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The Instrumentalist's New Clothes

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This paper develops a new version of instrumentalism, in light of progress in the realism debate in recent decades, and thereby defends the view that instrumentalism remains a viable philosophical position on science. The key idea is that talk of unobservable objects should be taken literally only when those objects are assigned properties (or described in terms of analogies involving things) with which we are experientially (or otherwise) acquainted. This is derivative from the instrumentalist tradition in so far as the distinction between unobservable and observable is taken to have significance with respect to meaning.

> Everything which we observe in nature imprints itself *uncomprehended* and *unanalyzed* in our percepts and ideas, which, then, in their turn, mimic the processes of nature in their most general and most striking features. – Mach (1893: 36)

1. Introduction: Moderate Instrumentalism

Instrumentalism is no longer a popular position, and is rarely discussed in serious depth (except when the object of the exercise is to show why it is refuted). The action in the realism debate now revolves around more recent alternatives to scientific realism, namely constructive empiricism, entity realism, and structural realism (or empiricism), and it is usually taken as a basic assumption that talk of unobservable entities may be understood literally. This is part of a general backlash against the linguistic turn in philosophy.

But the core idea behind linguistically-motivated instrumentalism, such as that of the logical positivists and Ayer, remains plausible. How can we name something with which we are not acquainted – where to be acquainted with an object is to 'have a direct cognitive relation to' or be 'directly aware of' the object (Russell 1911: 108) – unless that name is a substitute for a definite description made in terms of names for things with which we *are* acquainted (or

other names reducible to such descriptions)? It would appear that we cannot. To disagree with Russell (1918) that proper nouns (rather than logically proper names) should generally be understood as substitutes for descriptions does not suggest that we can employ such words in a referential capacity – to 'denote the individuals who are called by them' (Mill 1843: bk.I, ch.2, §5) – without being acquainted with their referents.[1] Moreover, theoretical terms are typically kind (or type) terms such as 'electron', and there is a peculiar description (involving a specification of mass and charge and spin, in this case) with which they are associated. Again, how could we understand such terms if we were not acquainted with the referents of the property names mentioned in the associated description? Surely we could not. Or, rather, surely it is a philosophically respectable view that we could not; and I will therefore say no more about it.[2]

But by accepting a fundamental link between naming and acquaintance, one does not arrive at instrumentalism. First, in line with the traditional talk of 'saving the appearances in an economical fashion' as the aim of science, associated with Mach and Duhem, one must add the empiricist thesis that our primary means of becoming acquainted with (or achieving knowledge-by-acquaintance of) things – both objects and the properties thereof – is sensory experience. Second, one must add that what we are acquainted with is limited in such a way as to render it impossible to discuss, and therefore comprehend, (at least some aspects of) any truth behind the appearances.

I take the first thesis to be reasonably uncontroversial, at least among philosophers of science; at the very least, all of us will be content with the idea that sensory experience is a major source of acquaintance, that there are many things (such as colour and pitch) with which we would never become acquainted in the absence of sensory experience, and that the unobservable entities discussed by science are generally taken to have observable effects (by which we are supposed to infer their existence). Note also that the instrumentalist need not rule out the view that we are acquainted with some things by means other than direct personal experience or description, e.g. via innate phylogenetic (or even ontogenetic) knowledge, in

[1] In the words of Searle (1958: 168): 'How... do we learn and teach the use of proper names? ... unless our student already knows another proper name of the object, we can only *identify* the object... by ostension or description...'

[2] Besides, as Sankey (2008: 15, f.4) notes, 'no commitment to a specific account of reference is required by the realistic interpretation of theoretical discourse.' Psillos (1999: ch.12) likewise appears to be interested in theories of reference only in the context of the incommensurability (or meaning variance) debate.

order to defend the second thesis. It is certainly incorrect that acceptance of the thesis that we can discuss only that with which we are acquainted 'leads inevitably into phenomenalism' (Maxwell 1962: 12).

