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DOI:
10.1111/j.1746-8361.2009.01206.x

Citation for published version (Harvard):
Wilson, A 2009, 'Disposition-manifestations and Reference-frames', *Dialectica*, vol. 63, no. 4, pp. 591-601.
https://doi.org/10.1111/j.1746-8361.2009.01206.x

This is a preprint of a paper published in *dialectica* 63:4, pp. 591-601, (2009).
The original publication is available at
http://www3.interscience.wiley.com/journal/123303779/abstract

Disposition-manifestations and Reference-frames

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Abstract:

Dispositions can combine as vector sums. Recent authors on dispositions, such as George Molnar and Stephen Mumford, have responded to this feature of dispositions by introducing a distinction between *effects* and *contributions to effects*, and by identifying disposition-manifestations with the latter. But some have been sceptical of the reality or knowability of component vectors; Jennifer McKitrick (forthcoming) presses these concerns against the conception of manifestations as contributions to effects. In this paper, I aim to respond to McKitrick's arguments and to defend the metaphysical and epistemological propriety of component vectors. My strategy appeals to varying kinematic frames of reference. By transforming to the appropriate non-inertial frame, component acceleration vectors can be transformed into resultant acceleration vectors, and in such frames they become directly observable. *Being a component acceleration vector* and *being a resultant acceleration vector* are both frame-dependent properties of properties; they are not to be thought of as intrinsic or fundamental properties of an acceleration vector, but as artefacts of our frame-dependent notation for representing vector quantities. To conclude the paper, I defend the view proposed against two styles of objection. The first objection resurrects scepticism about component vectors as scepticism about fundamental component vectors. The second objection questions the need for reference frames in the explanation by invoking a 'counterfactual' theory of contributions.

Almost every familiar event results from the combined activity of multiple dispositions. Simply standing up involves the disposition of many different muscles to exert forces on different parts of my skeleton, the Earth's disposition to attract me gravitationally, the ground's disposition to resist compression, and other lesser contributions such as air pressure. It is perhaps an open empirical question whether it is possible to isolate particular microscopic processes from all interfering factors in specific laboratory conditions; but even if it turns out to be possible to do so in special cases, such conditions are highly atypical.

This straightforward observation has consequences for the metaphysics and epistemology of disposition manifestations. An orthodox view has it that dispositions are individuated at least in part[1] by their manifestations; a particular force is a disposition to accelerate a mass at some particular rate in some particular direction, for example. But where two forces act together, the combined effect is an acceleration different from that which would have been produced by either force acting alone. Consider the case, described by Molnar (2003, p. 195) of a boat pulled along a canal by two horses, one on either side of the canal (see Figure 1). Each horse exerts a force at an angle to the canal, but the direction in which the boat accelerates is straight along the canal. In such a case, the activity of each disposition is partially 'masked' by the activity of the other. The resultant force exerted on the boat is the vector sum of the two component forces exerted by the two horses, and the resultant acceleration of the boat is the vector sum of the component accelerations produced by each component force. In what sense, then, are the component forces and component accelerations 'manifestations', if only the resultant force and the resultant acceleration are 'manifest'?

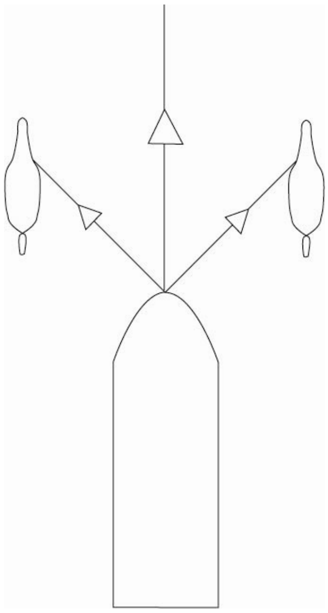

Figure 1

Some recent authors on dispositions have responded to this feature of dispositions by introducing a distinction between manifestations and effects. Here is George Molnar:

> ...we must sharply distinguish between *effects* and *manifestations*... Effects, that is, occurrences which have causes, are not isomorphic

[1] Generally, the stimulus conditions for a disposition also play a role in individuating it.

