

Converse Relations, Vectors, and Three Theses from Armstrong

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1. Three Theses from Armstrong.

The issues that I want to consider concern the explanation of what a converse relation is. The three theses from Armstrong are all to be found in his recent book *A World of States of Affairs*. The first thesis from Armstrong concerns the instantiation of converse relations and can be called the ‘instantiation postulate’: if two particulars instantiate a non-symmetric relation, then necessarily they also instantiate its converse, which is a relation that is just like it but with the opposite sense. The main difficulty here is in knowing exactly what is meant by the sense of a non-symmetric relation. It is, in fact, possible to formulate two notions of the sense of a relation one of which can be called the *linguistic* notion of the sense of a relation and the other the *metaphysical* notion of the sense of a relation, though it is not always clear which notion a particular philosopher is working with. I shall argue that if we take the metaphysical notion of the sense of a relation then the *instantiation thesis* for converse relations is false for many kinds of relation, though true for some kinds of relation.

The second thesis from Armstrong is that a relation and its converse are identical, so that the instantiation of the converse relation represents no increase in being. This is the *identity thesis* for converse relations. In the context of Armstrong’s notion of

supervenience, symmetrical supervenience implies identity, so that if two relations are necessarily instantiated together, they are the same. Therefore, if a relation and its converse relation necessarily occur together, they are the same in the sense that the instantiation of the converse relation represents no increase in being.¹ However, if a relation and its converse were identical in this way, there would be no objective metaphysical difference between them and a difference in sense would not be an objective metaphysical difference. My view is that the situation is more complicated than Armstrong recognizes. He is right that a relation and its converse are the same relation. But when a relation and its converse are instantiated together it is the same relation instantiated twice, once going one way and once going the other. The instantiation of the converse relation does represent an increase in being and there is an objective metaphysical difference between a relation and its converse. It is the same relation instantiated twice in the same way that any universal can be instantiated twice. It is similar to the situation where the particulars *a* and *b* instantiate a non-symmetric relation *R* and two different particulars *c* and *d* also instantiate *R*; they are the same relation, but there are two instantiations of it.

The linguistic notion of the sense of a non-symmetric relation implies that there is no objective metaphysical difference between the instantiation of a relation and its converse, and is presumably the notion of the sense of a relation used by those who claim that a relation and its converse are identical in the sense that the instantiation of the converse represents no increase in being. But there is something counter-intuitive about the suggestion that the sense of a relation is not objective: if Cassio loves Desdemona,

¹ D. M. Armstrong, *A World of States of Affairs* (Cambridge: Cambridge University Press, 1997), p. 11-2.

the fact that this relation proceeds from Cassio to Desdemona, and not vice versa, seems to be as objective as anything else about the relation. Moreover, I shall argue by considering certain kinds of vector that it possible for there to be kinds of relation that are such that there is an objective metaphysical difference between a relation and its converse. But unfortunately for Armstrong, this metaphysical notion of the sense of a relation implies that not all relations are necessarily instantiated with their converses (though some are), so that the first thesis from Armstrong is false.

The third thesis from Armstrong is that states of affairs are independent of each other.² But if there are kinds of relation such that there is an objective metaphysical difference between a relation and its converse, then there are what we should normally regard as two different states of affairs that necessarily obtain together, the state of affairs of the two particulars instantiating the relation and the state of affairs of the two particulars instantiating the relation going in the other direction, commonly called its converse. It follows that this third thesis from Armstrong, the *independence thesis for states of affairs*, is also false.

2. The Definition and Postulates

Armstrong explains a converse relation as follows: “It may be noted in passing that if *a* has a relation to *b*, then, by the usage of the logicians, *b* automatically has the *converse* to *a*. There is no increase of being here either.”³ If ‘automatically’ means the same as ‘necessarily’, then he is claiming that associated with any relation that has a sense (i.e. a

² Armstrong, op. cit., p. 139.

³ Armstrong, op. cit., p. 91.

non-symmetric relation), there is a converse relation that has the opposite sense, such that necessarily the two relations are instantiated together. Russell, in *The Principles of Mathematics*, states what Armstrong presumably assumes, that the converse of a relation is just like it except for having opposite sense.⁴ Formally, there are two distinct things here, the definition and the instantiation postulate:

Definition of a Converse Relation: the converse, R^{-1} , of a non-symmetric, dyadic relation R is a relation that is just like it except in having the opposite sense.