I shall therefore focus on the second thesis, in what follows. In the light of lessons learned in the debates over the last few decades on constructive empiricism – and with special regard to how van Fraassen's position on science has developed – I will be arguing for a moderate form of instrumentalism, which is not anticipated in the extant literature. It involves a denial of semantic realism in so far as this pertains to talk of unobservable *properties*, but not unobservable objects *provided that these are defined in terms of observable properties and/or by analogy with observables*. I call this position *cognitive instrumentalism*, because it rests on the notion that we can only think of (and therefore discuss) the unobservable in terms of the observable. I will flesh it out subsequently, but to avoid any early confusion, it should be emphasised that an entity may possess an observable property without the property being observable *in that peculiar instance* (i.e. as instantiated by that entity). The language of metaphysics helps here. The trope of red of a rose in my garden may be observable in a way that the trope of red of a tiny insect may not be. Yet we may nevertheless say that the unobservable entity instantiates an observable property, namely redness, in so far as some of its instances may be observed. I use this language for illustrative purposes, not to suggest that the cognitive instrumentalist should be committed to any particular metaphysical account of properties.

Now to see how a position like cognitive instrumentalism is typically unanticipated, consider part of Psillos's (1999: xix) definition of the semantic thesis of scientific realism:

> Theoretical assertions are not reducible to claims about the behaviour of observables, nor are they merely instrumental devices for establishing connections between observables. The theoretical terms featuring in theories have putative factual reference.

Agreement with the first claim does not signal agreement with the second. Rather, it is possible for an instrumentalist to accept that *some* theoretical terms 'have putative factual reference' while denying that they all do; as we will see, it may be considered reasonable, for

instance, to extrapolate observable properties into the unobservable realm, and to take talk of unobservable entities seriously when they are said to possess the 'right kind' of properties.

Psillos (1999) is not peculiar in this oversight. The instrumentalist may equally deny what Sankey (2008: 14) instead calls 'theoretical discourse realism', namely that 'scientific discourse about theoretical entities is to be interpreted in a literal fashion as discourse which is genuinely committed to the existence of real unobservable entities', without denying that *some* discourse about theoretical entities should be interpreted literally. As such, it is not correct to say that 'Instrumentalism denies the literal interpretation of theoretical discourse' (ibid.); rather, it involves the denial of the literal interpretation of *some* theoretical discourse. If one wishes instead to insist on Sankey's definition of instrumentalism (or something similar), then one must admit that it is possible to deny 'theoretical discourse realism' (or semantic realism) without being an instrumentalist (or a reductive empiricist), and without denying the metaphysical thesis that, in the words of Psillos (1999: xix), 'the world has a definite and mind-independent natural-kind structure' or a correspondence theory of truth. Either way, there is presently unoccupied territory where sweeping generalisations about theoretical discourse are rejected in place of finer grained distinctions. It is this territory that the cognitive instrumentalist occupies, and I call the position 'instrumentalist' because it shares a key feature of several of the (rather more radical) positions that have historically borne the name. Specifically it takes the distinction between observable and unobservable *to have significance with respect to meaning*.

2. Moderate Instrumentalism, Epistemological Voluntarism, and Common Sense

Before we continue, it is worth emphasising that a moderate instrumentalist need not insist that it is irrational to be a scientific realist, or indeed that instrumentalism is a superior alternative to scientific realism. Instead, it is possible to take a leaf out of van Fraassen's (1980, 2002, 2004) book and defend only the view that (cognitive) instrumentalism is a reasonable and rational alternative to scientific realism: that it is reasonable to refuse to take talk of theoretical entities literally when one is not acquainted (or takes oneself not to be acquainted) with the properties (or things in the analogies) discussed, as against the alternative of taking all (or simply more) theoretical talk literally.

