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### Epistemological Considerations Underpinning Spacetime Geometry

The purpose of this paper is to address the epistemological issues that arise when addressing the question of what type of geometry describes spacetime (including a brief discussion of "coordination principles" and related ideas). In particular, I will call into question the pervasive attitude that spacetime is an actual "thing" or ether that material is stuck to, like points on graph-paper. Further, there is a question of whether spacetime geometry is a matter of convention (as against being a non-optional matter of fact). To discuss these issues, it is first necessary to discuss a few basic issues in epistemology.

#### **Epistemology, generally**

I believe that to make any headway, it is necessary to dispense with the analytic-synthetic dichotomy and to clarify issues of context when discussing the a priori versus the a posteriori. These matters muddy the waters when discussing whether spacetime geometry is a matter of convention. But before discussing them, I need to first give a general sketch of my view of the nature of knowledge.

Consciousness--or awareness--is not a thing, but an action, and its two fundamental modes are differentiation and integration. Although perception is based on sensation, which we ultimately organize into concepts, epistemologically, the base of *knowledge* is perceptual data.

In this context, I take sensations to be the raw data (i.e., electrical impulses) provided by the sense organs to the brain. Through various automatic processes, the brain organizes a stream of sensations into perception, which differentiates sensory elements into discrete concretes. Take, for example, vision: the sense data that flows into the brain from the sense organs is a stream of colors and shapes. The brain automatically organizes these into discrete entities, such as chairs, tables, laptops, and books (although our identification of those things as chairs, tables, laptops, and books comes at a later stage of awareness).

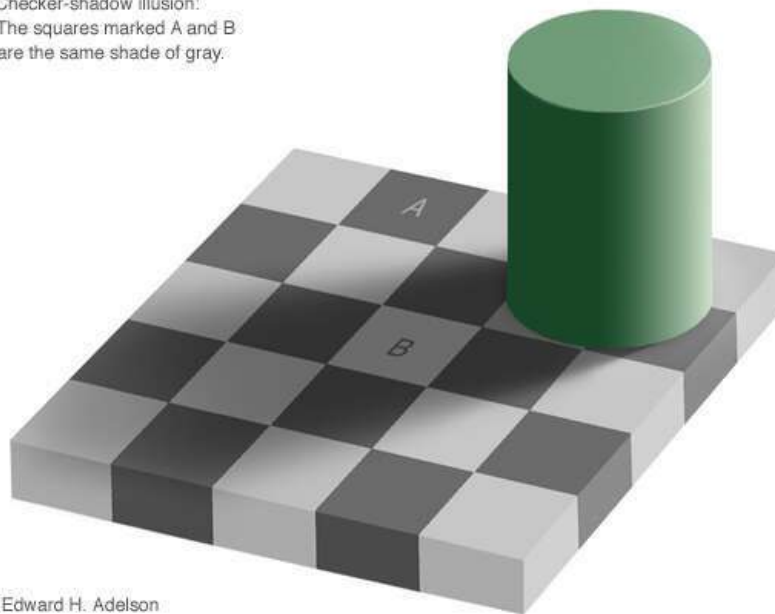
Thus far, the process has been entirely automatic. The point is that as such, senses and perception are incapable of distorting reality: they merely present the facts of reality from a certain perspective. (That is, perception gives part of the data about the entities perceived--but it is real data all the same.) Contra Kant, there are no "things in themselves" apart from how we perceive them. We perceive *actual* facts about objects--viz., properties of the objects combined with the facts of perception. Indeed, this takes perception squarely outside the realm of the subjective (that consciousness invents facts) *and* the intrinsic (that consciousness is a passive state of gaining insight into "things in themselves", like Plato's Forms). Excluding these two views, all that is left is that perception, properly understood, serves as the basis of an *objective* epistemology: that consciousness is a this-worldly, factual phenomenon that grasps actual facts, albeit in a human frame. Emphatically, the facts are *not* "distorted". Having "merely" a human perspective on the facts doesn't make it any less genuine knowledge of those facts.

