How to Conceive Virtual Entities: Peirce's Proposal

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The term "virtual entities" has a long tradition and a variety of meanings. My short article focuses on one particular meaning, as clearly defined by Charles Sanders Peirce in 1902. I will discuss the definition he provided and touch on the wide resonance it had and still has in science.

I.

In the current era, we are surrounded by more virtual items than ever before: first and foremost, all sorts of virtual meetings, coffee tables, conferences, and discussions. But even before the pandemic we had virtual exhibitions or virtual museums, virtual games, virtual laboratories (sometimes with online experiments, for use by both historians and scientists, e.g., https://virtualbiologylab.org/ or https://vlp.mpiwg-berlin.mpg.de/index_html, or even goggles to show us virtual reality.

What we understand the attribute "virtual" to mean in those cases is rarely explained. However, there is a basic common understanding: we mean the thing *in some way*, not in its real form but rather in a sort of substitute reality, typically on a display, and in most cases just for the eyes and perhaps the ears. Beyond that unspecific understanding the use of the term varies widely, as strikingly illustrated in the recently published *Handbook of Virtuality* (Grimshaw 2014).

The steep increase in the use of the term virtual, paired with such an unspecific meaning, raises interesting historical questions. We have, for example, been living with telephones for more than a century, with telephone conferences taking place at the latest since the post-war period and picture phones in use since the 1980s. Yet we never referred to virtual conversations or meetings in those contexts as we do today. Our modern use of the term needs to be embedded in a broader story, still to be explored.

These broad questions, however, are not the focus of this special issue (and have not been the focus of our workshop). Rather, and more specifically,

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we will focus on references to virtuality and virtual things in scholarly or scientific contexts. Nowadays, talk of virtual entities is extremely common in high energy physics, where virtual particles have been gaining steadily in importance since the mid-twentieth century and might well become even more relevant (Harlander et al. 2023) in the future. In a research project conducted over the last several years, the editors of this special issue have taken a historical perspective to investigating the early history of the concept, dating back to the 1930s[1]. But the talk of virtuality and virtual entities has a much longer history in science, and a longer varied history indeed, with virtual images and longer virtual displacements as the most prominent cases. The contributions to this special issue represent a select collection and are far from comprehensive. Moreover, in the historical records, we sometimes find reflections on what exactly is meant by the term virtual. In my brief introduction, I would like to provide some observations on those reflections and highlight one of them that strikes me as being a baseline of many scientific uses of the term virtual, both past and present.

II.

The historical root of our term virtual is, of course, the Latin noun *virtus*. It has various meanings, the most prominent of which point to moral virtues on one hand and the power or strength of affecting something on the other. The two are naturally related: a man having virtue was probably also considered to have the power to affect things. The former meaning in particular has a long tradition, dating back to the classical period, and will not be my topic here. The latter meaning, in contrast, had been discussed prominently in the ontological debates of the scholastic period. The adverb *virtualiter*, for example, mostly denoted a specific mode of existence of something and was typically used in contrast to *formaliter, essentialiter, materialiter*, or *actualiter* by Thomas Aquinas and Duns Scotus (Knebel and Grötker [2001] 2017). Despite all the differences between those terms, the virtual mode of existence was understood in contrast to the form or essence of the thing, i.e., in looser wording, to its nature. I will not delve deeper into the historical discussions nor follow them through the centuries (for a condensed overview, see Knebel and Grötker [2001] 2017). Instead, I shall discuss how one particularly sharp thinker brought the basic point clearly to the fore in the early twentieth century and presented his considerations not in terms of metaphysical discussion, but in language accessible for a non-specialist audience. I refer to Charles Sanders Peirce.

1. https://www.lhc-epistemologie.uni-wuppertal.de/projects/cluster-a-change-in-the-theoretical-foundations-of-physics/a1-virtual-particles.html. See also the articles by Ehberger and Martinez in this volume or Ehberger 2020.

III.