However, one need not go quite so far as accepting van Fraassen's brand of epistemological voluntarism, perhaps, in order to do this. Rather, one might suggest that there are no *evidential* grounds for preferring cognitive instrumentalism over semantic realism (although there may be prudential or functional grounds for preferring one alternative to the other).[3] One way to do this is to point to the strategies that scientific realists tend to employ when the chips are down, and they need to defend the basic metaphysical thesis which semantic realism presupposes, namely that there is a mind-independent objective world.

Sankey (2008: 23), for instance, appeals to nothing more than common sense:

> Common sense gives rise to a body of beliefs about the objects in our environment and our epistemic and practical interactions with these objects. On the whole, we may assume that this body of beliefs in true. The point is not that our commonsense beliefs are certain, indubitable or infallible. Rather, commonsense beliefs are *prima facie* justified... Any attempt to eliminate or overthrow such beliefs is to be regarded with extreme suspicion.

Sankey does not argue, however, that there are *evidential reasons* for treating common sense beliefs in such a way (or indicate how these are *prima facie* justified in an *epistemic* sense).[4] And it is hard to see, indeed, how he could; even an appeal to an evolutionary argument is only apt to establish that our beliefs are suitable for us to survive and flourish in peculiar environmental circumstances. A far more honest approach to defending metaphysical realism, it seems to me, is adopted by Rescher (1987: 126) when he says it is a: 'postulation made on *functional* rather than *evidential* grounds.' It is plausible that we start with common sense beliefs on similar functional grounds, indeed, but we should also remain mindful of Russell's (1953) masterly illustration of common sense's limitations. In any event, it is hardly a violation of common sense to insist that we can only talk about the kinds of things with which we are familiar, and that we extrapolate from those when we write fiction, or when we imagine how things might be in the microscopic realm. As such, if we followed Sankey's suggestion above we would take cognitive instrumentalism to be *prima facie* justified in a

[3] A rejection of evidentialism, namely the view that one should not believe beyond one's evidence, would also be required.

[4] Psillos (1999: xix) says only of the metaphysical component that it 'is a basic philosophical presupposition', and makes no attempt to defend it at all. Newton-Smith (1981) does something similar.

way that semantic realism is not. We would regard attempts to overthrow it with extreme suspicion.

It is also worth adding that a cognitive instrumentalist may accept that the aim of science is truth *concerning those unobservable things we can talk about*, or instead think that the aim is just empirical or structural adequacy (or indeed none of the above). In short, to adopt cognitive instrumentalism is not to adopt any peculiar view on the aim of science, although it is to rule out the view that the aim is (the whole) truth if there are unobservable things possessing properties of kinds with which we are not, and cannot become, acquainted.[5] It would therefore be wrong to characterise cognitive instrumentalism as a restricted form of scientific realism. Cognitive instrumentalism retains an instrumentalist character with respect to the aim of science in so far as *some* theoretical discourse is taken to fulfil a purely instrumental role.

3. An Articulation of Cognitive Instrumentalism

But why should we think that unobservable things are different from observable things, with respect to the kinds of properties that they bear? Perhaps one might make the case that some of the difficulties we've encountered with the interpretation of quantum mechanics support this view; for example, one might agree with Bohr that we are bound to use classical concepts that we cannot apply to quantum objects directly, but instead employ only as complementary descriptions on a context-by-context basis (Faye 1991 & 2008). Similarly, Ladyman (1998: 422) suggests that 'The demand for an individuals-based ontology may be criticised on the grounds that it is the demand that the structure of the mind-independent world be imaginable in terms of the categories of the world of experience.'[6] Yet even if we instead admit that there is no particular evidential reason to expect unobservable things to differ from their observable counterparts, there is equally no clear evidential reason to expect them all to be similar. As such, there is no clear evidential reason not to be a cognitive instrumentalist.

[5] For a detailed discussion of what talk of 'the aim of science' means, and how we should evaluate whether some *x* counts as such an aim, see [Author] (2010, §2).