> with the exercise of powers, considered distributively. A manifestation is typically a *contribution* to an effect, an effect is typically a *combination* of contributory manifestations. In other words, events are usually related as effects to a collection of interacting powers.
>
> Molnar 2003, p.195

Stephen Mumford has also recently committed himself to this distinction:

> This means that we cannot say simply that each event is a result of a power manifesting itself. Instead, we have to accept that events are polygenic, to use Molnar's term. They are produced by many powers working together, or against each other, with small additive, sometimes subtractive, effects.
>
> Mumford 2009, p.104

For the purposes of this paper, I will stick to Molnar's terminology, using the term 'effect' for particular events which are the outcome of a process involving dispositions[2], and using the term 'contribution' for a disposition's role in producing an effect.

Some philosophers have been suspicious of the sort of distinction introduced by Mumford and Molnar, primarily because they are sceptical about the reality of 'contributions'. Nancy Cartwright argues as follows:

> The vector addition story is, I admit, a nice one. But it is just a metaphor. *We* add forces (or the numbers that represent forces) when we do calculations. Nature does not 'add' forces. For the component forces are not there, in any but a metaphorical sense, to be added; and the laws that say they are there must also be given a metaphorical reading.
>
> Cartwright 1983, p.59

In a different context, Fodor and McLaughlin voice a similar scepticism:

> When a tensor product vector or superposition vector is tokened, its components are not (except *per accidens*)... the components of tensor product and superposition vectors can have no causal status as such. What is merely imaginary can't make things happen, to put the point in a nutshell.
>
> Fodor & McLaughlin 1990, p.345

[2] Here I am ignoring the distinction between states and events. A house continuing to stand because its internal forces are balanced will be counted as an event, and hence as an effect of the balanced forces. There are further tricky questions about the individuation of effects, such as their spatio-temporal extent, which I cannot engage with here. But, roughly speaking, I take an effect to be 'everything going on with respect to some particular property in some particular spatio-temporal region'.

In these passages, Fodor, McLaughlin and Cartwright are expressing a metaphysical thesis: that component vectors (also called virtual vectors) are merely calculational devices and have no reality *per se*. This thesis should be of concern to anyone who believes both that manifestations should be distinguished from effects, and that dispositions are individuated by their manifestations. If manifestations are 'merely imaginary', doesn't it follow that dispositions individuated by them are equally imaginary? And if all we can observe are overall effects, aren't manifestations (thought of as contributions to effects) necessarily unknowable?

Jennifer McKitrick (forthcoming) presses these concerns against the conception of manifestations as contributions, using them to motivate a conception of dispositions where manifestations are identified directly with resultant events. In this paper, I aim to respond to McKitrick's arguments against the Mumford/Molnar distinction between manifestations and events by defending the metaphysical and epistemological propriety of component vectors. This requires a characterization of component vectors which can underwrite their reality and their knowability.

Before we come to my account of component vectors, I first want to note an ineffectual response to the epistemological concern. This response is that, in certain scenarios, certain component vectors *can* be directly observed. We certainly feel the push of the wind when we walk in a gale, even though we can resist this push and not fall over. The push of the wind is not the overall effect of the forces involved; it is a contribution to the effect, and is counteracted by our own efforts. The overall effect is our remaining on our feet. It seems plausible that what we are feeling when we feel the wind is a component vector, and hence that such effects can after all be observed. The line of thought here is similar to the idea that we can observe singular causation directly.

The appeal to direct perception cannot be a general recipe for avoiding the epistemological problem. Clearly, it is of no help with the case of the horses and the barge, since we cannot perceive directly the forces in the ropes. Nor is it of any help when it comes to microphysical component forces. No-one is likely to say that we can observe directly the gravitational forces exerted on one proton by a distant pair of protons; but this kind of interaction is a paradigm example of the combination of component vectors. If we have to accept component vectors into our ontology at all, we will have to accept microphysical unobservable component vectors as well as the more homely and potentially observable macroscopic component vectors that feature in the common examples.

Despite the failure of the response which invokes direct perception, I don't think the epistemological line of argument against component vectors is in the end a convincing one. Although they are not (in general) directly observable, we can nevertheless postulate an inferential route, using familiar methods, to knowledge of component vectors. In the simple case of the horses and the boat, we could cut one of the ropes and observe the boat's resulting acceleration. We could then recreate the original situation, cut the other rope, and again observe the boat's resulting acceleration. Simple physics tells us that the resultant vector in each modified case is equal in direction and magnitude to one of the component vectors in the original case. Thus, even though we are not able to directly observe either component vector, we can still have good inferential reason to believe that each takes a particular value.