I anticipate several possible misunderstandings about perception, but before addressing them, I first want to outline three stages of awareness. At the most basic level, we are aware only of things (corresponding to the implicit concept "entity"). Next, we are aware of *different* things

within our perceptual field, based on perceptually-identifiable differences (corresponding to the implicit concept "identity"). For example, we are aware that the blue ball is different from the red ball--although again, our identification of these entities as blue or red or balls comes at a later stage (the next one). Finally, we grasp the relationships among entities by grasping the differences *and similarities* of their identities. This leads to the implicit concept "unit", which I will discuss after a few polemics.

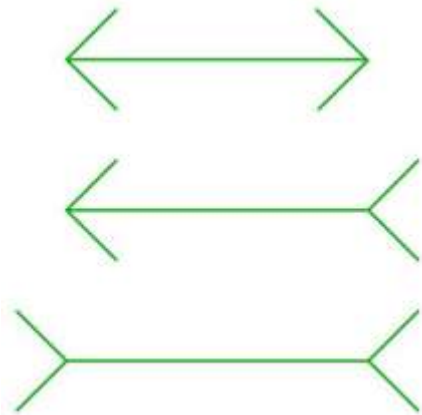
It is often suggested--especially in arguments against the reliability of perception--that the fact of being "tricked" by various optical illusions shows that perception is fallible and unreliable. There are two errors here: First, in cases of illusions, *perception* is not the faculty in error. Instead, the (more) sophisticated, conceptual faculty is in error. Second, if the conclusion is that therefore perception is unreliable, just how is it that its unreliability is established? By means of more perception? This is plainly an untenable position. What follows are a few examples:

Checker-shadow illusion:  
The squares marked A and B  
are the same shade of gray.

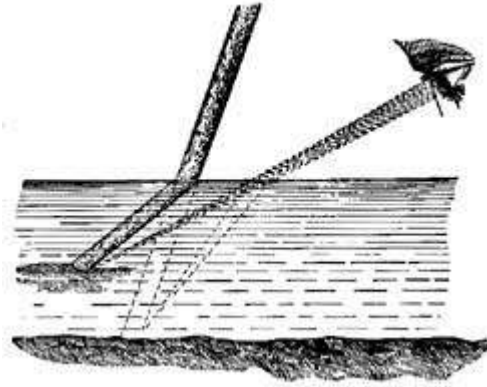


Edward H. Adelson

One would swear that the squares marked "A" and "B" are different shades--and that this is evidence of perceptual distortion of reality. But perception's difference-detection mechanism relies on differences occurring within a common context. What make "A" and "B" seem different is precisely their different contexts (the shading surrounding them), which becomes clear when they are directly juxtaposed, and we can verify, *perceptually*, that they are indeed the same shade.



In this illusion, the lines appear to be of different lengths--but again, this is a function of their differing contexts (the "in-ness" and "out-ness" of the arrowed lines). When the arrowed lines are removed, bringing the lines into a common context, their equivalence is again *perceptually* apparent.



Finally, there is the example of how a stick partially submerged in water will appear bent, even though "in reality", it is straight. Again we see the same contradiction as above: that a perceptual verification is supposed to undermine the reliability of perception. What this particular example illustrates, though, is that perception does not tell us that the stick is bent or straight: that is a *conceptual* identification. Perception gives us shape-of-this-stick-in-water, not the shape of the stick in an alternative context.

Another common argument levied against perception references hallucinations, claiming that because they do not correspond to entities in reality, perception *can* be a tool of distortion--and therefore we cannot necessarily trust perception. This argument suffers from the same contradiction as the optical illusions: the fact that some things are or can be hallucinations is established by reference to known, non-hallucinating states. If perception is unreliable, then it would be impossible to establish hallucination and the unreliability of perception in the first place.