[6] See also McMullin (1984: 14): 'The realist claim is that the scientist is discovering the structures of the world; it is not required in addition that these structures be imaginable in the categories of the macroworld.'

But is there a pragmatic reason not to be? Not in so far as any peculiar advantage is conferred by *expecting* that the unobservable is appropriately similar to the observable. What there arguably *is* a pragmatic reason to do is to endeavour to render scientific discourse as literal as one can, e.g. attempt to posit only unobservable things possessing observable properties in the hope that this will prove sufficient to save the phenomena (or, as we will see below, formulate appropriate analogies). One may do this without taking an overtly hostile view to theories that fail to meet this goal, in the absence of promising alternatives, and therefore avoid falling into the same methodological trap as Mach on the view of Brush (1968).

There are old worries about the very distinction between observable and unobservable, but the cognitive instrumentalist may use the same resources as those enjoyed by the constructive empiricist. It may be admitted that the distinction is vague, yet emphasised that there are clear examples on each side (such as rabbits and quarks).[7] On the question of how we work out which properties are observable (or observed) and which are not, and therefore judge whether to take a peculiar theory literally, the simple answer is that we may look to science itself (van Fraassen 1980: 59). *Whether some particular theoretical discourse should be taken literally is therefore an empirical question.*

This said, I will turn my attention to explaining the cognitive instrumentalist's stance on theoretical discourse in a little more depth, with the aid of some historical examples. There are two principal ways in which one may posit unobservables by appeal to observables. The first way, which is the most obvious, is by positing unobservable entities which possess observable properties.

Sometimes this may be done by straightforward extrapolation. When holding an apple in my hand, I feel the force that it exerts. But if I halve the apple, and so on, I will eventually reach a point at which there is no discernible force. It does not appear unreasonable, however, to presume that there is a force acting, and that said force is in proportion to the amount of apple remaining (as is the case when the forces are discernible). There is an upper limit to the force I can discern too. The difference between having my hand crushed by a car and crushed by a lorry is not directly sensible. We must therefore extrapolate 'upward' into some parts of the observable realm as well.

[7] Moreover, since the epistemic account of vagueness is now respectable following the work of Williamson (1994), this is no longer to concede that there is not a solid ontological line.

While failing to recognise that 'upwards' extrapolation may also be required, Mach (1893: 588) provides similar examples of the 'downward' process, concerning the frequency of sound and the amplitude of vibrations:

> Even when the sound has reached so high a pitch and the vibrations have become so small that the previous means of observation are not of avail, we still *advantageously* imagine the sounding rod to perform vibrations... We fill out the gaps in experience by the ideas that experience suggests.[8]

Where the cognitive instrumentalist differs from Mach is in taking such descriptions literally. Unlike Mach, she is not committed to the view that 'the world is not composed of "things" as its elements, but of colors, tones, pressures, spaces, times, in short what we ordinarily call individual sensations' (Mach 1893: 579) or that '[w]hat we represent to ourselves behind the appearances exists *only* in our understanding, and has for us only the value of a *memoria technica* or formula' (Mach 1911: 49). Nor is she committed to what Brush (1968: 197) appropriately calls 'empiriocriticism', namely 'a critical view toward all scientific hypotheses not directly induced from experiment.'

The history of atomism provides some nice examples.[9] The atmospheric atom model of the 18th and 19th century might be taken literally in so far as it involved two different kinds of atoms, matter-atoms and ether-atoms, attracting one another and repelling one another (via inverse square laws) respectively. And similarly, the kinetic theory of gases might also be understood literally in so far as it did not 'rely directly on a detailed atomic theory', and required 'little more information about atoms than their sizes' (Brush 1968: 195). According to cognitive instrumentalism, extrapolation of sizes and attraction and repulsion by inverse square laws – demonstrable in electrostatic contexts involving charged macroscopic objects, for example[10] – is (plausibly) not merely an artifice.

