with what *there is* to observe. In practice, we might never be able to determine the underlying causal mechanisms. Another reason why this assumption is important is pointed out by Mahoney (2008):

> "The only alternative to ontological determinism is to assume that, at least in part, 'things just happen'; that is, to assume that truly stochastic factors – whatever those may be (see Humphreys, 1989) – randomly produce outcomes. The assumption of a genuinely probabilistic world finds its best defence with indeterministic relations in quantum mechanics[9]. Yet, whether or not subatomic processes are truly indeterministic is still debated among physicists. Moreover, as Waldner (2002) suggests, quantum theorists argue that the kinds of issues addressed in the social sciences do not work like quantum mechanics. Randomness at the subatomic level seems inappropriate when applied to the world of human beings and their objects […]."

Conclusions

The purpose of this essay is to demonstrate how sciences do not differ ontologically. Their inherent logic is the same, merely the degree of abstraction rises the more complex phenomena get, which is what the reverse-pyramid model of the sciences depicts. First, I showed that all sciences conceptualise, which involves the process of abstraction. Second, conceptualisation requires a decision about "what is important about an entity" (Goertz, 2006). Good concepts base this decision on the ontology of the phenomenon. Third, the higher the degree of abstraction (i.e. the higher ranked the science on the reverse-pyramid), the lower the degree of positivity (i.e. the degree to which the "thing-in-itself" can be approximated). Fourth, all sciences deal with questions of causation, which is related to the ontology of phenomena. Fifth, as long as there is no basis for assuming an "inherently probabilistic world", the ontological reductionist model implies ontological determinism.

This essay, however, isn't only a philosophical discussion about what sciences are about. Instead, as demonstrated with many examples, the ontological reductionist reverse-pyramid model and its implications provide scientists with an understanding of causality to develop more accurate theories. In line with this, Brady (2008) suggests that "knowing more about causation can be useful for social science researchers", because it helps "developing better social science

[9] The assumption of an inherently probabilistic world "finds its best defence with indeterministic relations in quantum mechanics", which is a branch of physics (i.e. a low-level science), shows that scientists do not just accept magical emergences of phenomena, but require an ontological reductionism, where phenomena are based on their root causes.

methods". The reverse-pyramid model reflects a bottom-up approach to causality which "although to some […] will seem obvious, the more common approach to achieve unification [of the concept of causality] has been top-down: Scholars try to understand causation at the level of the individual cases using ideas that apply to the population level. […] This approach is fraught with problems […]" (Mahoney, 2008). Those problems come from the simple fact that mechanisms of more abstract phenomena cannot affect the mechanisms of those they are based on[10]. Ontologically, laws of upper-level concepts cannot affect laws of lower-level concepts as they are built upon them.

From that ontological reductionist point of view, physics is the most "fundamental" science, because everything in the universe is comprised of the elementary particles and their interactions based on the four fundamental forces. This does not mean that physics is more "worthy" than any other science. It also does not mean that upper-level concepts will ever lose their relevance if and when we can explain everything using lower-level mechanisms. As my examples above show, abstract concepts don't only have a good explanatory value, but are also more useful for pragmatic purposes than laying out the full complexity of all structures and processes involved (c.f. the glass example). Hence, every science has and will always have its place.

Social science, which is located at the top of the reverse-pyramid, was called by Comte the "queen science" as it is the "last and greatest of all sciences, one which would include all other sciences and integrate and relate their findings into a cohesive whole"[11]. The social sciences have the difficult task to conceptualise supremely complex phenomena. As outlined above, achieving universal applicability of concepts and theories becomes increasingly difficult the more complex the phenomena. Nevertheless, the social sciences (like any other science) need to develop good concepts that explain can as many cases as possible, while at the same time remaining comparative to explain their differences. The simple example of the glass shows that there can hardly be a universal concept of "a glass", because one could imagine a glass which could equally be interpreted as a vase.

That is why it is understandable that social scientists reject terms, which are regarded as deterministic – such as "mechanisms" or "laws" – to denote their theories and concepts. However, as explained above, those terms aren't to be taken strictly in the mechanical sense: they rather refer to an ontology, where phenomena are brought into being by causal operations that *in principle*[12] can be unpacked. When we talk about "laws" or "mechanisms" in the social sciences, we should be aware that they generally do not possess the same degree of positivity as laws or mechanisms in physics, making them less deterministic. Hence, they are rather tendencies, referring to the probability of a phenomenon to happen, stripped off the complexities which could, *in principle*, give a deterministic picture. This is comparable with the act of throwing a coin (which belongs to the realm of physics). Since we could *in principle* determine what way it lands by taking into consideration its angle and momentum at departure, the air resistance, the earth's gravitational pull and the surface it falls onto. However, this

[10] This is because of the temporal precedence of the lower level processes, which gave rise to the more abstract phenomenon. The possibility of more abstract phenomena affecting mechanisms of those they are based on would mean a violation of the second law of thermodynamics and its arrow of time. Naturally, however, this doesn't mean that more abstract phenomena cannot have performative (or reactive) effects on lower level concepts, where over time (notice that the arrow of time remains intact here) the mechanisms of the lower level concepts change in response to an interaction with the more abstract concept.

[11] Source: https://en.wikipedia.org/wiki/Auguste_Comte#Comte's_positivism

[12] In reality, this unpacking process is hindered by epistemological limitations or other limitations, such as not enough funding/ infrastructure/ human resources etcetera.

calculation is usually too complex as to perform it in the situations we throw coins. That is why we substitute the causal mechanism that leads to the coin showing heads or tails with a probability. We have seen that “chance per se” doesn’t exist, but “is simply a residual label referring to our ignorance about additional influences and/or inadequate measures for the variables under scrutiny” (Lieberson, 1991).