Finally, there is the argument from (what I believe is a misunderstanding of) quantum mechanics: perception is not a tool of perceiving reality because the *act* of observation affects that which is being observed--and therefore perception "invents" reality. In a sense, this is true:

the sense organs and the brain are entities taking actions in reality, and everything in reality affects everything else (even if only in the trivial sense of exerting a gravitational force). But it is not the case that perception is therefore "inventing" reality. The fact that the steps of perception can affect the object of perception (and only through specific physical means) is a separate issue from whether awareness *as such* makes things what they are.

We now return to the implicit concept "unit". When we see that two existents are similar as against a third--say, for example, two chairs versus a table (though, again, forming the concepts "chair" and "table" come later)--we begin to focus on a specific attribute (in our example, shape). We then differentiate based on differences (between the chairs and the tables) and integrate based on similarity (of the chairs *as against* the table), ultimately regarding each of the chairs as a unit of the group of chairs.

In this context, "unit" refers to a single existent regarded as a distinct element of a group of similar existents. It is this unit-perspective that gets us to the conceptual level. And just as with perception, there is nothing inherently distorting or arbitrary about this human perspective: it is a recognition of a certain relationship among existents according to their *actual* characteristics.

Finally, the last topic before taking on the analytic-synthetic dichotomy and the a priori versus the a posteriori is measurement. The role of measurement in concept-formation is a much broader discussion than is appropriate here, but establishing the basics of measurement is critical to our final discussion of the geometry of spacetime.

Measurement is a mode of consciousness: establishing a relationship between existents. It is an action, not an attribute (of a particular existent). A book, for instance, does not have a

measurement on its own (although we may foreshorten our speech and say "The book's measurements..."). The book has certain attributes, and the conscious process of measurement relates those attributes, like weight, to some other existent that serves as a standard.

The standard is itself a unit in the sense above, but, as a standard, inherits a second meaning of the term "unit"--one that we are more accustomed to in mathematics and the sciences. For instance, the unit for measuring the weight of the book might be the pound, which is based on defining some specific existent as representing "the pound", and using it (or its equivalents) for future comparisons.

There are two important points here: First, this is exactly the case of something being a convention. We could instead have used the metric system. But there is a limit to the optionality (and this again entails a broader discussion of the role of measurement in concept formation not appropriate here): when performing measurements, we need a standard appropriate to the perceptual range, so measuring the weight of a book in solar masses will not do. (Although, once measurements in the perceptual range are established, we can eventually relate them to macro- and micro-scales, and *express* the weight-measurement of a book in terms of solar masses.)

The second point is more crucial: if a measurement is made (i.e., relating two existents), it is improper to say something like "Well, this table measures five feet and two inches across by this ruler, but what is it *really*?" The implication of such objections is that measurements give only an approximation, not an exact account of the attributes of the object measured. Although it is true that by using more sophisticated measuring standards (e.g., using an electron microscope instead of a ruler), one can make a more *precise* measurement (in the sense of having more data), both measurements by a ruler and by an electron microscope are *exact*: they yield real, actual

data *within their context* about the relationship between the ruler and the table in one case and the electron microscope and the table in the other. Measurement implies a method of measurement, so when it is specified that an existent measures some amount by some specific means, that is absolute correspondence to reality: it is an exact statement of one existent's attributes as related to another's. To continue with our example of ruler-based measurement--the statement that the table is five feet and two inches is specifying a *range*: at the outside, that the table is no fewer than five feet and one inch, and no more than five feet and three inches.

Although there is much more to be said (that is not appropriate here), we have now laid the groundwork for concepts: they are a (human) mind's way of organizing the data provided perceptually, according to the unit-perspective, using the process of measurement to establish grouping. And like perception, it is now possible to establish concepts as objective: they are not a matter of subjective fiat, nor do they exist (intrinsically) in reality, apart from a human consciousness. Instead, they represent a factual, *real* knowledge of existents as they really are in reality.