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[8] See also Psillos (1999: 19–20).
[9] See also Mach (1893: 587).
[10] The inverse square character also accords well with experience. Consider an analogy between an isotropic source and a charge (or mass). If the power of the source is P, then the intensity of whatever it emits – sound, say – at any other point is $P/4\pi r^2$, where r is the distance between that point and the source.

The second way is to employ analogical means to describe (and/or posit) unobservables. Such analogies are common across all the sciences. In physics, one well-known example is the comparison between the atom and Saturn which was made by Nagaoka (1904); and such analogies remain commonplace in contemporary physics, as illustrated, for instance, by the analogy of Hawkins and McLeish (2004) between repressor protein dimers and rigid plates connected by springs. Such analogies are sometimes the subject matter of papers in their own right. Alexander (1999), for example, suggests an analogy between chemical plants and digestive systems: 'Our jaws are grinding machines, our guts are chains of biochemical reactors, our capacities to digest food and absorb the products are designed with substantial safety margins, and it may be useful to think of a mouse as a pilot plant for an elephant'. It is also clear that it would be extremely difficult to teach science without recourse to analogies concerning macroscopic entities and systems; most of us will remember having electric flow in a wire is compared to water flow in a pipe or car flow on a road, with resistance being compared to pipe diameter or number of lanes, and so on.

In the psychological literature on mental models and analogies – see, for instance, Gentner (1983) and Blanchette and Dunbar (2000) – superficial similarity is distinguished from structural similarity. The former involves similarity in intrinsic properties (such as mass and absolute volume), whereas the latter, which Gentner (1983) suggests is the basis of the most important analogies used in science, involves similarity in internal relations. When we compare an atom to the solar system, for instance, we suggest that the nucleus corresponds to the Sun, that the electrons correspond to planets, and that gravitational force corresponds to electromagnetic force. But we do not thereby wish to suggest that the nucleus (necessarily) emits radiation, that electrons have a range of masses and compositions, and so forth. What we wish to convey is that the nucleus *is much bigger than* the electron, that the electrons *orbit* the nucleus because they *are attracted to* the nucleus, and so forth.

If we look to the history of atomism again, we can see the importance of analogies simply by the popular names for various models: billiard ball (Dalton), plum pudding (Thomson), cubical (Lewis), Saturnian (Nagaoka), and planetary (Rutherford). In line with cognitive instrumentalism, moreover, some historians and philosophers of science have argued that such analogies are more than *aide memoires* or dispensable vehicles by which to promote understanding. In the words of Nersessian (2002: 146): 'analogies employed in conceptual change are not "merely" guides to reasoning but are generative in the reasoning processes in

which they are employed.' She takes Maxwell's method of physical analogy – see Nersessian (1988) – to illustrate this.

It is important to recognize, however, that often many different analogies are used to describe the same thing *in different contexts*. We have already touched on Bohr's notion of complementarity, and the idea that we can conveniently think of quantum entities as waves at some points (e.g. during motion), and particles at others (e.g. during energy exchange), without thinking of them as genuinely having 'wave-particle' natures. In this regard, it is crucial to note the *limited scope* of appropriate analogical statements. To say "Electrons are like waves" is an error. What should be said, rather, is that "Electrons *move* like waves".

It appears to be correct *to take such analogies perfectly literally in so far as such analogical statements may have truth conditions (derivative from appropriate structural resemblances being in place)*. It may very well be true to say that the sodium and chlorine ions in solid salt are arranged in a similar way as cannonballs were once typically stacked – after Harriot's investigation, at Raleigh's request, of the most efficient way to do so – and oranges are still stacked by greengrocers (i.e. in a face-centred cubic manner).[11] On the other hand, it is clear that Cassius Clay neither floated like a butterfly nor stung like a bee.