This epistemic situation is not at all a peculiar one. The postulation of component vectors is justified in the same sort of way as the postulation of unobservable theoretical entities like quarks, and we have the same kind of epistemological access to them as we do to these other unobservable entities. In complex cases, the procedures required to investigate particular component vectors may be more difficult than the procedure described for the simple case of the horses, of physically removing one factor and observing the resultant behaviour; in many cases, it will not be practical or even physically possible to remove certain other factors. However, such problems are endemic within scientific methodology and we have developed a battery of inferential techniques to help avoid them (for example, statistical methods and the use of independent convergent sources of evidence). So it looks like we can postulate a familiar inferential route to knowledge of component vectors, perhaps combined with non-inferential knowledge of a macroscopic subset. I take it that this line of thought defuses the epistemological objection.

However, dealing in this way with the epistemological problem does not help with the metaphysical problem. Indeed, the account of the epistemology of component vectors given above apparently relies on some prior solution to the metaphysical problem; a convincing argument that component vectors are merely imaginary would block the kind of inference to the best explanation required for an inferential route to knowledge of them. Mumford and Molnar give us no clear account of what kind of thing they take component vectors to be. And component vectors do have unusual properties: they must always occur along with at least one other component vector, for example. Perhaps component vectors are simply too bizarre and unworldly to be admitted into our ontology.

The main project of this paper is to give a characterization of component vectors which will allow defenders of the distinction between contributions and effects to respond to the metaphysical problem. The plan is to do so by appeal to varying frames of reference. The notion of a frame of reference employed here is familiar from elementary kinematics: in the frame of reference of a train, a seated passenger is motionless, but in the frame of reference of a station through which the train is passing at a constant velocity, a seated passenger is moving at the same constant velocity as the train.

In the context of classical mechanics and special relativity, reference frames come in two varieties; inertial and non-inertial. To a good approximation, the surface of the earth constitutes an inertial frame; that is, it is a frame within which the laws of electrodynamics (and hence the laws of classical mechanics) take their simplest form[3]. The set of inertial frames is one of the fundamental structural features of the theory of special relativity, and of classical mechanics in the neo-Newtonian spacetime formulation[4].

A non-inertial frame is a frame which is not moving with constant velocity with respect to an inertial frame. The frame of an accelerating car constitutes a non-inertial frame; objects in such frames experience 'pseudo-forces', such as the felt force pressing you back into your seat as a car moves off, or the 'centrifugal force' swinging you sideways as the car turns a corner. While the laws of electrodynamics and classical mechanics do not take their simplest form in non-inertial frames, such frames are nevertheless perfectly physically well-defined: there is an objective fact of the matter about whether a particular frame is non-inertial or not, and about which pseudo-forces would be experienced by objects from the perspective of such frames.

Non-inertial frames give us the resources to characterize the component vectors at work in the boat case. Instead of considering accelerations in the inertial frame of reference of the canal, we can evaluate the accelerations in the non-inertial frame of reference which is itself accelerating in the direction of the force applied along the left-hand rope, with an acceleration equal to the component acceleration of the boat in that direction. In this special non-inertial frame of reference, there is no acceleration at all of the boat in the direction of the force applied by the left-hand horse. Instead, there is only an acceleration of the boat in the direction of the force applied by the right-hand horse, with the same magnitude as the acceleration that the right-hand horse would have caused the boat to undergo in the absence of the left-hand horse.

What this means is that, when we move to some particular non-inertial frame, what was a component acceleration vector in the original frame (a contribution) becomes a resultant acceleration vector (an effect) in the new frame. By transforming to the appropriate non-inertial frame, component acceleration vectors can be transformed into resultant acceleration vectors, and

[3] This characterization, and the account to follow, excludes complications due to general relativity.

[4] For an account of neo-Newtonian spacetime, see Earman 1989, ch.2.

in such frames they become directly observable. This undercuts McKitrick's metaphysical argument against component acceleration vectors; in the right reference frame, we *can* give a positive account of component acceleration vectors, as simply identical to resultant acceleration vectors. This provides a positive account both of component accelerations and of component forces, where the latter are identified as dispositions to produce component accelerations.

The account straightforwardly generalizes to cases involving more than two component acceleration vectors. The appropriate frame to use in isolating a particular component acceleration vector will not now be identified by consideration only of a *single* other acceleration vector, but rather the appropriate frame can be identified by consideration of the vector sum of *all* the other acceleration vectors involved in the interaction. In the frame of reference which is accelerating along with this vector sum, the remaining component acceleration vector which we are interested in will become directly observable.

