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From Spacetime to Space and Time:

A Reply to Markosian

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forthcoming in *Analysis*

In a recent article, Ned Markosian gives an argument against the Spacetime Thesis, namely the view that "time is one of four similar dimensions that make up a single manifold that is appropriately called spacetime" (Markosian, 2019, p.1). The argument proceeds by considering a series of seven notes played out in time and constituting a melody. Markosian asks us to imagine a rotation of the series of notes in spacetime, resulting in the seven notes being played out at the very same time. Markosian points out that those notes will lose their aesthetic value. According to him, this *Argument from Sideways Music* shows that time cannot be identical with other spatial dimensions, as the aesthetic value of entities populating reality cannot survive a rotation mixing up space and time—unlike rotations taking place in and only in space, that preserve the aesthetic value of the rotated entity.

Whether or not the argument is correct is irrelevant to a broader concern. The concern is that Markosian attacks a straw man since *the Argument*

from Sideways Music targets a theory known to be false on empirical grounds, that I will label "defective four-dimensionalism" and that may not be seriously considered as an interesting version of four-dimensionalism. *Defective four-dimensionalism* is the view that the time dimension is identical with the three spatial dimensions *in all respects*. I label this view as "defective" because the view is essentially flawed and does not correspond to four-dimensionalism as defended by its proponents. *Four-dimensionalism rightly conceived*, on the contrary, acknowledges the existence of a distinction between space and time.

I disagree with Markosian on three points. First, four-dimensionalism as he defines it (the "Spacetime Thesis") does not correspond to four-dimensionalism as defended by its proponents. Second, the Spacetime Thesis is flawed by being at odds with modern physics. Third, the two reasons given by Markosian to worry about four-dimensionalism rightly conceived can easily be addressed.

First, the Spacetime Thesis as he defines it does not correspond to the standard four-dimensionalist view. Four-dimensionalism rightly conceived relies on the *existence of a distinction between space and time*. The B-theory describing time as intrinsically orientated—with the systematic orientation of phenomena being a primitive aspect of temporal relations—is a very popular form of four-dimensionalism (see e.g. Kajimoto, Miller, and Norton forthcoming). Furthermore, even assuming an alternative block universe view stating that the orientation of time is *extrinsic* to time (as with the C-theory of time) by depending on for instance laws of nature or the distribution of matter in spacetime, the view acknowledges the existence of a difference in the world between

spatial and temporal directions. Therefore, the two most popular kinds of four-dimensionalism (the B-theory and the C-theory) do make a difference between spatial and temporal directions in the four-dimensional block and, consequently, are not affected by Markosian's argument.

Actually, this distinction between space and time is to be found in all physical theories, a fact that motivates my second point of disagreement with Markosian: *defective four-dimensionalism is inconsistent with contemporary physics*. Indeed, it is generally assumed (correctly to my mind) that contemporary physics strongly suggests four-dimensionalism, namely a package of views about the flow of time (a B- or C-theory rather than an A-theory), temporal existence (eternalism rather than presentism or no-futurism) and perhaps about the cross-temporal identity of material objects (perdurantism or the stage theory rather than endurantism).[1] However, the very same physics also signals the existence of a *local split* between space and time, establishing a difference between spatial and temporal *directions* (see Callender 2017 and Le Bihan and Linnemann 2019).

[1] I use the expression "strongly suggests" rather than "logically entails" because there exist research programs in physics at an early stage of development which seem consistent with 3D ontologies (as with shape dynamics; see e.g. Gomes et al. 2011) or growing block approaches (as with the causal set theory; see e.g. Dowker 2006 and Wüthrich and Callender 2016). Furthermore, there exist hybrid views such as the moving spotlight theory combining an A-theory with a four-dimensionalist picture. Here I am simply stating that four-dimensionalism, generally regarded as the most natural reading of relativistic physics, even when understood as denying the existence of a flow and direction of time, acknowledges the existence of a difference between space and time.

Indeed, if we look at modern physics, we may distinguish between two parts of the discipline: physics that is empirically well-established and constituted from distinct and *prima facie* incompatible theories—general relativity and quantum field theory—and speculative research programs aimed at the elaboration of a broader, in some sense more fundamental, framework—labelled "quantum gravity", which aims to describe phenomena that are both quantum and gravitational (in particular black holes, the earlier instants of the universe and the deep fabric of spacetime). The most promising approaches to quantum gravity at the moment are string theory and loop quantum gravity. A generic feature of approaches to quantum gravity is that they seem to entail the emergence of spacetime as described by our most fundamental theory of spacetime, namely general relativity, by a non-spatio-temporal structure (see e.g. Huggett and Wüthrich 2013 and Lam and Wüthrich 2018). In this context, Le Bihan and Linnemann (2019) have recently examined which properties of spacetime are denied reality to. They found that a local distinction between space and time[2] is not one of those properties. That distinction always appears, in some way, not only in empirically well-confirmed contemporary physics (in particular in special and general relativity, our two most fundamental theories of spacetime at the moment), but also in virtually all approaches to quantum gravity.