Since Peirce's discussion of the virtual appeared in quite a special location, I will provide a brief outline of it here for context. Between 1901 and 1905, the American psychologist and philosopher James Baldwin published a *Dictionary of Philosophy and Psychology*. Baldwin, who had studied in the 1880s with the Leipzig pioneer of experimental psychology Wilhelm Wundt, held positions in Toronto, Princeton, and John Hopkins universities, and is regarded as pioneer of experimental psychology in North America. At the same time, he was keen to keep psychology in close connection with philosophy and epistemology, as Wundt and many others had practiced it. In 1897, he started working on the *Dictionary*, gathering around 60 authors for it. The immensely wide scope of the work was indicated by its full title: *Dictionary of Philosophy and Psychology, Including Many of the Principal Conceptions of Ethics, Logic, Aesthetics, Philosophy of Religion, Mental Pathology, Anthropology, Biology, Neurology, Physiology, Economics, Political and Social Philosophy, Philology, Physical Science, and Education; and Giving a Terminology in English, French, German, and Italian*. Indeed, the work appeared in three volumes, after Baldwin had spent much time in Oxford supervising the editing process, and it had several later editions.[2] I mention all this since it strikingly illustrates the high visibility and importance both of Baldwin and his monumental *Dictionary*, and is of relevance to the entry that interests me here.

Among the authors of the *Dictionary*, the mathematician, logician, and pragmatist philosopher Charles Sanders Peirce, already well known and highly acknowledged at the time, contributed around 150 entries, some of them coauthored with others. In most cases, they addressed philosophical and logical notions like dualism, light of nature, maxim, modality, opposition (in logic), paradox, presupposition, symbol, tautology, truth, and so on. He also wrote on the scientific method.[3] One of Peirce's entries addressed the keyword virtual (Peirce 1902). As typical for Peirce's entries, it was short and precise. I will take a closer look at it in the next section.

2. A not yet complete online version of the *Dictionary* has been developed by Christopher D. Green: https://psychclassics.yorku.ca/Baldwin/Dictionary/.

3. Based on the online version, John F. Sowa has developed a collection of Peirce's entries up to the letter O. https://www.jfsowa.com/peirce/baldwin.htm. My counting is based on that collection and its extension by Gary Fuhrman at https://www.gnusystems.ca/BaldwinPeirce.htm.

IV.

Peirce gave both a definition of how he understood the concept as well as a number of examples.

> (1) A virtual X (where X is a common noun) is something, not an X, which has the efficiency (*virtus*) of an X. This is the proper meaning of the word; but (2) it has been seriously confounded with potential, which is almost its contrary. For the potential X is of the nature of X, but is without actual efficiency.[4]

The core concept here is "efficiency," taken by Peirce as a translation of *virtus* and understood as the power of producing effects, much in line with the traditional meaning. While his focus on the "nature" of X resonates nicely with what former thinkers had called form or essence, he drew, more sharply than they had, a contrast between the nature and the efficiency of something. The basic idea is that there are cases in which the efficiency of X is there while X itself, with its nature, is not: these are the cases in which he speaks of a virtual X. In order to make his point as clear as possible, Peirce uses the contrast between virtuality and potentiality. A potential X is, in his understanding, a full-blown X that happens to be not actually efficient but can possibly be actualized in its full nature and efficiency. In this understanding, the contrast with the virtual X becomes particularly clear: the full nature of X without actual efficiency on the one hand, efficiency without the nature of X on the other. The contrast serves to clarify both notions at the same time. It should be noted that Peirce makes the contrast between virtual and potential much clearer than it had been in scholastic discussions. Aquinas, for example, had used the term *actualiter* that formed the classical contrast to *potentialiter* as well as to *virtualiter*, thus leaving the distinction between the latter two much more subtle. It should also be noted that, up to this day, Peirce's contrast is not always accepted. In the prominent Larousse dictionary, for example, one of the meanings of "virtual" is taken to be "potential,"[5] and this understanding seems to have a longer tradition in the French language.[6]

4. Peirce also pointed to the use of "virtual" in ethics, again following the long tradition, and gave his article a third section: "(3) Virtual is sometimes used to mean pertaining to virtue in the sense of an ethical habit." I will not discuss this meaning here.