### **The analytic-synthetic dichotomy and the a priori versus the a posteriori**

My goal here is to "clear the air" before talking about "principles of coordination" and what epistemological status they hold--in preparation for ultimately discussing spacetime geometry. I don't intend to give a full refutation of the dichotomy, but only to sketch out why I think it is false based on the principles I've articulated thus far. (I will not be giving an account of what the dichotomy is.) The reason that it is necessary to dispense with the dichotomy is that it

destroys the possibility of knowledge: analytic truths, being the product of arbitrary groupings and intuitions of essentials, are held to be self-contained and to not correspond to reality.

Synthetic truths are held to be unreliable because, unlike "necessary" analytic truths, they are "contingent", and therefore uncertain.

At a basic level, the dichotomy is false because it is built upon an incorrect view of concepts. Specifically, the dichotomy equates a concept with its definition. An example of this error would be to say that a "man" is not an entity that possesses all the characteristics that men possess, including, for instance, only two eyes, but is only the specification of the genus and species, "rational animal". There is much more to be said about just what a definition is (and some I will have to declare by fiat for brevity's sake), but the point is that the concept "man" is everything about men, whereas the definition is only a specification of what's necessary to retain the concept in a dealable-with form (which depends on one's context of knowledge). On my view, then, "Man is a rational animal", is both analytic and synthetic: analytic because being a rational animal is part of the concept "man", and synthetic because one comes to know such a thing through experience. (Consider: a child has the concept man--he understands the concept's referents in reality--but given his elementary context, he doesn't hold the concept by the definition "rational animal".) Further, I would argue that the statement is not "contingent", but I'll leave that aside--my argument is implicit from the above section on epistemology generally. Similarly, "Man has only two eyes" is also both analytic and synthetic: analytic because having only two eyes is part of the concept "man" (remembering the context of possible biological deformities), and synthetic because one comes to know such a thing through experience. A problem with exponents of the dichotomy is that they ultimately have to intuit just what gets to

be part of the concept, since they have no rational (i.e., reality-based) means of discovering a concept's essence (again, a topic outside the scope of this paper). Is a "triangle" a "closed, plane figure consisting of three straight lines" or is it "a figure composed of straight lines whose interior angles sum to 180 degrees"? My answer is that it's all of these and more--with the definition being a separate, more sophisticated issue.

There is much more that can be said about the problems with the dichotomy, like the false (!) distinction between a falsehood and a self-contradiction, the empirical "versus" the logical, and more about necessity and contingency. But at this point, let us turn our attention to the a priori versus the a posteriori.

By the nature of the terms, they imply a relationship: that knowledge comes before or after something. That something is experience, but what experience precisely is often ignored. On my view, perception serves as the base of knowledge, and as such, no knowledge is possible before experience of *some* kind. Since knowledge is knowledge of reality, a mind without the means of perceiving reality cannot have knowledge (of it). Some axiomatic concepts are (at least) implicitly grasped almost immediately, such as existence, identity, and consciousness (the last of which I haven't discussed), but grasping them even implicitly, as described above, requires perception of some existent with some identity.

This completely throws out the idea of a priori knowledge. Indeed, even the rules of deductive logic are grasped through observing (i.e., perceiving) causality in reality--no matter how much intuitive sense these rules make. Symbolic logic requires that the symbols be abstracted away from some actual datum--some real observation in reality. Similarly, arithmetic depends on devising a number system based on actually counting things in reality.

(There are other senses of "a priori" that I will not treat here, like whether I have "a priori" knowledge that the sun will rise tomorrow, since I have not yet experienced it.)

## **Coordination principles**

To correct, on my view, others' ideas about "coordination principles", I believe that these axiomatic concepts (and their immediate corollaries, like the law of non-contradiction) are the only valid coordination principles that we need to "get off the ground". The rest is merely engaging in more perception and building knowledge upon knowledge and abstractions upon abstractions. When, for instance, Reichenbach and others conflate into "coordinating principles" genuine issues of convention in selecting a standard for measurement, actual axiomatic concepts, and high-level abstractions regarding spacetime geometry (e.g., "spacetime is Euclidean"), they muddy the issue, making it impossible to discuss it with any clarity.