Importantly, this local distinction between space and time need not have anything to do with time exhibiting a flow or an (intrinsic or extrinsic) orien-

[2]Or to use their terminology, between "quasi-space" and "quasi-time" if features which are regarded as essential to the existence of space and time are missing in the more fundamental quantum theory of gravity.

tation. There is another, deeper (i.e. logically anterior), more neutral way to distinguish between space and time. This distinction is encoded in the (local) Lorentz symmetry of our best physical theories to date (namely the general theory of relativity and the standard model for particle physics) and in many approaches to quantum gravity.[3] Lorentz symmetry is a particular sort of symmetries which constrains the way physical systems can be *transformed*. These so-called Lorentz transformations necessarily mix to some degree the temporal coordinate of the system with at least one of the three other spatial coordinates thereby signaling that spacetime must be, in some sense, more fundamental than space and time. However, and this is the crucial point to appreciate, *these transformations cannot mix quantities of space with quantities of space only*—leaving time out of the story. A set of special directions within spacetime, labelled as "time", must always be part of any physically meaningful transformation. So when we consider Markosian's thought experiment, we should not regard it as presenting us with a rotation of a physical system (from a particular state to another state) but rather as a transformation of a physical system into *another* physical system in a way which is inconsistent with the laws of physics.[4]

In brief, there is no doubt that physical theories indicate the existence of a

[3]Some approaches of quantum gravity such as the causal set theory do not seem to embed Lorentz symmetry but they nonetheless rely on a different diachronic principle distinguishing between space and time. See Le Bihan and Linnemann (2019).

[4]Furthermore, the very idea of a four-dimensional rotation is also problematic at a conceptual level as it seems to require a second-order time to make sense of the substitution of a four-dimensional system (including first-order time as one of its dimensions) by another four-dimensional system (including the very same first-order time as one of its dimensions).

difference between space and time. A small caveat here is that this separation is only local in the context of general relativity as the reference frames themselves are only local in general relativity; a set of special directions nonetheless always exist locally. Having said that we still have no explanation about the *source* of the difference though, as we only have a mathematical representation of it. This situation is consistent with two distinct metaphysical interpretations. Either the local split between space and time is an *intrinsic* feature of spacetime, or it is an *extrinsic* feature of spacetime, inherited from its material content or from some laws of nature evolving this content. As a result, and although we do not know with certainty what the actual source of the distinction is in terms of metaphysical categories (laws, dimensions, etc.), we must nonetheless acknowledge its existence.

However, and this is a subtle point to appreciate, the distinction between space and time does not entail that they should be regarded as *two distinct manifolds*. Modern physics entails or, at the very least, strongly suggests that we live in *one four-dimensional manifold*. One might object to this *spacetime unitism* that *spacetime separatism*,[5] namely the view that there exist two distinct manifolds, the three-dimensional spatial manifold on the one hand, and the one-dimensional temporal manifold on the other hand, can be made sense of by subscribing to an ontology of spatial hyper-surfaces absolutely ordered by an empirically undetectable absolute time, namely by dropping the assumption of the relativity of simultaneity. Nonetheless, as Baron (2018, 9) points out,

[5] I borrow this terminology from Gilmore et al. (2016).

it is far from clear that it would be possible to extend this unnatural interpretation to general relativity (see also Gilmore et al. 2016, 103-105). Spacetime unitism, with its unified four-dimensional manifold and metric straightforwardly generalise to general relativity. What it means is that space and time seem to be mere abstractions as there is no unique and obvious way to slice spacetime into three-dimensional hyper-surfaces.[6] Therefore, relativistic physics seems to suggest *both* spacetime unitism *and* the existence of local differences between temporal and spatial directions within the spacetime manifold.

I now come to my third point of disagreement with Markosian. He raises two issues against the sort of four-dimensionalism that posits the existence of a difference between the three spatial dimensions on the one hand, and the temporal dimension on the other hand—namely, against the view that I identify as four-dimensionalism rightly conceived. As we have seen, four-dimensionalism should be understood as positing the existence of a four-dimensional manifold in which, locally, there actually is an ontological difference between spatial and temporal *directions*. Keeping in mind this important refinement of four-dimensionalism, let us look at the two alleged issues.