The question now arises of how we should take talk of theoretical entities which are partially described in terms of (or assigned) observable properties, and partially described in terms of (or assigned) unobservable properties. (To simplify the discussion, let us forget, for the moment, about analogies.) Take electrons as a case in point, and accept for present purposes that the property of spin is an unobservable (as mass and charge are arguably not, particularly if these are understood as dispositional properties to attract and repel).[12] Should we take talk of electrons literally? Strictly speaking, the cognitive instrumentalist's answer lies in the negative. But the talk of something possessing discrete mass and charge (and therefore similar to the electron) may indeed be taken seriously; and some cognitive instrumentalists may accept that we have isolated such an entity, while believing that the talk of 'spin' is just a way to account for its behaviour in some circumstances. In short, the story is taken literally

[11] Harriot's thoughts about sphere stacking also encouraged him to think of atoms as spheres. See Shirley (1983: 242) and Hales (2000).
[12] Mass (as opposed to weight) is an interesting case. It is plausibly observable on several of the understandings covered by Jammer (1961).

enough for the possible existence of something similar to electrons to be acknowledged. Talk of 'spin', on the other hand, is taken to be a convenient fiction. It should be emphasised, however, that this need not be understood to be a fiction merely for explaining how observables interrelate. Rather, it may be taken by the cognitive instrumentalist to be a fiction for explaining how those things 'similar to electrons' behave.

It may be asked, given this, whether cognitive instrumentalism amounts to little more than entity realism (Hacking 1983). It does not, it should be emphasised, since it denies semantic realism, and furthermore denies that it is correct *in general* to believe in those entities appearing in the theories of contemporary mature science. It is an empirical question as to whether some entity is defined purely in terms of observable properties and/or by using analogies involving these (and observable objects).

Nor does cognitive instrumentalism entail structural realism, especially of an ontological variety with 'epistemic commitment to more than the empirical content of a scientific theory, namely to the 'structure' of the theory' (Ladyman 1998: 415), or structural empiricism (Bueno 1999) in so far as unobservable structures may not mirror observable structures.[13] Furthermore, cognitive instrumentalism is compatible with (but does not require) a syntactic view of theories, whereas structural realism arguably – according, for instance, to Ladyman (1998) – requires a semantic view.

4. Conclusion: On the Applicability of Cognitive Instrumentalism

This has been a brief outline of a new form of instrumentalism which is more moderate, and therefore considerably more defensible, than those that have gone before. I hope already to have shown that it is reasonable in principle, with reference (in particular) to the history of atomism. But the question remains as to whether it is reasonable in practice, given contemporary science. In closing, I will use a brief example from physics in order to argue that it is.

[13] The same goes for the new empiricist structuralism advocated by van Fraassen (2008), in so far as cognitive instrumentalism need not involve acceptance of van Fraassen's view of representation. See Giere (2009).

This concerns the virtual particles of quantum field theory (QFT), which *ex hypothesi* violate the relativistic equation for the total energy of an entity, $E^2 = p^2c^2 + m_0^2c^4$ (where p is momentum and m_0 is rest mass), due to considerations relating to uncertainty, and may even possess negative energies (and impart negative momentum). To a cognitive instrumentalist, however, talk of negative energy (and therefore virtual particles) will likely be taken to be non-literal in this context. The argument would run that the concept of energy is derived from, and explicable in terms of, observables such as velocity and mass. And in classical contexts, i.e. when employing the equation $E_k = ½pv$, negative kinetic energy is precluded (although it is, of course, possible to speak of negative potential energies since the zero-point may be arbitrarily defined). Now the cognitive instrumentalist would not object to understanding the notion of energy literally when this is *extended* into the unobservable realm in a way that is compatible with how it is applied in the observable realm. But this is inconsistent, arguably, with positing negative energies.[14]

The difference between the scientific realist and the cognitive instrumentalist is therefore brought into perspective by the Casimir effect – e.g. that two parallel uncharged metallic plates brought very close together in a vacuum experience an attractive force – which has recently been demonstrated in a number of experiments.[15] A full-blooded scientific realist will take this as evidence for the existence of virtual particles (and accept the explanation that only virtual particles with wavelengths that fit a whole number of times into the gap between two plates will appear there, whereas virtual particles with a broader range of wavelengths will appear outside). A cognitive instrumentalist will not, because she does not take talk of virtual photons literally.