If coordination principles are needed to "get off the ground", then spacetime being Euclidean was not a coordination principle relied on (correctly or not) by Newton in devising his mechanics. Although Newton was mistaken in his views on the nature of space and time (yet another topic I'll set aside), these views are not relevant to the truth of his physics. Although he implicitly used a Euclidean geometry (not that there was an alternative in his time), that is a function of the types of measurements he was able to make--and therefore in the context he made them, they were correct. (Imagine here, Euclidean geometry to be the analog of a ruler, with a more sophisticated understanding of General Relativity to be like the electron microscope.) That a Euclidean geometry seems to arise out of his physics is *not* a statement about the ultimate

structure of spacetime. Inductively, his theory only extended to that class of observations that he made (that is, including neither the super-galactic nor the microscopic). His physics certainly didn't imply "And gosh darn it, spacetime is absolutely Euclidean everywhere, under all circumstances, always", even if he himself explicitly held an incorrect view. (This is related to a philosophic issue of what we actually mean when making scientific claims--a topic again outside the scope of this paper. For instance, on my view, when we say "Swans are white", we are *not* implying "All swans are white" or "There are no black swans". This is a matter of keeping the context of one's knowledge...)

Coordination principles as conventions for measurement, like using meters or feet, are more properly designated by a term like "unit convention". Although there is a coordination involved, the former term introduces too much ambiguity.

### **The geometry of spacetime**

Finally, we can discuss the geometry of spacetime directly. There are two main issues I'd like to address: first, the treatment of spacetime as an existent, and second, whether spacetime geometry is a matter of fact or of convention. However, my discussion of the former implies an answer to the latter.

Space is a void--which is a bizarre thing to say, because a void is not *something* to be. So perhaps a better formulation would be "space isn't anything". "Nothing" can't have a geometry. Something lacking substance cannot have form--and isn't a something anyway. All that exists are entities. So a proper understanding of the concept of spacetime geometry would be as an

intermediary concept (a concept of method) describing the relationships among existents. Let us take an analogy: the imaginary number  $i$  has no referents in reality. It is not a concept about some existent, but rather an intermediary mathematical concept used to describe relationships between existents that really do exist. Similarly, spacetime geometry is not the shape of some grand graph-paper onto which existents are stuck. It is therefore inappropriate to discuss spacetime geometry without keeping the context that it is ultimately a method of relating (measuring) existents. And although General Relativity provides us with equations to describe this intermediary "landscape", to apply those equations to a situation where there are no existents is arbitrary speculation--or worse. Not only is it irrelevant what the geometry of spacetime "would" be if there were nothing in the universe, but spacetime does not have an identity apart from the existents it relates--it is not itself an existent! Moreover, given that the equations were induced from the context of there being existents, it is not clear that the equation can straightforwardly be imported into such a radically different context.

Clearly, this implies that as a method of measuring actual relationships among existents, spacetime geometry is not a mere matter of convention. Gravity wells caused by massive objects are not analogous to choosing between feet and meters. However, just as one context may demand an electron microscope while another demands only a ruler, measurement of the relationships between existents may demand the full complexity of General Relativity in one context and the relatively simpler Euclidean geometry in another. And as discussed above, both are exact and accurate within their respective contexts. That is why we cannot ask "Well, yes, spacetime *seems* Euclidean in this room, but what is it *really*?"

And even if I am wrong in my relatively unsophisticated state of knowledge of physics and cosmology, and it turns out that space is not a void, but instead is some sort of ether for existents, that would imply that it has a specific, knowable identity, and we could drop the ruler / electron microscope analogy, saying plainly that it is the graph-paper that serves as the standard for measuring relationships among existents.

To conclude, I'll just reiterate that on my view, the geometry of spacetime (whether as an existent or a concept of method) does not constitute a coordinating principle in any rational sense of the term. And moreover, spacetime geometry cannot be a matter of mere convention: it is a description of actual relationships among existents.