It may be helpful to think of the account I am giving in the following terms: *being a component acceleration vector* and *being a resultant acceleration vector* are both frame-dependent properties of properties. The very same property will appear to be a resultant acceleration vector in one frame, and a component acceleration vector in others. It follows that the distinction between component and resultant acceleration vectors cannot support the ontological weight placed on it by sceptics about contributions; if we accept the reality of resultant vectors but not of component vectors, then what exists becomes a frame-dependent matter.

In a sense, then, I am in agreement with those who doubt the existence of component vectors where such vectors are conceived of as being *intrinsically* component vectors, or as being component vectors *simpliciter*. 'Componentity' and 'resultantity' are not to be thought of as intrinsic or fundamental properties of an acceleration vector; instead, they are to be thought of as artefacts of our system for representing vectors. Accordingly, a covariant notation for representing acceleration vectors (that is, a notation which is tied to no particular co-ordinate system and hence to no particular reference frame) leaves no room for a distinction between component acceleration vectors and resultant acceleration vectors.

Perhaps those who are sceptical about component vectors will complain that this misses the point of their objection. They could try to reformulate the worry by appealing to the distinction between sparse (or fundamental) and abundant (or derivative) properties, and claiming only that component vectors are not among the sparse properties. Maybe, once we take the distinction into account, the problem I have been considering can be dissolved as follows. Component vectors might not feature among the sparse properties, because the sparse properties consist only of (say) scalar field values at points. But, the objection might run, we can construct any abundant properties we like; so component vectors will certainly feature among the abundant properties. Does the question I have been considering stem from failing to distinguish between two questions, each of which has an unproblematic answer?

The first thing to note is that many common examples of supposedly dubious component vectors are firmly planted in the abundant, or derivative, level of properties. It is obvious that the forces and accelerations involved in the example of the horses and the barge will not correspond to any sparse property. But even if these vectors are not perfectly natural, they are still relatively natural; they play important roles in high-level scientific generalizations, and are not gerrymandered. It is also worth noting that most examples of resultant vectors are also non-fundamental, which provides further reason to think that the distinction between component and resultant vectors cannot be assimilated to the distinction between abundant and sparse properties.

Once this much is established, the part of the objection that remains is a charge of triviality. Won't a believer in abundant properties believe in component vectors simply by virtue of believing in every possible property? But this complaint misses the mark. A believer in abundant properties will certainly believe in *resultant* vector properties with all possible magnitudes and all possible directions (albeit not all of them instantiated). But this does not require them to believe in *component* vectors with all possible magnitudes and all possible directions[5]. I am therefore not too worried about any potential dilemma stemming from the abundant/sparse distinction. My question is not: are component vectors elements of the fundamental furniture of the universe? Rather, I am interested in the following question: are component vectors elements of the furniture of the universe, whether fundamental or derivative?

Another objection might question the need to bring reference frames into the explanation of component vectors. Someone might try to identify component acceleration vectors with counterfactual properties concerning accelerations: perhaps they are given by the accelerations which *would* be the resultant effect of an interaction *if* other component acceleration vectors were absent. The epistemology associated with this suggestion would work out in the same sort of way as the epistemology associated with the reference-frame suggestion. But I have three reasons for wanting to avoid the appeal to merely possible accelerations. Firstly, many people would be suspicious of properties which are

[5] Indeed, if 'componentity' is being thought of as intrinsic to vectors, the notion of a component vector is an impossible one; and then a commitment to abundant properties might not buy us a commitment to component vectors. I would like to remain neutral on whether being intrinsically a component vector expresses an uninstantiated property, or fails to express a property at all.

characterized counterfactually. It would be best to leave contentious issues in modal metaphysics out of an account of component vectors. Secondly, it is not clear that the counterfactuals by which vectors would be characterized will always behave as we would like them to. In many cases it might be physically impossible to remove all of the component accelerations in a given situation; the physical impossibility of unconfined quarks might well provide such a case. The counterfactual supposition 'were other component vectors absent' would then require for its assessment the consideration of worlds with different physical laws. This sort of 'counterlegal' counterfactual supposition presents complications for various views of counterfactuals, in particular dispositional essentialist views which hold (roughly) that the laws governing a particular property are essential to it. Finally, it is unclear how the counterfactual account should incorporate the undeniable frame-dependence of accelerations and velocities, while the reference-frame account builds in this frame-dependence in a natural way. However, if you are unworried by any of these concerns, then the counterfactual account of component vectors will comprise an appealing alternative to the account developed in this paper.

