

## Presuppositions for Realist Interpretations of Vectors and Vector Addition

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This paper is about realism and vector magnitudes. It takes its departure from the basic realist presupposition that there exists in the world at least some mind-independent property-universals. In particular, I will take it for granted that volume, mass and density are *in re* existing monadic universals. When quantified, as in physics, these three properties are represented by scalar magnitudes. So, in other words, in order to discuss the possibility of realist interpretations of vector magnitudes I take it for granted that some scalar magnitudes can be given a realist interpretation.

One thing should be noted at once about scalar magnitudes: a quantitative scalar concept can be used to refer to a monadic property. For instance, the concept 3.12 gram can be used to refer to a specific mass in a material thing or in a mind-independent field. Although the quantitative concept 3.12 gram is in itself relational, it can refer to non-relational individual masses. The explicit referent of a *relational concept* can very well be a *non-relational property*, and a scalar magnitude can correspond to a real property. This is not a problem.

What, on the other hand, I have found somewhat problematic, and what I am going to discuss in this paper, is whether any *vector* magnitude can correspond to a real mind-independent property. The problem, then, is not the fact that vector magnitudes, like all other magnitudes, are relational; the problem is the directedness of vectors. If a vector is to correspond to some kind of mind-independent property, this property has to have a kind of directedness in itself. Is that possible? And, if 'yes', what is the nature of such directedness and what are its ontological presuppositions? As I hope to show, there is much to be said about this. Or, to be more precise, I will try to show that there are at least seven interesting presuppositions to discuss.

Among vectors, the magnitude of movement is probably the primary candidate for a realist interpretation to most philosophers of science. So, let us consider movement. A

movement is always a movement *from* one place *to* another place, and it needs some time. In one single temporal point no entity can move from one place to another. This *from-to structure* cannot possibly be a purely spatial directedness. From a purely spatial point of view, there is only a distance between the two places; and a distance has no directedness in itself. Mind-independent spatial distances must not be conflated with perceptions of spatial distances. Such perceptions have of course a direction, but that is quite another thing. Non-directed spatial distances can be contrasted with two kinds of perceptual directedness, one purely spatial and one spatiotemporal. First, if I am looking at the distance between me and a certain thing, there is a spatial directedness from me to the thing in my perception, but no directedness in the purely spatial distance itself. Second, if I am looking at a distance between two things by first looking at one of the things and then gradually move my gaze to the other, then there is also a directedness which belongs to the temporal stretch of my observation, but there is no directedness in the object of my observation, i.e. in the observed distance itself.

In order for the directedness of a movement to be regarded as a mind-independent feature of the world, there has to be a mind-independent time with a direction. A movement of something is a movement between spatial positions; it is not a *movement* between temporal positions, even though the existence of the movement depends on the existence of time. A movement has to start at one point of time and end at another. It is not a change of temporal position; it is a change of spatial position which *takes place in time*. However, if time is a mind-independent temporal order with a direction, then this direction will impregnate the movement, too. There is a direction between the starting point and the terminal point in space only because there is a direction between the starting time point and the terminal time point. If time has a direction, movements will have a direction, too. Otherwise not.

The direction of time which I am speaking of cannot be reduced to a mere linear order of before and after and in-between among points, where it does not matter if, so to speak, before comes before or after. Of course, such a mere linear order can be abstracted from the directed temporal order which I am going to speak about. My point is only that the directed temporal order cannot be identical with the merely linear one. The last order is like a linear spatial order.

My remarks about movements, i.e. changes of place, can easily be extended to cover property changes, too. Suppose a thing, for some reason, suddenly undergoes a certain expansion, i.e. it changes its volume. The change starts with the thing having a certain

volume at a certain time, and ends with it having another volume at another time. It is a change *from* a lesser volume *to* a larger one, and the change can be described as a movement along an abstract volume scale. This scale contains in itself no direction; it is a mere linear order. However, like all changes, a change of volume necessarily exists in a time interval, it *is* not a change of time, it is a change of property which *takes place in time*. And if the time interval is real and has a direction, then the change in volume will inherit this direction. If there is no temporal direction, there will only be different volume magnitudes connected with different temporal points, but no directedness.

Both changes of place and changes of volume can be described as processes in which one order which lacks internal direction is connected with another order - time - which has an internal direction. It seems to be a general truth that changes requires two orders: (i) the order of that which is changing (e.g. property or spatial position), (ii) time as a directed order. Therefore, the directedness of a change is always a *derived* directedness. It seems to me as if the temporal order is the only order which can "ground" changes.

