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Measure is the Measure of All Things

Introduction

A recent item from the science news website of *Physics Today*[1] describes in readily accessible detail the plans to update the International System of Units of measurement (abbreviated "SI") so as to base those units on what are currently understood to be "universal constants" of nature. This is viewed as a very exciting development in the field of metrology (the study of measurement), as it ends reliance on supposedly "arbitrary" units (such as the official meter rods held in one of several designated repositories) and replaces them with the objectively "universal" and "absolute" physical constants of reality. This discussion paper will be devoted to explaining the preceding scare quotes, as well as a handful of others.

Units of measurement are the sorts of things that get embedded in a culture to such a degree that changing them is no mean feat, even when there are excellent reasons for doing so. Thus, the Imperial system that still holds hegemonic dominion over most metrical activities in the United States is like a drug resistant infection: it is downright pernicious, but nothing can seem to get rid of it. The analogy is not strictly fair, as Imperial units do, in fact, serve a great many measurement purposes, some of which even require a high degree of precision. But with only a few exceptions, such as scientific inquiry and maintaining Japanese cars, the metric system has made only a sprinkling of inroads against the Imperial in American life.

But that is not to say that the traditional metric system is a "perfect" "standard" either. (And yes, more scare quotes.) Platinum rods and titanium alloy cylinders[2] held in environmentally controlled vaults remain subject to the empirical vicissitudes of physical things. The new SI is intended to remove such variables by

1) For those who do not already know, *Physics Today* is a respected journal that is highlighted as "the flagship publication of the American Institute of Physics." The article may be found here: Andrew Grant, "Revamped SI measurement system approved," *Physics Today*, Politics and Policy, November 16, 2018, https://physicstoday.scitation.org/do/10.1063/PT.6.2.20181116a/full/.

2) The standard physical representatives of the meter and kilogram, respectively.

linking the extensive units of length and mass to fundamental constants of the universe. (The qualifier "extensive" will be explained momentarily.)

The technical skill and mathematical cleverness involved in developing the new SI is not to be underestimated; some of the challenges are glossed in the *Physics Today* article cited above. But amidst all the congratulations and celebratory cheer, I feel obliged to interject some philosophical observations which, while relatively substantive in (philosophical) content, are unlikely to sway the enthusiasm of metrologists to any notable degree. But in all fairness, the new SI units are equally unlikely to have much practical impact either, so you will not have to get a new set of socket wrenches for Christmas after all.

But the philosophical issues are worth pointing out on their own account. These break out into two generic trends that have been making themselves visible in the more abstract reaches of physics for some time now. The first of these is the habit of valorizing recondite theory over all else, most especially facts and evidence. This attitude, prominent among such "gate keepers" of physics as Stephen Hawking, Lawrence Krauss, and Brian Greene, is what I call "model centrism," a term that others are coming to adopt as well. The second generic tendency might be described as the elevation of absolutes over inquiry. While not strictly identical with model centrism, this attitude is certainly a fellow traveler with it.

My first step here will be to cover some background issues regarding the philosophical and "logical" issues regarding measurement. This will lead up to what I will call "the three impossibilities". I will conclude with some remarks on the bedazzlement of absolutes and what John Dewey called "the quest for certainty."

Background

One potential source of confusion that needs to be set aside immediately is my use of the words "logic" and "logical" throughout this essay. Persons with a background in American philosophy will be perfectly comfortable with my statement that I mean these words in the sense of Charles Sanders Peirce and Dewey as a shorthand for "the theory of inquiry." However, persons whose backgrounds focus on science or engineering disciplines (whether specific to metrology or not) are likely to be confused, even outraged, by my use of the term here. So some quick words are necessary on what it means to call logic "the theory of inquiry" ("ToI").