The reverse-pyramid model of the sciences gives a consistent picture of what causality is, how the sciences are related, and it grants each one of them their right place. It assumes no magic to happen, but that everything can, at least *in principle,* be explained through lower level processes. It is very important to make the following conclusion explicit: **Ontological reductionism does account for social constructions**. In fact, all concepts are social constructions. They reduce complexity, and hence do not describe the “thing-in-itself”, but rather characteristics, which are brought into being by underlying structures and dynamics. Social constructions such as the value of money aren’t ontologically different to (man-made) physical constructions. In the case of the latter, it is easy to see that they are re-arrangements of physical constituents to build a certain structure with certain dynamics, like a computer or a house. Those constructions have consequences on us, just like the former, more abstract kind. It is a common misunderstanding that ontological reductionism means that social constructions can be directly reduced to their inherent properties. This would be a kind of “radical reductionism”[13]. In the case of the value of money this would mean that the value of a banknote can be directly reduced to its molecular structure. This is of course not how the value of money comes into being, but by social interactions. Nevertheless, those social interactions are based on neurological brain activities and their interactions with the body. Those can be further reduced to their molecular structures and interactions and so on, which is why the value of money is no emergent phenomenon, but can *in principle* be reduced down to physical components. Aliens visiting Earth wouldn’t see a “society” that exists as an entity, but rather individual humans, behaving a certain way. Alternatively, if they have electron microscope eyes, they would see the molecular structures we are made of and our neuronal activities, from which they could deduce what value we give to money or what we call a society. The Homo Sapiens Sapiens is nothing different: a socially constructed concept. In the end, social and physical constructions both manifest themselves in physical entities. That is what a shared ontology means and that is why no constructions and no sciences are ontologically different from each other.

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[13] “Radical reductionism” also happens when committing the error of mixing up “reducing complexity” with “reducing” according to reductionism as described above; Instead of investigating the lower level processes of the studied phenomenon, hence appreciating its full complexity, only those aspects of the phenomenon are investigated which are left after reducing complexity. Unfortunately, “radical reductionism” also sometimes happens in practice. For example, nutritionist studies are often criticised to be “too reductionist”. This means that they only look at a certain part of the human bodily system when they want to know what effects certain diets have on the whole body, and fail to account for interactions of that part of the system with other parts, which could mitigate/ enhance those effects. Another related example is the common misperception that weight gain/ loss is solely determined by an energy balance, which is understood as the sum of the calories taken in (i.e. eaten) and the sum of the calories burnt by sports. Many other processes aren’t accounted for here, like some people burn more energy when they are stressed and for some the opposite is the case. Reducing weight gain/ loss solely on a simple energy balance is pragmatic, but in many cases not accurate. A final example for a “too reductionist approach” is a tale of my childhood. I had to wear braces and the dentist told me, if I didn’t want to wear them every day, every second day would be sufficient. Being a math geek already back then, my first thought was “Great, then I can only wear them for the first half of the prescribed time to get it over with and skip the other half of the time.” I realised quite quickly, that this is probably not now my teeth work. I found it curious though, how it makes a difference to by teeth whether I spread the time I wear the braces over the whole prescription time, or whether I wear them only in the first half, even though the total wearing time is the same (in strictly mathematical terms there is no difference).

This essay has also emphasised that ontological reductionism does not necessarily imply epistemological reductionism. Since, according to ontological reductionism, all concepts are social constructions, and constructivism is an *epistemological* tool, **realism and constructivism can be reconciled**. This is possible when we assume realism about the reduced most fundamental phenomena (conceptualised as "elementary particles") and not naïve/ radical realism, which claim that entities are exactly like we perceive them or which suggest radical reductionism, leading to inaccurate concepts. Furthermore, we cannot assume a radical constructivism where reality is solely a construction of each individual's perception, not rooted in anything that can be objectively determined.

Finally, adopting ontological reductionism relieves the social sciences from the often perceived pressure to justify that they are "real" sciences. In the heat of generating justifications, often social scientists feel the need to demonstrate that they also produce "objective" findings. However, as we have seen, social sciences deal with phenomena whose incredible complexity needs to be substituted by concepts, so that they can be understood and dealt with. Conceptualising those phenomena is the task of the social sciences – not to generate objective and universal concepts. Like Goertz (2006) states, "we tend to identify as core dimensions those that have causal powers when the object interacts" and that choice "depends on the theoretical context". Hence, if a different theoretical context is chosen, it makes sense to conceptualise the phenomenon differently. In fact, those different concepts or theories of the same phenomenon represent different angles of how to look at the problem. Nobody would demand a decision about whether an object, which could equally be interpreted as a glass or a vase, is more objectively a glass or a vase. It can be both, depending on the context. The lower-level characteristics, however, are the same – our choice of which are more important simply depends on the context. Only when the social sciences accept that ontology can they be logically consistent. This involves consulting lower-level sciences for explanations on the foundations of social behaviour and furthermore, making the limitations of (pragmatic) those concepts that don't rest upon lower level concepts more explicit. It is the sum of the different concepts (representing different angles) and their consistency with other sciences, which make them "objective". When having discussions about which science is more worthy than another, one shouldn't forget that the borders between sciences are merely socially constructed, depending on the level of abstraction, and that we need all of them to make sense of ourselves and the complex universe that we are part of.

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