[6]One might point out that we find a cosmic time in scientific cosmology, and that there is a most natural way to slice the observable universe into three-dimensional hyper-surfaces allowing us, for instance, to attribute an age of 13.8 billion years to the universe. This is true of course but, although this slicing is natural on cosmic scales, it nonetheless depends on the contingent distribution of matter in spacetime and more importantly, it is a mere global approximation that does not take into account the local curvature of spacetime due to massive bodies. See e.g. Smeenk (2013) and Wüthrich (2013).

According to Markosian, four-dimensionalism rightly conceived is not attractive because it is a middle position that lacks the elegance (i.e. simplicity) of defective four-dimensionalism and the intuitiveness of the dynamic theory of time. However, it does not seem correct to ignore scientific data and use elegance and intuitiveness as the only guiding principles when addressing metaphysical matters. Four-dimensionalism rightly conceived might be a complex view lacking the simplicity of defective four-dimensionalism, and a counter-intuitive view lacking the immediate intuitiveness of the dynamic view; but this is the most straightforward way to read modern physics, which results of a long theoretical work to make sense of surprising empirical results. Note that the problem here is not the appeal to the simplicity of defective four-dimensionalism or to the intuitiveness of the dynamic view; the problem is to ignore a third theoretical virtue that should not be ignored: consistency with contemporary science in general, and modern physics in particular. And when we include consistency with modern physics as a legitimate criterion for theory selection in metaphysics, the middle position turns out to be an appealing position. (Furthermore, one might take a step further and remark that consistency with scientific data as a methodological virtue should be more important than intuitiveness or beauty, thereby offering a reasonably good argument in favour of four-dimensionalism.)

Let us now consider Markosian's second argument against four-dimensionalism rightly conceived:

> For whatever small differences are posited between time-like dimensions in the manifold and merely space-like dimensions will presum-

> ably not be enough to account for the great difference in aesthetic value between normal music and sideways music. (Markosian, 2019, p.8)

The claim that a small difference between time-like and space-like dimensions, or more accurately, time-like and space-like directions, will not be enough to ground the aesthetic value between normal and sideways music is hard to parse. Indeed, Markosian offers no clear argument for why the asymmetry between space and time, regarded as a pre-requisite to the grounding of an aesthetic value of music, should be related to A-theoretic machinery, such as an ontological distinction between the past, the present and the future, or a flow of time. It seems that a local causal structure, or some *laws of nature* distinguishing between space and time, could play the very same task. With no further argument to the point that the conceptual machinery available to the four-dimensionalist cannot achieve this goal, Markosian's second argument remains question-begging.

Markosian concludes the essay as follows:

> One thing that The Argument from Sideways Music brings out is the crucial importance of certain "tensed facts" (i.e. facts involving A-properties), such as the fact that only this note is present. (Perhaps it is equally important that that note is in the recent past, and also that the next note is in the near future.) Another thing that the argument brings out is the importance of the fact that there is an essential, dynamic aspect to time. For it is literally the pas-

> sage through the sequence of the sounds (the 'jerk and whoosh' as Williams (1951, 466) memorably puts it[...]) that gives music the compelling quality it has. The dynamic aspect of music is essential to its aesthetic value, and is directly tied to the dynamic aspect of time. (Markosian, 2019, p.8)

None of this will satisfy a four-dimensionalist. The Argument from Sideways Music only establishes that defective four-dimensionalism is false and that there must exist in the actual spacetime structure a local distinction between space and time. From this, it only follows that the disjunction of four-dimensionalism rightly conceived and the A-theory must be true. Therefore, the dynamic aspect of music, essential to its aesthetic value, is directly tied to the specific aspects of the time directions that make them different from the spatial directions, whatever those features and their origin turn out to be. Those specific features of time, grounding the "dynamic" aspect of music do not need to be realised by a "dynamic" time. (Note here the two different meanings of the word "dynamic" in the sentence: it does not follow from the fact that a melody is dynamic by being spread out in time, or more accurately, along a temporal direction, that time must be dynamical in the metaphysical use of the term.)

The Argument from Sideways Music does not establish the falsity of four-dimensionalism; it merely emphasises that defective four-dimensionalism—a non-standard view inconsistent with virtually all spacetime theories to be found in modern physics—is defective.[7]

[7]I want to thank Jiri Benovsky, Alberto Corti, Nick Huggett, Saakshi Dulani, Christian

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