[14] Moreover, the issue of negative energy need not be raised. Consider virtual photons, for example; it is possible for them to 'carry momentum but no energy' (Williams 1991: 15).
[15] See Lamoureaux (1997), Mohideen and Anushree (1998), and Bressi et al. (2002).

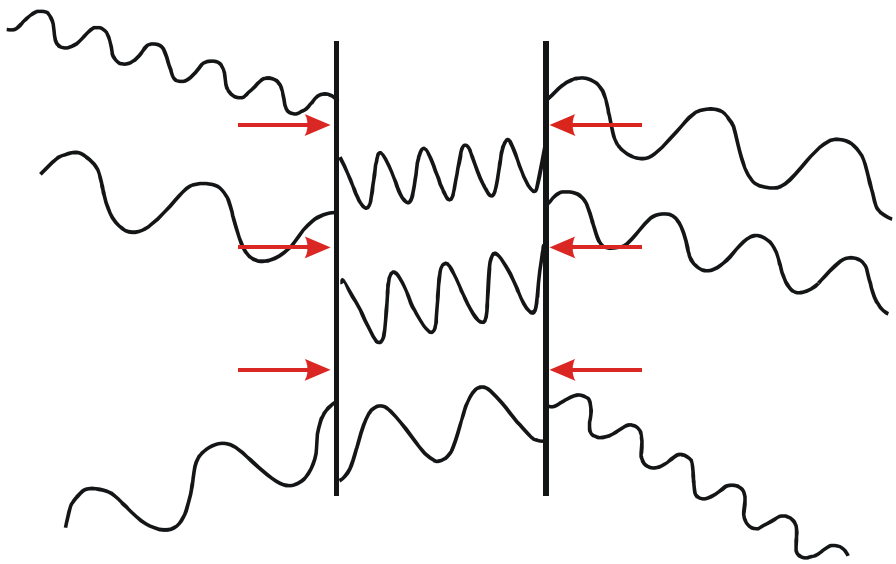

Fig. 1 – Depiction of the Casimir Effect in terms of Virtual Particles

It would also appear that a few physicists, at least, would agree with the cognitive instrumentalist stance on virtual particles. If one consults the website of the SLAC National Accelerator Laboratory, which is operated by Stanford University, one 'learns':

> Virtual particles are a language invented by physicists in order to talk about processes in terms of the Feynman diagrams. These diagrams are a shorthand for a calculation that gives the probability of the process... Particle physicists talk about these processes as if the particles exchanged in the intermediate stages of a diagram are actually there, but they are really only part of a quantum probability calculation. It is meaningless to argue whether they are or are not there, as they cannot be observed.[16]

I take virtual particles to be an interesting example because almost anyone adopting cognitive instrumentalism would agree that talk of these is not to be construed literally. And other examples from physics – such as quarks (which possess 'colour') and tachyons (which possess imaginary mass) – are possible. Nonetheless, it should be reiterated that cognitive instrumentalists may legitimately disagree with one another about what is an observable property (or allowable extrapolation thereof) or thing (in the context of an analogy).

[16] URL (accessed on 15/01/10): http://www2.slac.stanford.edu/vvc/theory/virtual.html

My aim in this paper was just to emphasize that instrumentalism is not as dead as one might think by looking at the contemporary literature on the realism debate. By learning from the failures of previous forms of radical instrumentalism and helping herself to tactics developed by constructive empiricists and others working in the empiricist tradition, the instrumentalist may adopt a more sophisticated and moderate position (namely cognitive instrumentalism).

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