If it is true that every change contains a connection between two orders, then this fact explains a firm linguistic intuition. It is odd to say that time itself changes, but it is not odd to say that time has a direction. The direction of time exists in the temporal order itself, but for changes of time to exist, there has to be a secondary time from which these temporal changes derive their direction of change. However, I will assume that we live in a world which contains no secondary time.

My reflections above show that vectors which represent changes of place and changes of real monadic properties can be given a realist interpretation on the following two presuppositions: (1) there is a mind-independent temporal order, and (2) the time intervals contain a directedness, "time's arrow". Such vectors can be used to describe a starting point and an end point of a real change as well as the direction between these points.

All changes are, as I have said, necessarily extended in time. Consequently, in physics no change is correlated with a momentary time point. What about punctually defined vectors then? Some of the most important vectors both in classical and in modern physics are primarily defined for momentary instants. And any realism that cannot provide a realist interpretation of a momentary velocity is a very "thin realism". Therefore, I think that as realists we have to ask ourselves whether or not there is some kind of mind-independent directedness which can exist in a momentary point of time. This, I would like to say, is "the hard problem" for a realist interpretation of physics. As

far as I know, there is, surprisingly enough, only one contemporary attempt to attack this problem; see Bigelow and Pargetter (1989). They state the problem very well, explaining it against the background of medieval philosophy in which it was really regarded as an important problem, but they do not discuss the aspects which I am focusing attention on.

The from-to structure of the change vectors I have spoken of thus far requires the existence of *two* time points. A temporally punctual vector, however, is confined to one single point. Could such a point really contain a from-to structure? Is it not simply logically true that a from-to structure requires at least two points? Superficially, in a punctual vector the "from-entity" and the "to-entity" seem to refer to the same point - and then there can be no direction. Let us take a closer look at velocity.

Velocity can be regarded as the intensity of movement, just as density can be regarded as the intensity of mass. The higher the density the more mass there is in a certain region of space, and the higher the velocity "the more movement", so to speak, there is in a certain time interval. Since a movement is directed, its intensity (its velocity) will inherit this direction, too. This inherited direction, however, can only be inherited in a time interval, since, to repeat again, in a single time point there can be no movement.

Let us next take a look at the temporal parts of a movement with a *constant velocity*. It is quite trivial that the smaller the temporal parts we look at are, the shorter the contained movements will be. At the limit, when we reach a momentary instant, there is no movement at all. But the velocity is the same in every temporal part, however small, and the velocity can therefore be non-zero even at the limit, i.e. in the momentary instant. All temporally punctual *movement* vectors have to be zero, but punctual *velocity* vectors need not. This fact highlights the problem I am discussing. Can a momentary velocity vector be given a realist interpretation? Can there be a mind-independent directedness in a momentary instant? Can there be a velocity where there is no movement?

Above, I have argued that the directedness which a velocity inherits from the movement of which it is an aspect is, in its turn, an inherited directedness. Ultimately, the directedness of a velocity, just like the directedness of a movement, has to come from the directedness of time. In a temporal point there is no movement, but let us presuppose (3) that there is something temporal, the temporal point itself. Given this presupposition, it seems reasonable to claim that if there is a kind of directedness in temporal points, then this directedness will be inherited by momentary velocities. If

actual movements can inherit directedness from the directedness of time intervals, it seems reasonable to think that punctual velocities can inherit directedness from the directedness of time points.

I will not argue that there has to be (4) a from-to structure in temporal points, only that such a structure is both logically and ontologically possible. Now, of course, any directedness must for logical reasons involve two points or two entities of some kind. But this truth does not entail that a directedness must, literally or metaphorically, be stretched out between the two entities in question. Perhaps a directedness between two entities can be contained in merely one of the entities? In fact, this is the way many philosophers analyse the directedness of intentional acts. When one is thinking of something far away, there is a from-to structure which involves two entities; the act of thinking on the one hand and the object of the thinking on the other. The directedness, however, is wholly *contained* in only one of the entities, in the intentional act of thinking.

From the fact that any directedness must involve at least two entities, it does not even follow that the directedness is a direction between two *existing* entities. It can be a direction between one existing and one non-existing entity. Such is the situation when we read or think of fictional entities. If Meinong's analysis of fictional objects is wrong, and so I think, then many intentional acts contain a directedness from an existing act to nothing that either exists or subsists. In contradistinction to veridical presentational intentionality (as in veridical perceptions) and to true representational intentionality (as in thinking of an obtaining state of affairs), such acts might be said to instantiate *fictional* intentionality.

The conclusion which I think can be drawn from these remarks is the following (5): *if* temporal directedness can be of the same nature as fictional intentional directedness, then there can be a temporal directedness in every single momentary instant of time.