One advantage that the counterfactual account does have is that it applies directly to all types of component vector. The reference-frame account has so far been given in terms of dispositions whose manifestations are accelerations[6], and it generalizes straightforwardly to component forces (thought of as dispositions to produce accelerations) and component velocities (thought of as dispositions to change position.) What about other kinds of component vectors? Although many common examples of dispositions are manifested directly in forces or changes in motion, some instead are manifested in intrinsic changes in objects. One important case is that of a room which is being simultaneously heated by an electric radiator and cooled by an air-conditioning unit. The change due to each machine can be represented as a vector in the thermodynamic state space of the air in the room; and the total change in thermodynamic state of the air is the vector sum of the two vectors.

In the thermodynamic case, there are no alternative reference frames to which we can transform in order to isolate each particular effect. Although the metaphysical status of component forces, component accelerations and component velocities is illuminated by considering transformations to non-inertial frames, this trick does not appear to shed any light on the status of component thermodynamic changes. Does this mean that the manifestations of

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[6] Of course, individual dispositions can still be manifested in accelerations even when the whole system is not accelerating at all in the most natural reference frame. A familiar example of this is when the forces on different parts of a house are balanced, and the house does not collapse. No overall acceleration of the house takes place in the reference frame of the earth, but all the forces involved are still being manifested as component accelerations.

dispositions to heat a room, which are in fact counteracted by the manifestations of dispositions to cool the room, are metaphysically mysterious in a way that manifestations of dispositions to accelerate a boat are not?

It should be borne in mind that equilibrium thermodynamics is a theory of high-level emergent phenomena, which can in large part be given a reductive explanation by reference to statistical mechanics. Statistical mechanics itself is based on forces, velocities, and accelerations as primitive quantities (as well as positions); and the status of component forces, component velocities and component accelerations seems unproblematic. It is therefore open to us to identify the 'component heating' and 'component cooling' of the room as complex combinations of component accelerations and component decelerations of the gas particles in the room. We will not in general be able to identify which complex combination of accelerations and decelerations corresponds to some particular component heating or component cooling; however, this is no more than a corollary of our general inability in statistical mechanics to know the exact micro-state a given system is in, even when we know its exact macro-state.

A similar policy, of reducing intrinsic changes to complex combinations of accelerations and changes in relative position, will frequently work to give reductive accounts of dispositions whose manifestations involve intrinsic change. If either classical mechanics or special relativity were part of the true and complete fundamental theory, then this would in fact comprise a complete account of disposition-manifestations: all phenomena could be reduced to forces, accelerations, velocities and positions, in accordance with the mechanist vision. However, we know that this is not the case: quantum mechanics and general relativity each point the way to a breakdown of classical mechanics and special relativity, and they involve fundamental new vector quantities in unfamiliar new vector spaces. Nothing I have said is intended to apply to these novel vector quantities. However, whatever we end up discovering about quantum mechanics and general relativity, we know in advance that classical mechanics and special relativity must be recoverable as approximations; indeed, as approximations which are extremely accurate over a wide range of familiar macroscopic phenomena. Thus we ought to be able to identify elements from the underlying theory which correspond approximately to velocities, forces, and accelerations; and then we will in principle be able to give an account of component velocities, forces, and accelerations in these terms.

To reiterate a point made earlier, my question is not whether there are any component vectors at the 'fundamental level' of reality. The question I am concerned with is a much more straightforward one, which needs no recourse to fundamental physics. Can we give a positive characterization of component vectors which can vindicate the distinction between manifestations and effects? I have suggested the following response: at least for straightforward macroscopic dispositions, we *can* give a metaphysical picture which underwrites the account of manifestations as contributions to effects. Component vectors in some reference frames are resultant vectors in another frame; contributions in some frames are effects in another frame. McKitrick's defence of manifestations as effects amounted to a pair of arguments against the component vectors picture; and these arguments are inconclusive in a range of central cases, a range covering all the main examples found in the dispositions literature. We can get epistemological access to this important class of component vectors through standard scientific inferential procedures, and we can identify them directly with resultant physical quantities by making use of varying frames of reference. My conclusion is that the Mumford/Molnar conception of manifestations as contributions can be given a solid epistemological and metaphysical foundation*.

* Thanks to Frank Arntzenius, Antony Eagle, John Hawthorne, Jennifer McKitrick and Barbara Vetter for comments on earlier drafts of this paper, which was written during a period of research funded by the UK Arts and Humanities Research Council.

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