Jaakko Hintikka, one of the leading logicians of the twentieth century, makes the credible argument that the ToI approach to logic is at least as old as Aristotle.[3] But regardless of whether we accept that argument or not, it is clear from those American thinkers that ToI runs far beyond the purely abstract, formal conditions of what constitutes a "proof" or qualifies as a mathematical "model." These formal/mathematical systems, while they can be useful, remain mere adjuncts to ToI, adjuncts whose value is often mischaracterized by the very people who teach those subjects.[4] The short form of this (and using Hintikka's terminology) is that formal logic is *tactical*, not *strategic*; in my own words, it is *eliminative*, not *constructive*. Formal logic will show us what hypotheses *cannot* stand, not which ones inquiry *ought to* embrace (this latter being a "strategic" concern.) Notice the *modal* character of that "ought to"; it involves *possibility* and not just actuality. This will not be the only point at which modal concerns intersect with issues of measurement.

So what is the basis of ToI? Put simply, it is a refinement and generalization of the philosophy of science to take into account the full structure of rational inquiry, including those eliminative formal characteristics that

3) Jaakko Hintikka, *Inquiry as Inquiry* (Netherlands: Springer, 1999); especially chapter 1, "Is Logic the Key to All Good Reasoning?"

4) See, for example, Gary Herstein, "The Pedagogy of Logic," a paper delivered at the Midsouth Philosophy Conference, Rhodes College, February 21–22, 2014, Memphis TN, https://www.academia.edu/6685394/The_Pedagogy_of_Logic

enable us to narrow our choices of hypotheses to ones we can effectively test. The auto mechanic diagnosing your car, the computer tech running through lines of code, the medical doctor investigating your illness, are all *using the products* of science, but they are not (in fact) scientists nor are they doing science. ToI is bigger than science, it is about the full range of rational inquiry, and by all *traditional* standards of such things (i.e., prior to the fetishism of formalism) this is precisely what *logic* is about. Metrology involves a wide range of formal issues, but the problems I am raising here are fundamentally *logical* in nature.[5]

With regard to those logical issues, two areas that deserve to be highlighted are the physical facts, and the theoretical presuppositions. Attention to the physical facts draws out a pair of fallacies, one of which I name myself, and the other I follow Alfred North Whitehead in characterizing. The first (my own) I will characterize by the rather ugly title of "the fallacy of specious precisification." (I told you it was ugly.) The FSP (saves a lot of typing) is the notion that just because you generate a long string of numbers, you have actually generated that much control of a metrical situation. Thus, the "calculator" app on my computer will, upon command, present me with Pi rendered to 31 decimals to the right of the decimal point. Very impressive; very precise. Except that, regardless of how "accurate" it might be, it is utterly meaningless. My slide rule – and yes, I have a slide rule[6]: a 70 year old Keuffel & Esser log log duplex decitrig #4081 that I inherited from my father – only goes to the first two such digits, nothing but 3.14 … Yet, somehow, that is always enough. In confirming baseline figures the engineers at NASA needed no more to put men on the moon and return them safely to Earth. FSP is the delusion that if we just throw more and bigger numbers around, that proves we have a better grasp on matters. But one of the reasons why I love my K&E 4081 is precisely because I *can and do grasp it*; I literally hold it in my hands. A few extra digits were necessary for things like, say, sending the Voyager spacecraft out past Jupiter and Saturn. But the digits of our calculators generally exceed the accuracy of our instruments. And we are, on the basis of our calculators rather than our instruments, imagining that our grasp of reality is far greater than anything we can actually observe or test. This is the primary aspect of FSP that I wish to emphasize here.

The fallacy that Whitehead first described over 90 years ago is the one he called "the fallacy of misplaced concreteness" (FMC). In many respects, FSP is just a sub-species of FMC. This is because specious precisification is misplacing concreteness from the real facts in hand onto the extremely abstract notion of "calculator digits." More generally, the fallacy of FMC is taking that which is abstract, and treating it as concrete. The more you study contemporary physics, the more you see this fallacy trampling over everything in sight. One of the more egregious expressions of FMC is what I am calling "model centrism." This particular sin against rational inquiry will be making its appearances at multiple points in the following.