If "the now" is mathematically punctual, then necessarily the directedness of all time points has to be a direction *from* such a now *to* non-existing future time points. If "the now" has a certain extension, then at least "the last point" has to be directed towards non-existing future time points. In both cases the temporal directedness has to be akin to that of fictional intentionality. But there are differences, too. Temporal directedness seem not to allow any distinction between a mode (like perceiving, thinking, dreaming, etc.) and an intentional content. All temporal points are directed towards the future in the same way.

I am not the first philosopher to try to link temporality and intentionality together. Franz Brentano has written that "The relation of earlier and later is in a certain sense to be compared with that between thinker and what is thought: the thinker exists in the proper sense, but what is thought exists only as being thought" (Brentano 1988, p. 96). One subtle difference between my approach and Brentano's is that he wanted to see temporality and intentionality as two species of the genus *one-term relation*, whereas I would like to see temporal directedness and all the different kinds of intentional acts as species of the genus *intentionality*.

Intentional phenomena are mostly regarded as mental phenomena. So let us assume that all intentional acts like perceiving, thinking, dreaming, imagining, feeling, and desiring, are mental phenomena. Does it follow from this assumption that if there is in the world any other kind of intentional phenomenon, such a phenomenon must also be a mental phenomenon? My question can also be framed in the following way: Has intentionality such a nature that it has to be a mental phenomenon? If the answer is 'yes' there can be no directedness in temporal points of the kind I have tried to find, since I am investigating a presumed objective temporal order. I have found no arguments which I think conclusively show that intentionality may be mind-independent, but, on the other hand, I have found no strong counter-arguments either. However, I will put forward two remarks which speak in favour of the view that intentionality may be non-mental as well as mental.

Firstly, it seems to be generally agreed that some properties are of such a nature that they can exist both in mind-independent objects and in mind-dependent intentional objects. Speaking metaphorically, the gulf between matter and mind can be traversed. Spatial extension is the best example. Every physical theory takes it for granted that there is a mind-independent world which contains entities which have spatial extension, and it is quite obvious that we perceive entities-with-spatial-extension and that we perceive spatial extension. In this sense the gulf between mind-independent phenomena and mind phenomena is not absolute. At least spatial extension bridges it. Why then should not intentional directedness be able to do the same?

Secondly, in the kind of ontology which I subscribe to, intentional acts exist in the spatiotemporal world, and they depend for their existence upon some kind of material substrate, normally a human body. This means that I do not regard intentional acts as mind-dependent. To me they *are* mental phenomena, and as such phenomena they are matter-dependent. If the intentional directedness within intentional acts is matter-

dependent, why should it be ontologically impossible for intentional directedness to inhere in points of objective time? Perhaps an old and strong tendency to think all mental phenomena as necessarily inhering in a mental *substance*, has blocked philosophers from entertaining the possibility that the direction of objective time might be an intentional phenomenon.

These two remarks show that it is at least possible to give reasons in favour of a realist interpretation of punctual temporal directedness. Such a directedness, however, is only a necessary, not a sufficient condition for a realist interpretation of punctual velocity. There is yet another problem which has to be solved. As I have said, a temporally punctual velocity cannot, like a temporally extended velocity, be an intensity of a movement. But, perhaps, there can be something within zero-dimensional temporal instants which corresponds to temporally one-dimensionally extended movements and their velocities? I will present my positive answer by means of an analogy with spatial entities.

Assume we have a sphere in a three-dimensional space. What happens if we take away one dimension? Obviously, the sphere shape disappears since a sphere shape cannot exist in a two-dimensional surface. But something remains which corresponds to the sphere shape, a circle. If we take away yet another dimension, then the circle shape disappears, too, but a line with the length of the circle's diameter remains. When in this way we "go down" one dimension, some shapes disappear, but not wholly. Something of them seems to remain.

Let us now think of a movement of a thing and make a similar thought experiment. What happens with the movement if we "go down" from its one-dimensional temporal interval to a zero-dimensional temporal point? In the interval, there is the thing, its movement, and the velocity of the movement. But in the temporal point there is only the thing and a punctual velocity; there is no movement. However, I think temporal points may contain an ontological creature which corresponds to movements. They may contain *tendencies to movements*. Punctual velocities are then of course to be regarded as intensities of tendencies to movement, just as velocities in time intervals can be regarded as intensities of actual movements.

What I am trying to say is that, from a realist point of view, (6) it is possible to interpret the punctual velocity vector as something by means of which we can refer to a momentarily existing *tendency* for movement which has a directedness which is inherited from the intentional directedness of temporal points. In a tendency for movement, the *from-entity* of the

from-to structure has actual existence, whereas its *to-entity* has merely potential existence. The from-entity is the tendency itself.