Exactly what the converse of a relation is depends on what the sense of a relation is; and it is conceivable that there be several possible meanings of the term ‘sense of a relation’.

Instantiation Postulate for Converse Relations: necessarily, if two particulars instantiate a non-symmetric relation R , they also instantiate its converse R^{-1} .

This is the first thesis from Armstrong under discussion.

Having stated what a converse relation is by means of a definition, it might appear that the next thing to do would be to formulate an existence postulate that says that for every non-symmetric, dyadic relation R , that there exists one and only one converse relation R^{-1} . But an existence postulate would be redundant, because the converse of a relation is not another relation that is just like it except in having the opposite sense; it is the same relation.

One could say that the expression ‘the converse relation’ refers to a relation as instantiated, in fact one instantiated in the other direction, and then to add that when the relation is considered in the abstract apart from any instantiations, a relation and its converse are the same. I think that this way of speaking is helpful, providing that it is not

⁴ Bertrand Russell, *The Principles of Mathematics* (London: George Allen & Unwin, 1903), p. 95-7.

thought to imply that there is an ontological distinction between a relating relation and an abstract relation, as Russell appeared to suppose.⁵ It is the same relation whether it is thought of as instantiated by two specific particulars or whether it is thought of independently of any instantiations. The instantiation postulate says, in effect, that if two particulars instantiate a non-symmetric relation, then, necessarily, the same relation is instantiated a second time by those two particulars going in the other direction: it is instantiated going one way and also instantiated going the other way.

Let us consider this situation from the point of view of the various theories of universals. Both sorts of realists about universals agree that a property, or a relation, is a single entity that can be instantiated by many particulars. And consequently, both sorts of realist will agree that a relation and its converse are the same relation. For the Platonists (or transcendent realists) the property or relation sits in the Platonic heaven and is participated in, or not, by many or few particulars, remaining exactly what it is however many times it is participated in. If a relation and its converse are instantiated by two particulars, then those two particulars participate in the same relation twice, but in different ways. For the Aristotelians (or immanent realists) the property or relation occurs as a whole at each particular that instantiates it, being exactly the same property or relation wherever it occurs. And if a relation and its converse are instantiated by two particulars, then the relation occurs as a whole twice at the same two particulars, going one way and going the other. For both sorts of realist saying that a relation exists is not

⁵ For a discussion of the twofold role of the relation, or the double aspect problem for relations, see Andrew Newman, *The Correspondence Theory of Truth* (Cambridge: Cambridge University Press, 2002), pp. 97-102.

the same thing as saying that the relation is instantiated. Even if Armstrong's instantiation requirement for the existence of a universal were granted, namely that a universal exists if and only if it is instantiated, the existence of a universal would be independent of any particular instantiation of the universal providing that it is instantiated somewhere.

For particularists, if a relation and its converse are instantiated by two particulars, then there are two numerically distinct tropes existing side by side and differing only in sense. If it were possible to prize off these two tropes and replace one with the other, then the converse relation would do the work of the relation and the relation could do the work of the converse, with no difference except that the same work is now being done by numerically different tropes. Particularists agree with the ordinary language statements that many particulars can instantiate the same property and that many pairs of particulars can instantiate the same relation; they just have rather complex ways of explaining them.

If two particulars instantiate a non-symmetric relation going one way and also its converse, the same relation going the other way, then Armstrong asks us to believe that those two relations are identical. Indeed, they are the same relation, but there are two instantiations of it. There will be an increase in being if there is something objective about the sense of a relation, and, if you believe in states of affairs, there will be two states of affairs.

3. The Linguistic Notion of the Sense of a Relation

There is no mention in Armstrong or Russell of linguistic expressions in the passive voice, which are, however, frequently associated with converse relations. The sentence

‘Cassio loves Desdemona’ and the noun phrase ‘Cassio’s loving Desdemona’ describe a non-symmetric relation from Cassio to Desdemona, while the sentence ‘Desdemona is loved by Cassio’ and the noun phrase ‘Desdemona’s being loved by Cassio’ apparently describe a relation from Desdemona to Cassio. In the active sentence, ‘Cassio loves Desdemona’, the subject term is ‘Cassio’ and the object term is ‘Desdemona’, while in the passive sentence, ‘Desdemona is loved by Cassio’, the subject term is ‘Desdemona’ and the object term is ‘Cassio’. The things that were subject and object in the active voice become object and subject in the passive voice. If the sense of the relation were regarded as proceeding from the linguistic subject to the linguistic object, then the sense of the relation referred to by ‘loves’ is from Cassio to Desdemona, while the sense of the relation referred to by ‘is loved by’ is from Desdemona to Cassio. On this account, the relations referred to by ‘loves’ and ‘is loved by’ are converses of each other, because they necessarily occur together, have opposite sense, and are otherwise alike.