5. https://www.larousse.fr/dictionnaires/francais/virtuel/82149.

6. See, for example, the discussions (Berthier 2007; Noël 2007; Parmentier 2017). Many thanks to Jean-Philippe Martinez for pointing out that tradition.

In his definition, Peirce aimed at sharp contrasts, and he immediately continued with some examples. I shall briefly comment on two of them. First:

> A virtual velocity is something not a velocity, but a displacement; but equivalent to a velocity in the formula, what is gained in velocity is lost in power.

Virtual velocities had been introduced into analytic mechanics in the eighteenth century as a conceptual tool for finding the motion of a system under constraints. The reasoning relied on d'Alembert's principle, according to which the motion was such that the external constraints would never yield work under the motions of the system. For the reasoning procedure, infinitesimal displacements of the system were imagined, and the ensuing work calculated. The demand that the work had to be zero would lead to the equation of motion. The displacements were not imagined as real displacements in space, they were used only to calculate the work, hence they were labelled virtual. The notion was successively widened to virtual velocities and virtual work (Fraser 1983, 1997, among others).

Pierce gave a further example:

> So virtual representation was the non-representation of the American colonies in the British Parliament, which was supposed to be replaced by something.

Peirce referred to a famous episode in American history, widely known even today from high school courses: when the American colonists protested in the early 1760s against the plan to be taxed without a representative in the British parliament (with the famous slogan "No taxation without representation"), the British lawyer and MP Thomas Whateley devised the idea of "virtual representation" in 1765. In a nutshell, he aimed to show that the colonists were represented in the minds of MPs. The MPs had the right, according to Whateley's argument, to speak not only for the district by which they were elected but also for the interests of all British subjects. Hence there was no need to worry. Even if the colonists were not represented in person, they were represented in a "virtual" mode. Unsurprisingly, the colonists were not happy with that view, and the episode did not mitigate the conflict. On the contrary, it is considered one of the important triggers of the development that led to the 1776 Declaration of Independence (e.g., by Greene 2010).

Peirce's two other examples are from literature (the first is from Milton's *Paradise Lost* of 1667, while the second refers to the sun being considered "to be *virtualiter* on earth" in a passage I could not locate so far) and it is

beyond my competence to explicate their meaning in any solid way. However, the two examples I have discussed illustrate the central point of the definition very clearly: virtual entities are considered or imagined as having certain effects, even though the entities themselves are clearly not present. Peirce's definition and his examples thus highlight and illustrate the core point that could be taken from the century-long metaphysical discussion, which was certainly well-known to him. His strategy to highlight the contrast, even the opposition, between "virtual" and "potential," makes the point even clearer.

It is worth noting, however, that the definition leaves fundamental questions unanswered. These arise from the point that one can, of course, never take into account the complete efficiency of X but must instead select specific aspects. At least two basic and related problems occur as a result: first, why speak of a virtual X in contrast to a virtual Y, Z or so on? In other words, what exactly makes the efficiency we experience appear as the efficiency of an **X**, not a Y or Z? The second problem addresses the point the other way round: Why would we speak of a *virtual* X in contrast to the real one? In other words, how many properties of X—besides the efficiency we perceive or imagine—must be there (or how many must be missing) in order to enable us to judge that there is "not an X" present in that efficiency? The point is brought to the fore in Peirce's quote when he contrasts "the nature of X" to its "efficiency." Offering a response to the two questions above would be closely related to clarifying Peirce's distinction between efficiency and the nature of something. Peirce does not treat those questions or mention them in his short article in the *Dictionary*.

