Reconciling Newtonian and Simonian Concepts of Space: Some questions for Dr. Downes

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Abstract

This brief note summarises and expands Downes’ (2006) contribution in this journal. I argue Downes’ conclusions emanate from a misunderstanding of Newtonian physics and it’s relationship to Simon and Newell’s ideas in several key aspects, and pose some questions for Dr. Downes to test if this is, indeed, the case.

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1. Summary of Downes’ Argument

Downes (2006) presents a reinterpretation of Newell and Simon’s assumptions about space used in their attempts to build a workable model for cognitive science. Downes criticises Newell and Simon’s approach as depending on an unexamined assumption of the absolute (i.e., Newtonian) space through which problem solvers search. The space is said to be flat, non-interactive and dull, a background or bow against, or in which, objects in the space can be searched, operated upon somehow, and changed, perhaps into solutions for Simon’s ‘problem solvers’, perhaps not.

The assumption by Newell and Simon of a non-interactive (as Downes describes it) search space is at the core of the paper. By Downes’ lights, in importing concepts such as the absolute Newtonian space from physics into cognitive science wholesale, Newell and Simon are guilty of introducing an unexamined and wholly unjustified further dimension into their models, and Downes calls for this dimension to be explored.

The implications for implicitly assuming a Newtonian (that is, strictly Euclidean and/or geometric) state space is a lock on the type of causality one can attribute, and the loss of action-at-a-distance type relationships in cognitive science (ibid, pg. 46). Physical and hypothetical spaces have to be kept separate, creating an unnecessary mind-body problem in the Simonian theory of mind. The consequences of this are two fold.
First, by introducing an unobserved state space system into the theory, one adds a degree of freedom to all models built upon the framework. When models must be ‘closed’ to produce steady state or equilibrium solutions, these solutions will by necessity be partial. This is philosophically unappealing.

Second, there is the possibility of infinite recursion via nesting of successive If-Then statements in algorithmic implementations of the theory (vide the entire artificial intelligence and computational economics movements), though this possibility is mooted but not explored in Downes’ article.

The chief limitation of choosing a passive, mostly neutral Newtonian space as the fundamental frame in a theory of mind is the lack of interactivity and therefore dynamism with the space itself, so experience within the environment (the space) and the learning outcomes associated with that experience can’t affect the space itself, only the observer/agent.

The chief reason Simon and Newell expend such energy on a limited space is that their results are clearer. It makes more sense when one is trying to found cognitive science on a theory of search as the fundamental process to use the mathematics of computer science, which requires a dull state space. In computer science this is normally a fine assumption: because the state space is dull: it is 0 or 1 with nothing in between. Other non-dull computations are simply rules built on top of the motion of 0s and 1s on computer hardware. But in cognitive science, though computations (the search for heuristics, essentially) are carried out in a similar sense (and Penrose
(1990) has many Turing machine models of the mind like this), as these computations are carried out, they change the substrate being used for the computation, the mind itself.

Simon and Newell can use simulation as the tool of choice for the analysis of large scale problems, because they assume the mind is made up of the same causal relationships as the computer model they study. “The compatibility of [Newell and Simon’s] problem-space simulations with the physical world is only at best an approximation” (ibid, pg. 51). If the ‘frame’ of analysis is not correct, one is losing information (i.e. increasing in-model error) by modelling incorrectly. Since the whole point of a simulation approach to the working of the mind is to understand the workings of the mind, these simulations are much less useful if they are not “physically realizable” (ibid, pg. 54). Practitioners working in the Simonian tradition thus find themselves working with models which do not replicate features of the mind but represent “mere change[s] of place”.

Downes’ paper is to be commended because it forces one to think about appropriate model closure when simulating aspects of reality in economics, but there are some questions and comments I have about the way the concepts are approached, which caused some confusion, to which I now turn.

2. Newtonian Space in Simon’s Ideas
2.1 Defining Newtonian space as absolute everywhere is incorrect

Newton did actually allow for changes within his state space, just not in the kernel theory developed in the *Principia*. The searcher in Newton’s space is not just moving from point A to point B, but travelling against something (a force) with something at its back (another force). Newton tells us in the *Principia* (Definition III, pg. 2)

“The *vis insita*, or innate force of matter, is a power of resisting, by which every body, as much as in it lies, endeavours to persevere in its present state, whether it be of rest, or of moving uniformly in a right line”.

Crucially, this definition of inertia leads to a description of space in the Scholium of the first chapter of the *Principia* (pgs. 13–14):

“Absolute space, in its own nature, without regard to anything external, remains always similar and immovable. Relative space is some moveable dimension or measure of absolute spaces; which our senses determine by its position to bodies… Absolute and relative space, are the same in figure and magnitude; but they do not remain always numerically the same.”
The reason for the choice of absolute space in relation to the description and analysis of fundamental forces was measurement. Newton explicitly acknowledges that space is not absolute in relation to the observer, but continues his analysis of Space to include Place (this would correspond to the measure of the space in our language). So in Scholium I, part III (pg. 14), we find Newton averring that

“Place is a part of space which a body takes up, and is according to the space, either absolute or relative.”