The main difficulty with this approach is just that the notion of sense is linguistic, being founded on the linguistic notions of subject and object: the things that go into the slots of the relation are labelled ‘subject and object’, ‘first and second’, or ‘reference and relatum’ (Russell) on account of the order in which the terms that refer to them appear in the sentence. In effect, the slots of the relation itself are labelled ‘subject and object’, or ‘first and second’, merely on account of whether the linguistic expression used to describe it is in the active voice or the passive voice. In symbols the relation “loves” would be described by $L(x)_1(y)_2$, while the relation “is loved by” would be described by $L^{-1}(x)_1(y)_2$. The sentence ‘*a* loves *b*’ would be represented by $L(a)_1(b)_2$, which describes the relation as proceeding from *a* to *b*, that is as proceeding from the first slot to

the second slot. Whereas the sentence ‘ b is loved by a ’ would be represented by ‘ $L^{-1}(b)_1(a)_2$ ’, which describes the relation as proceeding from b to a , that is as proceeding from the first slot to the second slot. The linguistic notion of the sense of a non-symmetric relation leads to the conclusion that the distinction between a relation and its converse is merely a distinction in mode of presentation.⁶ The sense of a relation is not an objective feature of a relation and that there is no objective, metaphysical difference between a relation and its converse.

But a relation, so I assume, is an objective thing existing in the world. And if a relation is something objective existing in the world, then the sense of a relation should also be something objective, a feature of something existing in the world. The sense of a relation, then, would either go one way or the other, and it would not be possible in one instantiation of a relation for it to go both ways at the same time, as the linguistic view seems to imagine; if this is what is implied by Armstrong’s statement “There is no increase of being here either”, then he has gone too far. Consequently, if one relation holds between a and b , then another relation with opposite sense that is also supposed to

⁶ It could also be called a distinction of reason. It is difficult to avoid mediaeval terminology here. If two things do not necessarily occur together, so that they can be presented separately, the distinction between them is a *real distinction*. If two things necessarily occur together and therefore cannot be presented separately, and the distinction between them is nevertheless objective (*a parte rei*), then the distinction between them is a *formal distinction*. And if two things necessarily occur together and the difference between them is merely a matter of mode of presentation, then that distinction is a *distinction of reason*. For the linguistic notion of the sense of a relation, the distinction between a relation and its converse is a distinction of reason, whereas for the metaphysical notion of the sense of a relation, the distinction between a relation and its converse would have to be a formal distinction.

hold between a and b must differ from the first in more than mode of presentation; because if the difference is only one of mode of presentation there is no difference in the world. Changing a sentence into the passive voice is merely changing the mode of presentation of reality. The instantiation postulate for converse relations, says that for any non-symmetric relation there is instantiated a unique relation with opposite sense, not, that for any non-symmetric relation there is another way of presenting it.⁷

It is instructive to note that when we talk about symmetric relations we use exactly the same linguistic forms, some in the active voice and some in the passive voice. But in this case most people would prefer to follow Armstrong, as opposed to Russell, in agreeing that metaphysical considerations dictate that a symmetric relation does not have a converse, since there is just one relation.

It is difficult to know what motivates the linguistic view of the sense of a relation. Someone who thought that relations were linguistic things, as opposed to things in the world, would, presumably, regard the sense of a relation as something linguistic, and would conclude that the passive sentence described a relation with opposite sense. And it is conceivable that someone who thought that the structure of the world can be inferred from the structure of language (syntactic priority thesis) might conclude that the sentence in the passive voice describes a relation with the opposite sense.⁸

⁷ For Russell the notion of sense of a relation is a fundamental notion not capable of definition, *The Principles of Mathematics*, p. 96.

⁸ Many people think that the formalism of symbolic logic reveals the true logical form of language. But the passive voice has no place in symbolic logic and therefore, if such people are right, would not represent anything about the true logical form of language.