Among the theoretical aspects that need to be addressed are the presuppositions regarding the possibilities of comparison (because all extensive measurement is a comparison of a standard unit with some objective reality), and the attendant modal issues about what qualifies as a meaningful possibility. But a word on the preceding uses of the term "extensive" is necessary. The "extensive" in this context simply means any form of measurement that can be set in a simple, linear order, such as when one measures length with a ruler. But the reality being measured need not be strictly spatial in character. The measurement of weight, for example, also lines itself up in a linear order. Hence, as noted above, the forms of measurement that SI is focused upon are themselves all extensive in character, and what we say henceforth will focus on these types of measurement exclu-

5) For those with a taste for top caliber analytical philosophy, the previous Hintikka citation is certainly one of the "go-to" sources on this subject. But for a more general philosophical discussion, see: John Dewey, *Logic: The Theory of Inquiry, The Later Works of John Dewey, Volume 12, 1925–1953* (Carbondale: Southern Illinois University Press, 2008).

6) And I am not afraid to use it!

sively. As one might guess, there are kinds of measurement that are not extensive in nature (statistical measures, for example). But these are not relevant to our problem here, so I will not say anything about them.[7]

There are some other formal issues that are relevant here, which formed important elements in the natural philosophy[8] of Alfred North Whitehead.[9] These issues all come back to the comparison of extensive realities with standards of measurement. The comparison itself goes by the technical name of "conjugacy." When we make a measurement of this sort, it is the fundamental presupposition of our activity that the standard of measure and the thing measured can in some manner or other be made conjugate with one another; that is, lined up together and directly compared. For most purposes, this will involve proxies rather than the "real thing" when it comes to the measuring instrument. Thus, I do not remove the meter bar from its climate-controlled enclosure when I go to the hardware store, I simply take my tape measure and assume that all the intervening steps between my proxy and the "real thing" have been executed with an acceptable level of care. SI hopes to eliminate these proxies, because it makes the metaphysical assumption that the standards it has chosen are genuinely universal, certain, omnipresent, and unchangeable. The preceding language should already hint at some of the problems I will be enumerating below.

But one final step is needed, and that is to glance at the *modality* of conjugacy – that is, at the forms of *possibilities* of comparison, and most particularly, how we fail to notice or represent these in our discussions.

From his earliest mathematical writings (his *Treatise on Universal Algebra*) Whitehead recognized that any claim of equality, say "A = B", is always suppressing or ignoring a great deal of context. All such declarations of equality are made with respect to various other factors and considerations. If we are talking about numbers, then they must be the same *kinds* of numbers, operating within a common system of logically coherent inquiry; "A" from the natural numbers *cannot* be equal to *any* "B" from a non-standard model of arithmetic, even though they might appear to be similar in some superficial sense. Whitehead expanded this discussion in the third chapter of his *Principle of Relativity*, by schematizing "A = B" as "$A = B_{\gamma}$". The position of the subscript gamma is a bit misleading for, as Whitehead's discussion makes clear, the terms are gathered together thusly: $(A = B)_{\gamma}$. (In other words, the gamma operates on the entire formula, not just on B). A still better way of writing this would be: $A =_{\gamma} B$. This latter now makes it clear that the sense of equality that is functioning here is indexed by gamma, with such indexing running across possible contexts, models, or – what is rather unhappily and misleadingly referred to in modal logics – possible worlds.[10] This treatment clearly shows that equality – and conjugacy in measurement *is a form of equality* – is an intransigently *modal* concept, and not in the least bit ontologically innocent.

This shows that there are significant issues involved in the empirical processes of measurement which have been rather sanguinely trampled over in both practice and theory. It is known that modal logics can be

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7) For a detailed examination of the mathematical technicalities involved, see: David H. Krantz, et al., *Foundations of Measurement*, Volumes I–III, (New York: Dover Publications, 2006).

8) I am among what is currently a minority of scholars who prefers the term "natural philosophy" for the work Whitehead produced that is more commonly lumped under the heading of "philosophy of science." This is because Whitehead's focus is on the "nature of Nature," and the interest in the interpretation of science emerges from this.

9) Alfred North Whitehead, *The Principle of Relativity* (Cambridge: Cambridge University Press, 1922); chapter 3 in particular. It is worth noting that Whitehead was already addressing the relativity of "equality" in comparison in the earliest pages of his first major publication, his *A Treatise on Universal Algebra*. For more, see: Alfred North Whitehead, *A Treatise on Universal Algebra: With Applications*, Volume 1 (Cambridge: Cambridge University Press, 1898).