At the same time, it is difficult to imagine that Peirce, with all his clarity, would not have foreseen those challenges. The fact that he did not discuss them might, on the one hand, be due to a dictionary not being the place for deep philosophical discussion. On the other hand, however, it might be an indication that Peirce wanted his statement to be read in a specific way: not as a comprehensive definition that would allow the reader to clearly identify the specific meaning of virtual in each particular case, but rather as a guideline that presented the core idea, with the necessity for specification in any individual case. To corroborate this historical guess would require far more Peirce scholarship than I have at my disposal. Instead, I would like to point out, in my last section, how fruitful that guideline might be in cases of other virtual entities in science as well.

V.

Indeed, the meaning discussed above seems to me to be the baseline of many uses and instances we find in the sciences, from early modern to

recent times. Besides the one Peirce himself mentioned, others come to mind, some of which are addressed in this special issue.[7]

In optics, a virtual image was considered not to be a proper optical image since it could not be projected upon a screen. It had the effectiveness of images in two ways, however: it could be constructed with the same geometrical procedure as an image (and hence was an effective tool in creating optical constellations), and it could even be perceived by the eye (not a screen) if put in a particular position (see Borrelli, in this special issue).

The Lyon physiologist Jacques Raphaël Lépine, in his extended research on diabetes, coined the term virtual sugar (*sucre virtuel*) in 1910 for a substance that had some physiological effects of sugar but could not be identified as sugar (Lépine and Boulud 1910). His proposal led to a debate across several decades (e.g., Laquer 1924; Bergh 1926, p. 65n).

Hans Leo Przibram, a prominent experimental zoologist in Vienna, introduced the notion of a virtual embryo for an anatomical structure he had found in an amphibian embryo—a structure that had some effects of an embryo, but obviously was not an embryo (Przibram 1923).

The notion of virtual adrenaline was introduced in the early decades of the twentieth century to refer to a still unknown substance that was not adrenaline but had many of the same effects and even served as a parent substance in physiological adrenaline formation (Abelous and Argaud 1934; Abelous and Soula 1922; Devine 1936; Ooisi 1943, among others).

In early quantum physics the notion of virtual oscillators denoted entities and processes that were not considered real but had the same effects as oscillators and were introduced as successful tools to schematize processes that otherwise were difficult to understand. In their contribution to this special issue, A. Blum and M. Jähnert discuss this point in detail.

Likewise, the notion of virtual particles in particle physics was introduced in the 1930s (Ehberger 2020; Ehberger forthcoming) and has been steadily gaining prominence ever since. For our purpose, the central point is that virtual particles are considered to have some effects of particles (in particular in perturbation theory) but can hardly be conceived of as real since they are "off-shell," i.e., do not warrant such fundamental principles as energy conservation.

As different as these examples are, all of them can be understood using the baseline that Peirce expressed so distinctly. What efficiency meant in each of those cases varied greatly, but in each of them scientists were sure that the effects were there while also being pretty sure (or at least uncertain) that the thing that usually would bring about those effects was not

7. Thanks to Markus Ehberger and Jean-Philippe Martinez who have brought some of them to my attention.

there. As Martin Jähnert formulated in a personal communication (many thanks!), the use of virtual might in many cases reflect some epistemic embarrassment or uncertainty.

Most of those uses of the term virtual occurred after the publication of Peirce's definition, but it remains unclear (and sometimes improbable) that those uses were inspired by his short piece, however prominent it was in the English-speaking world. Nevertheless, given the prominence and visibility of the *Dictionary*, it might have inspired and solidified an understanding of virtual even beyond specialist philosophical circles, and in that indirect way also have shaped the various uses of "virtual" in the sciences.[8]

At the same time, it should be kept in mind that Peirce's definition was not new, but just brought the core of a much older understanding to the fore in a particularly clear manner. For me at least, it came as a surprise to realize how well some ontological discussions of the often-dispraised scholastic era have not only survived, but have come up again in recent times in the abundant use of a concept that was formed eight centuries ago.

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8. In that respect, it is surprising that no reference whatsoever is given to Peirce and his definition of virtual in the Oxford Handbook.

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