4. The Metaphysical Notion of the Sense of a Relation

But there is something counter-intuitive about the suggestion that the sense of a relation is not objective: if Cassio loves Desdemona, the fact that this relation proceeds from Cassio to Desdemona, and not vice versa, because Cassio loves Desdemona and Desdemona does not love Cassio, is as objective as anything else about the relation. The most serious objection to the linguistic notion of the sense of a relation is that a metaphysical notion of the sense of a relation is available, and is, so I claim, the natural notion of the sense of a relation. If it is all a matter of satisfying the definition of converse relation, then we have an example of a converse relation that is not a matter of mere difference in mode of presentation. Moreover, if there were a relation R such that whenever the sentence ' aRb ' was true, the sentence ' aSb ' was also true, where S differed from R only in sense, with a difference in sense in this case being an objective difference in the world, then S would be the converse of R and the instantiation postulate would be satisfied.⁹

⁹ Williamson also suggests, in effect, that there is a metaphysical notion of the sense of a relation and that is to be preferred to the linguistic notion of the sense of a relation. See Timothy Williamson, "Converse Relations", *The Philosophical Review* 94 (1985), pp. 249-62. "Given the identity of converses, not only are the argument places of relations not intrinsically 'first' and 'second': they do not even naturally correspond from one relation to another in such a way that, although calling one argument place rather than the other of the relation first would be arbitrary, calling the corresponding argument place of another relation first would be a non-arbitrary consequence of this decision. Argument places in different relations can be associated only in terms of the content of the relation . . . These associations have no systematic significance for the theory of relations." (p. 260) He regards his work as part of a larger project. "The

In the case of a relation like “loves”, there is a metaphysically active term and a metaphysically passive term that provide a metaphysical notion of sense as proceeding from the active term to the passive term, independently of any way in which the terms are presented in the sentence, and independently of whether the sentence is active or passive.

The relation “loves” can be represented by the symbol ‘ $L()_L()_B$ ’, where the subscript ‘L’ represents the slot for the lover and the subscript ‘B’ represents the slot for the beloved. Using this notation, the relation “is loved by” can be represented by the symbol ‘ $L^P()_B()_L$ ’, where the superscript ‘p’ stands for passive voice. The sentence ‘*a* loves *b*’ would then be represented by ‘ $L(a)_L(b)_B$ ’, while the sentence ‘*b* is loved by *a*’ would be represented by ‘ $L^P(b)_B(a)_L$ ’. Both the relation referred to by ‘ $L()_L()_B$ ’ and the relation referred to by ‘ $L^P()_B()_L$ ’ have the same metaphysical sense, since both proceed from the lover to the beloved. And since they have the same sense, one is not the converse of the other; they are in fact the same relation in every way and when it is instantiated only one relation is instantiated. The relation proceeds from the lover to the beloved, whatever kinds of linguistic expressions are used to describe it. This seems to be the natural meaning of the sense of a relation. From this point of view, transforming a linguistic expression into the passive voice makes no difference to the sense of a relation.

Some people are likely to doubt that intentional relations like “loves” are genuine or real relations. Intentional relations do have unusual features, but are nevertheless perfectly respectable relations. It is characteristic of intentional relations, such as loving, perceiving, thinking of, etc, that they involve a modification to one term only, namely the

identity of converses suggests a larger project, of explaining the diversity of linguistic forms from a tighter system of non-linguistic entities whose nature allows them to be represented in diverse ways.” (p. 262)

subject term, whereas the other term, the object term, is quite unmodified by the instantiation of the relation. But because the object term is unmodified is no reason to regard an intentional relation as anything less than a real relation — spatial relations, for example, do not involve modifications of either term.

If a person is dreaming or hallucinating that person is in an intentional state and an intentional relation is not instantiated. However, when there is an object that the person perceives, an intentional relation is instantiated and an intentional state is not instantiated. It is not always possible for a person to know whether there is an object out there, and so it is not always possible for a person to know whether it is an intentional relation or just an intentional state. Because the person sometimes cannot tell whether he is in an intentional state or participating in an intentional relation, is no reason to regard an intentional relation as anything less than a real relation. Intentional relations are interesting and useful relations to consider in the context of the sense of a relation, because there is such a clear distinction between the subject term and object term. They are genuine relations and they have sense.¹⁰

In the case of an intentional relation like “loves” there is clear sense in which the relation proceeds from one person, who is active, to another, who is passive. However, in the case of non-symmetric relations like “taller than” there is no sense in which one term of the relation is active and the other term of the relation is passive term, but there is nevertheless something at least analogous to a metaphysical notion of sense. There is a slot into which the taller particular goes and a slot into which the shorter particular goes,

and we can, if we like, think of the relation as proceeding from the taller to the shorter, but it is really only a convenient way of thinking. In this case, the two sentences, ‘ a is taller than b ’ and ‘ b is shorter than a ’ describe the same reality and differ merely in the way they present it. It appears that how the slots are labelled will depend on the kind of non-symmetric relation that is being considered.