10) The reason this is unhappy and misleading is because some philosophers, in paroxysms of the metaphysical vapors, take this to literally mean there are ontologically real alternative "worlds" objectively "out there," rather than just dealing with the obvious fact that relations and possibilities are simply real, right here in *THIS* world. For an argument championing "relational realism," see: Randall Auxier and Gary Herstein, *The Quantum of Explanation: Whitehead's Radical Empiricism* (New York: Routledge, 2017).

radically undecidable, in the formal sense of computer science. This means that they can pose questions which cannot be answered by any computer or algorithm based method.[11] But all science, in order to be empirically meaningful, must ultimately be rooted in such computable methods, else it is simply declaring, in effect, "and then a miracle occurs"[12], and blithely skipping along as though nothing has happened.

These issues are hopefully sufficient to set up my discussion of the "three impossibilities," the particular problems I have in mind with regard to the recondite theoretical considerations that are giving us the updated SI. The three impossibilities are, then, (1) the impossibility of eliminating human error, (2) the impossibility of eliminating ambiguity, and (3) the impossibility of eliminating arbitrariness. I will deal with each in turn.

Impossibility 1 – Human Error

This impossibility is a variation on the old Latin homily, *quis custodiet ipsos custodes* (who watches the watchers themselves)? Stated simply, every instrument that is used to make a measurement is either used by, or calibrated by, human hands and eyes. There might be many layers in between the use and the human eye/hand action, but it is never "turtles all the way down"; at the base there is always one or more persons eyeballing a needle on a gauge, and tweaking a dial by hand. The existence of digital instruments is not a counter-example to this; the world, being hopelessly analog, must first be given an analog measure to which the digital representation is always and only an approximation.

Now, these facts do not preclude the refinement of either the standards or the practices of measurement; The Navy, for example works with significantly more subtle units of measurement these days than just and only a cubit. The point, rather, is that *no amount of progressive improvement is capable – in theory, much less in practical fact – of eliminating the human element* that is the absolute *sine qua non* of any act of measurement. Because at the end of all the intervening layers that have masked the original fact of human hands and human eyes, we are still brought back to *the fact* that human hands and eyes – to say nothing of interpretations and attitudes – are involved at every level in generating the long string of decimals that the instruments have produced. Progressive efforts can – hopefully! – minimize such sources of error, but they can never *eliminate* them.

Those interpretations and attitudes are currently being shaped – to a significant, if not overwhelming degree – by what I am calling "model centrism." Model centrism is the attitude (most frequently evinced in high-level theoretical physics these days) that valorizes theory to the point of dismissing empirical evidence and testability as essentially irrelevant.[13] In the case of SI and metrology, this is expressed by the legislative dismissal of the modalities of human choice, and the facts of direct human activity, in the presumed establishment of these "objective" standards of measurement.

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11) Patrick Blackburn, Maarten de Rijke, and Yde Venema, *Modal Logic* (Cambridge: Cambridge University Press, 2002); especially chapter 6.

12) With acknowledgments and apologies to Sid Harris, specifically his famous one, "And then a miracle occurs." His cartoons can be found here: "Index," *Science Cartoons Plus*, http://sciencecartoonsplus.com/index.php, accessed November 29, 2018. I am arguing we should at least be more aware of, if not more explicit, in "step two."

13) See: Auxier and Herstein, *The Quantum of Explanation*; especially chapter 10. For a more strictly scientific view see: Peter Woit, *Not Even Wrong: The Failure of String Theory and the Search for Unity in Physical Law* (New York: Basic Books, 2006). Woit does not use the term "model centric," but that is clearly the attitude he is criticizing.