The concept of tendency must not be conflated with that of causality. Causality is a relation between two entities whereas a tendency is property-like. A tendency *inheres* in an individual. Nor should the concept of tendency be conflated with the concept of disposition. The difference is easily explained. A functioning rubber band has always the dispositional property of being elastic, but it has a tendency to return to a previous size only when stretched.

Punctually defined velocity vectors can be mathematically added. If the velocity vector can be given a realist interpretation on the presupposition that there is an objective temporal order which contains temporal points which, in turn, contain intentional directedness, what are we then to say about the corresponding vector addition? For the sake of a brief argument I will exemplify my line of thought by means of an empirically false (somewhat Aristotelian) law. Instead of (as in Newtonian mechanics) saying that forces cause accelerations, I will say that forces cause velocities; instead of Newton's second law, ' $F = m \cdot a$ ', we get ' $F = m \cdot v$ '. This can be done since my philosophical point relies only on the fact that the law used in the example is logically possible.

Let us investigate a situation in which a certain body, B, is affected by two other bodies. If B were not affected by anything at all, it would, according to my Aristotelian law, have no velocity at all. However, in the assumed situation one of the other bodies gives rise to a velocity  $v_1$  and one to a velocity  $v_2$ . Therefore B has two *partial* velocities in this situation. From an ontological point of view, each such velocity reflects a tendency for movement in B, and each such tendency is a property of it; even though the tendencies are caused by other bodies. According to my ontological conjectures, there are here two different tendencies for movement in one and the same body in one and the same spatiotemporal region. Each such tendency has an intensity and a direction of its own which can be described by a velocity vector.

The two velocity vectors mentioned can be added by ordinary vector addition:  $v_1 + v_2 = v_R$  (the resultant velocity). The question is whether this addition can correspond to anything real. From a realist point of view, the peculiar thing with partial velocities is that, although they actually exist, they never appear as they are in themselves. It is only the resultant tendency, described by the resultant vector, which appears as such. The body B does not actually move according to any of its partial velocities. It moves with

the resultant velocity. This fact is perhaps more clear in a situation in which B is at rest in spite of the fact that two bodies are affecting it. This becomes the case when the two partial velocities are equally intense but diametrically opposed. In this case the resultant velocity is zero. Despite the fact that the thing has two tendencies to move, the thing does not move. My reason for thinking that these partial velocities cannot be given an instrumentalist interpretation is easily stated. In the situation envisaged, B does not actually move. But it also would not move if the other bodies were *not* present. *Prima facie*, B ought to be different in these two situations. As far as I can see, only the assumption that there are tendencies which inhere in B in the first situation but not in the second, can explain the difference.

If the superposition principle for velocities is to be given a realist interpretation, (7) tendencies have to be able to mix in the sense that several tendencies, at one and the same time, can occupy exactly the same spatiotemporal region. Although tendencies are property-like, not substance-like, they behave like the *mixtures* discussed by Anaxagoras, Aristotle, and the Stoics. A true mixture is something quite distinct from a blend or a juxtaposition. In such a mixture the parts mixed occupy, to repeat, exactly the same spatiotemporal region.

Phenomenologically, we experience the coming into being of mixtures very often. Usually, when we mix two liquids we experience a total fusion of the two liquids. It appears as if both of the original liquids exist within each part of the new liquid. If that should be true, which we today think it is not, then liquids would be true mixtures. Now, even though our molecular theory tells us that a mix of two liquids, in spite of appearance, is a blend, this truth in no way rules out the possibility that other parts of nature can contain mixtures. In other words, a realist interpretation of vector addition of velocities commits one to nothing that is ontologically impossible.

Let me summarise. There are some quite specific ontological presuppositions that have to be true if a vector magnitude like that of velocity shall be given a realist interpretation. Though I have not discussed whether or not all these presuppositions are in fact true, I think that is worth discussing. The seven presuppositions mentioned in the paper were the following:

1. There is an objective temporal order.
2. Time intervals have a direction.
3. The objective temporal order contains actual temporal points.

4. Time points have a direction.
5. Momentary temporal direction is a special kind of (fictional) intentional directedness.
6. Tendencies exist and their direction is derived from the direction of time points.
7. Tendencies can mix and create true mixtures.

If I may call realism with regard to (some) punctual vectors "thick realism", then my view is that although thick realism is not easy to defend it can be done.

### **References**

Bigelow, J. and R. Pargetter (1989), "Vectors and Change", *The British Journal for the Philosophy of Science* 40: 289-306.

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