The reason for Newton’s grounding of his theory of gravitation in a fixed and passive plane was twofold. First, Newton wished to refute the Cartesian duality of body and spirit, which he saw as atheism (Westfall, 1980, pg. 302—304 and pgs. 189). Newton’s ultimate goal was to demonstrate the dependence of matter on God. Newton describes spaces in another way in his De Gravitatione (Halls, pg. 139, latin original, pg.106):

“Spaces are not the very bodies themselves but are only the places in which bodies exist and move… ”

2.2 Existence of Measurement Error

Newton had to contend with large measurement errors in the observations of physical phenomena, even for the most carefully measured astronomical phenomena (See for example, Westfall, (1980), pg. 23). In Newton’s day, measurements were so
inaccurate that holding some concepts fixed and assuming others to have zero mass in a friction-less world would actually have been the only way to move physics forward.

So the notion of Newton’s space as passive an unaltered perhaps needs quite a large clarification: Downes is right to say the searcher is unaffected by the place they search in, as the ant (his analogy) remains unaltered by the roughness of the terrain it encounters—it just takes the ant longer to get where he is going, and in practice the ant may never, ever, arrive.

### 2.3 Simonian concepts of Complexity

The relevant account of Simon’s views on complexity is Simon (1962), and he does not take the rhetorical angle ascribed to him by Downes on pages 37 and 38. Perhaps a better way to proceed is to take Simon’s own conception, much stronger than the Newell and Simon ‘ant’ idea, and use it as a straw man to attack. It is suggested on pg. 37, for example, that “Simon’s (1996) emphasis on the searched terrain is basically that of Newell’s (1990) “connectivity””. Re-reading Simon (1962) in this light will convince any reader the causality is the other way around.

### 2.4 Einsteinian/Riemannian spaces

Why does Downes introduce these concepts, except as alternatives, when he argues against the wholesale importation of concepts from physics? Surely a quantum cognitive science would have the same unexamined (and unnecessary) assumptions about space, time, or something else, built into them? If the intention is to compare
the effects on Simon’s theory of the inclusion of these types of spaces into the analysis then the argument must run the other way, from empirical psychology (vide the foreground/background experiment, etc), to the theory, which supplies a story for the connections between the two phenomena robustly, and predicts that behaviour not just in Japan and the US and Ireland today, but in Bolivia in 1922 and Ireland in 2107.

A Riemannian space is just a Euclidean space that rejects the Euclidean parallel postulate, on the assumption that there are no parallel lines, and if extended far enough, any two straight lines on a plane will meet. This is elliptic geometry, which allows one to model a space where a straight line exists in a space that can be bounded (like, perhaps, the universe) but infinite. In Riemannian geometry, all perpendiculars to a straight line meet at a point, and the point of all of this is that the sum of the angles of any straight line is always greater than 180 degrees. One is actually embedded in the other, more generally.

Similarly, the revolution Einstein initiated did not do away with Newton’s laws at all, but modified them slightly to take account of very large changes (close to the speed of light) and very small changes (in quantum mechanics) between objects. It is hard to see how inclusion of references to the quantum and space-time arguments from Newton’s successors gives any direction to today’s cognitive scientists. If the problem is wholesale importation (pg. 35) of physics concepts, surely the quantum is a stretch too far as well.
2.5 The paradox of infinite recursion via successively nested If-Then statements

This paradox isn’t, to the best of my knowledge, resolved by imposing priority orderings on pre existing transitivity conditions—only optimal stopping rules for recursion do this, and even then this is an arbitrary step which has to be justified, most often on the grounds of computational complexity, tractability of models, etc. Computer scientists normally do away with this problem via the introduction of a base case.

Obviously one cannot do any of these things to the Newell-Simon model without making some sort of inductive closure: make the smallest generalisation such that all sub-problems arising in an attempted proof by induction belong to the same class and are therefore subject to the same solution. Knuth (1997, pg. 22) studies Fermat’s problem solution technique of ‘infinite descent’ with this problem in mind. Is Downes therefore suggesting a more general model of cognitive science be used to replace or do away with Newell-Simon? I remain confused on this point, and sceptical of a more general model based on search or pattern selection that does not have this problem within it, unless the model is explicitly computable, that is, built from and based on classical recursion theory.

2.6 The metaphorical connection between cause and effect in Newell-Simon

Essentially Newton’s assumptions about space boiled down to his need for clarity when it came to causality. So we find him discussing space in the following terms:
…because the parts cannot be seen, or distinguished from one another by our senses, therefore in their stead we use sensible measures of them. For from the positions and distances of things from any body considered as immovable, we define all places; and then with respect to such places, we estimate all motions, considering bodies as transferred from some of those places into others…. [W]e may distinguish rest and motion, absolute and relative, one from the other by their properties, causes and effects.

As each of Simon and Newell’s iterations on their theory considers causality as stretching linearly from the searcher to the thing or object being searched (research ➔ knowledge ➔ more knowledge, etc), the division of cause and effect is clearly retained throughout. The searcher is affected by the object he encounters when searching, not the space in which he searches. What does it imply for causality (and hence prediction and explanation) in cognitive science if this restriction is removed? If this is the case, Downes is really talking about taking the carpet right from under the theory itself.

To do this, Downes must at least decide what to replace the existing theory with, and describe that replacement. The loss of the arrow of causality from a theory leads, most of the time, to nothing.
3. Summary

In summary, I would like to simply ask Dr. Downes a few questions that a clarification to his article should be able to answer:

1. Dr. Downes, assume everything you say is correct. What, in detail, is to replace the Newtonian space concept?
2. Where is the Newell-Simon/AI conception of mind in this new space?
3. Can a conception of mind even exist at all?

Finally, a word of thanks to Dr. Downes for his stimulating and original article.
References

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