Impossibility 2 – Eliminating Ambiguity

An unspoken, but otherwise unqualified assertion of model centrism is that theory makes everything "clear." And in certain narrowly specified mathematical senses this is true. Problems only arise when some measure of empirical adequacy and narrative intelligibility are allowed to stake any claims as to the real scope of human understanding. This is why empirical adequacy is so scornfully disdained by the model centrists: it muddies everything up with recalcitrant facts that decline to be shoe-horned into anyone's dogma. (Meanwhile, narrative intelligibility is ignored wholesale, even by most philosophers.[14])

This is one of the points where FSP so rabidly dogs our steps. Long strings of digits do not necessarily eliminate ambiguity; in fact, they can increase it by masking it. Model centrism, with its imposing spectacle of clever and recondite mathematics, makes the problem worse by dismissing those lines of data that do not cooperatively stuff themselves into their preassigned pigeon holes. The issue that arises here goes by various names, but I like the term "data density."

Model centrism only takes serious hold where the available data is quite "thin." Thus, for example, the physicist Michael Disney has shown that, in the Standard Model of Gravitational Cosmology (SMGC), there are more free parameters built into the model than there are independent observations to test those parameters.[15] Thus, whatever happens, SMGC is "miraculously" "confirmed." Compare this with contemporary climate science, where the data is so rich and dense that it threatens to overwhelm one. Model centrism gains no toe-hold against such a tsunami of independent observations, along so many independent threads of evidence. It is this density of data that supports the theoretical aspects of the science of climate change, just as it is the absence of such density the makes the mathematically clever superstructure of SMGC so frustratingly vacuous. In addition, it is worth noting that there are well formulated, peer-reviewed alternatives to SMGC. But these alternatives are held to a different standard than SMGC, in that should they deviate from the observed evidence in the slightest, they are rejected wholesale, whereas SMGC can (and has!) suffer catastrophic failures, and all that is done is a new free parameter is added to the theory to mathematically erase the observed deviations and falsifications.

These and other challenges to the orthodoxy completely undermine the supposed elimination of ambiguity, because the theoretical bases of such elimination are themselves far from being the unambiguous rocks they are presented as being. Even if these other interpretations are categorically rejected, the lack of data density means they cannot be excluded on purely scientific bases. Thus, much of the attractiveness of general relativity (for example) is purely *aesthetic* in character, which includes the notion that it is "simpler" than most or all of the alternatives. But, of course, "simplicity" is itself a complex, contextually sensitive matter, rather than a "given objective fact." (Indeed, those contextual aspects mean that it takes on some of its own *modal* characteristics; this is yet another item that gets packed into the subscript gamma discussed above.) Thus, the "disambiguation" of SI is forced, not found; it is achieved, borrowing Russell's phrase, through theft rather than honest toil.

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14) See: Auxier and Herstein, *The Quantum of* Explanation. The forms of human understanding – logical coherence, empirical adequacy, and narrative intelligibility – are discussed at length throughout.

15) Michael Disney, "Doubts About Big Bang Cosmology," *Aspects of Today's Cosmology*, ed. Antonio Alfonso-Faus (London: IntechOpen, 2011), ISBN: 978-953-307-626-3, http://www.intechopen.com/books/aspects-of-today-s-cosmology/doubts-about-big-bang-cosmology.

Impossibility 3 – Eliminating Arbitrariness

The problems here bear an obvious connection to those relating to ambiguity, but can be usefully employed to highlight a different range of factors. In particular, more needs to be said about the "universal" constants that are held up as eliminating the "arbitrariness" from our standards of measurement. First, however, a few words need to be said about the idea of arbitrariness itself.

The term "arbitrary" is often – even generally – used to mean something like "random," or "based on no reason." But even the old Imperial system is not really "arbitrary" in this sense. Stories about the origination of units such as the inch or the foot – the distance between knuckles on the king's hand; the size of his (evidently large) foot – might not be especially *good* reasons, but given the standing of the ruler (get it, "ruler"?) in European society, they are still reasons. The same is true with other, traditional units (the above mentioned cubit, for example.) These are not the products of an *arbitrary* roll of the dice, they are the rationalized standards of the human practices of their culture and day. So the issue with SI is not one of reason vs. unreason, it is one of better vs. lesser *reasons*. The SI enthusiasts often lose sight of this important distinction, if they are even aware of it, as is made obvious by their rhetorical use of the term "arbitrary".

As for "universal" constants … Well, speaking of arbitrariness, notice that we have *no possible evidence* for the *ex cathedra* declaration that our current list of constants are "universal." The only region of the universe for which we have any manner of "direct" measurement is just and only our own solar system; it has only been in the last year or so that the Voyager spacecraft has officially traveled beyond those boundaries, determined by the interface where interstellar forces finally exceed those from our own sun. Every measurement – including that of the speed of light[16] – have, of necessity, been painfully *local* in nature. The supposed "universal" character of things like the speed of light or the gravitational constant are *assumed* to be "universal," and that assumption is then superimposed, *ipse dixit*, upon such observational evidence as we possess.[17]

Notable among the few who actually recognized this assumption, both for what it is and for the necessity of making it, was Alfred North Whitehead. This came in the form of Whitehead's challenge to Einstein's general theory of relativity, and the metaphysical assumptions incorporated therein. You see, Einstein's theory collapsed the (necessarily uniform!) relations of geometry into the inescapably contingent and empirical facts of physical forces, presented as such in his famous metrical tensor "$g_{\mu\nu}$". Whitehead recognized that this rendered the very possibility of cosmological measurement meaningless, as conjugacy depends upon uniformity; Whitehead argued against it on both philosophical and mathematically robust scientific grounds.[18]

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16) A list of examples of scientific research into the possibility of the variability of the speed of light, the search link below (verified 12/01/2018). This list focuses exclusively on articles with the words "variable" "speed" "light" in the title, published by the physicist John Moffat, from the scientific preprint service arXiv.org. Less specific search terms will produce vastly more research articles. https://arxiv.org/search/advanced?advanced=1&terms-0-operator=AND&terms-0-term=variable+light+speed&terms-0-field=title&terms-1-operator=AND&terms-1-term=moffat&terms-1-field=author&classification-physics_archives=all&date-filter_by=all_dates&date-year=&date-from_date=&date-to_date=&date-date_type=submitted_date&abstracts=show&size=50&order=-announced_date_first

17) By the bye, the assumption of the universality of the gravitational constant, as measured here on Earth, led to the *catastrophic falsification* of general relativity when applied to the observational evidence of distant galaxies: the structure and rotation of those galaxies, on the assumption of that constancy, demonstrated that Einstein's general theory of relativity *must be wrong*. Rather than face this option, gravitational cosmologists fabricated the conveniently undetectable factor of "dark matter" to preserve the theory from the evidence. For details, see: Auxier and Herstein, *The Quantum of Explanation*.

18) Besides Whitehead's original argument, cited above, details can be found in: Gary Herstein, *The Measurement Problem of Cosmology* (Ontos-Verlag: Frankfurt, 2006).

Notice once again that there is nothing *mathematically* deficient in general relativity or the SMGC that is built upon it. Whitehead's (and my) criticisms are directed at the *logical* foundations, at the assumptions that remain all but entirely implicit in those theories.

Moreover, questions as to the "universality" of these "constants" not only have a spatial character, but a temporal one as well. Because notice how it is not only assumed that these "constants" are identical and unchangeable across space, but that they are equally immutable across time: never changing, never evolving. The two assumptions are independent. The "constants" might be "universally" constant across space, yet evolve with time. This still means that when we look at, say, a quasar that is 2 billion light years away, we are looking at a phenomenon that was governed by constants that are (to us) 2 billion years old. At the risk of straining the limitations of euphemism, this is problematic for our cosmological pronouncements.

Here, once again, model centrism rears its smug head to brush aside criticisms, whether they are directed at the empirical vacuity of the cherished theory, or the metaphysical assumptions which the model centrists deny even exist. The truth of the matter is, there is nothing wrong *per se* with the universality and uniformity assumptions at the root of SMGC and other abstract physical theories. The problem arises when these assumptions are not acknowledged *for* what they are, *as* what they are. Model centrists not only eschew, they adamantly damn any notion of such acknowledgment, for to do so would undermine the absolute standing of the cherished model. This brings us to our final section.

The Quest For Certainty

The above phrase comes, of course, from John Dewey's rightfully famous book of the same title. The book was based upon Dewey's Gifford lectures and published in 1929. Thirty years later, no less a hard-nosed analytic philosopher than Herbert Feigl could state, without qualification or apology, in his introduction to one of the Minnesota Studies in the Philosophy of Science that, "the quest for absolute certainty is a childish, if not infantile trait of mind." It would seem, at least to some, superficial considerations, that the stake had been driven through the heart of that vampire, and good riddance to it. But sadly, it has re-emerged (what decent vampire movie ever allowed the monster to be genuinely destroyed?) in the form of model centrism. This is unsurprising, considering that the gatekeepers – people like Stephen Hawking, Lawrence Krauss, Neil DeGrasse Tyson – express contempt and vituperation so thick and so dense for the mere thought of learning anything about the philosophical bases of their own enterprise, that one could easily set the foundations of a tall building in it.

Science does not truck in certainties, but model centrists do. This is incredibly unfortunate since model centrists tend to be among the noisiest of persons nominally popularizing science. The model centrists are *not* popularizing *science*, of course; they are only ever popularizing their cherished *models*. Science – *real* science – is not a list of empirically vacuous "conclusions," but a mode of refined inquiry. It is, as such, the paradigm of what I have been calling "logic" in this article. But inquiry – logically valid inquiry – acknowledges the context in which it operates. This rather naturally brings us to that line of philosophy known as "pragmatism."

One of the stand-out features of pragmatism is its emphasis on *methods of inquiry* over putatively "completed results." In this regard, it is at the opposite end of the spectrum from model centrism. But for our purposes here, pragmatism is of interest not only for its critique of the "quest", but also for its attitude toward possibilities and its insistence upon a refined sensitivity to context. Both of these latter factors relate directly to the problems of metrology, and the underlying assumptions of SI. The pragmatists attitude toward possibility was generally not stated in so explicit a fashion as I am going to state it here, but it is pretty clear that the classical ones were "relational realists"; that is, relations are *real* in their own right, and not a mere short-hand form

of discourse in which relations are exclusively parasitic upon actualities. This is a consequence of James' "radical empiricism," which Dewey certainly accepted (albeit, by different names.) These relations, in turn, include *relations of possibility* (the *modal* frame in which measurement occurs) which, together with other aspects of context sensitivity, has been the foundation of our challenges to the sanguine assumptions of SI. Thus, despite the numerous references to Whitehead above, the foregoing can be viewed as a pragmatist critique of model centrism generally, and of SI in particular.[19]

Model centrism ultimately involves a kind of essentialism that currently infects SI as well; there is nothing necessary about this latter, though it does seem inevitable with the former. Model centrism valorizes recondite theory to an absolute degree, as a kind of "Truth" which is hailed as the genuine heart of reality, all with little or no concern for empirical evidence. Such a move as this is one that any marginally adequate pragmatist or Whiteheadian will reject out of hand. SI – as it *currently tends to be discussed* – ends up positioned in the model centrist camp, but there is no reason why this should happen beyond sloppy philosophy that doesn't even acknowledge itself as philosophy, much less sloppy.[20] If one takes the logical issues raised above seriously – both the formal, modal ones, and the more generic, inquiriential matters as well – then there is nothing fundamentally wrong with the SI program *per se*.

Thus, assumptions of uniformity – which are, at base, the root of the possibility of conjugacy as well as any discussion of "universal constants" – are perfectly reasonable things to make as long as one is clear that they are *operational hypotheses*, and not (as the model centrists do) "divine revelations" that exist beyond the possibility of empirical test. The changes argued for in this paper are in many ways rhetorical in nature. But the rhetoric we use in *talking* about things reflects and reinforces our habits of *thinking* about those things. Model centrism is enabled by habits of talking that disdain the contingencies and provisional realities of our inquiries in favor of mathematically clever models. This is the essentialism I mentioned earlier, and it has no place in the SI revision of metrical standards. When they are placed upon logically sustainable grounds of *pragmatically* validated empirical inquiry.

19) Whitehead, for his part, also embraced James' radical empiricism. However, Whitehead's position became infinitely richer than James' original stand, because Whitehead the mathematician had a vastly deeper grasp of the forms and kinds of relations that are possible. For more details, see: Auxier and Herstein, *The Quantum of Explanation*.

20) Ibid., chapter 10.