It is not the case that “shorter than” is the converse of “taller than”. The relation “taller than” is a typical relation with foundations in both terms, namely the heights of both terms, which are monadic properties. The symbol ‘ $>$ ’ is standardly used to represent the ordering relation on the set of objects with height — a first order relation that takes particulars as its terms; and it could also be used to represent the parallel ordering relation on the set of height properties — a second order relation that takes monadic properties as its terms. There is something conventional about how we talk about the sense of relations of this kind. The sentence ‘ a is taller than b ’ could be symbolized by ‘ $a > b$ ’ or by ‘ $a < b$ ’. The first is chosen because it suggest a ’s being taller than b . The converse of the relation “taller than” is a relation just like it but with opposite sense; considered apart from any instantiations, it is just the same relation. For relations of this kind, necessarily, the converse relation is not instantiated, because it is not possible for a to be taller than b and for b to be taller than a . But this is not true for relations of all kinds.

If Cassio loves Desdemona, it is of course quite possible that Desdemona should also love Cassio, but it is not necessary by any means, and, in fictional fact, would have been rather unlikely. The love relation from Desdemona to Cassio would be just like the

¹⁰ For a defence of this view of intentional relation, see Andrew Newman, *The Correspondence Theory of*

love relation from Cassio to Desdemona but with the opposite sense. It is indeed the converse relation by the definition of converse relations. But because it is not necessarily instantiated, the instantiation postulate, the first thesis from Armstrong, is false.

Although not all pairs of relations that differ only in sense are necessarily instantiated together, there is no reason why there should not be pairs of relations that differ only in sense and are necessarily instantiated together, or to put it more precisely, there is no reason why a relation with sense should not be instantiated twice between two particulars, both going one way and going the other way. Whether the converse relation is instantiated or not depends on the kind of relation. In the case of *intentional relations*, the instantiation of the converse relation is entirely contingent. In the case of *order relations*, necessarily the converse relation is not instantiated. The next sections give an example of a kind of *vector relation* that is such that a relation and its converse are necessarily instantiated together.

3. Vectors and Relations

With all due respect to Heraclitus, who is supposed to have said that “the path up and down is one and the same”¹¹, it does appear to the traveller, particularly to the traveller on foot, that the downhill journey from say Jerusalem to Jericho is different from the uphill journey from Jericho to Jerusalem, a distance of about 15 miles and a difference in

Truth, pp. 124-7

¹¹ G. S. Kirk and J. E. Raven, *The Presocratic Philosophers* (Cambridge: Cambridge University Press, 1963), Fr. 203.

height of about 3,600 ft. If the journeys are different, and there is something objectively significant about direction, then there is a sense in which the spatial relation in one direction is different from the spatial relation in the other direction. But, someone will argue: surely Jerusalem should be placed in the uphill slot of the dyadic spatial relation, and Jericho in the downhill slot; the ideas of uphill and downhill are merely how travellers experience a spatial relation, which is in itself indifferent to which way they are travelling. This suggestion certainly makes sense, but we should look more closely at spatial relations.

Moving to the cities of the plain, so that direction and sense can be specified by means of the points of the compass, three types of dyadic spatial relation can be distinguished:

- a) the scalar magnitude — “*they* (Omaha and Lincoln) are 60 miles apart”,¹²
- b) the scalar magnitude and direction — “*they* (Omaha and Lincoln) are SW-NE 60 miles apart”,
- c) the scalar magnitude, direction, and sense — “Lincoln is 60 miles south-west of Omaha”.

To be precise, direction is something that specifically excludes sense and is represented by ‘SW-NE’, while direction and sense, which is a single thing, is represented by ‘SW’.

What is at issue is whether the sense of a spatial relation has any metaphysical significance. A type-c spatial relation is a *vector displacement* rooted at one particular and directed towards another, and clearly such relations always, and presumably necessarily, occur in pairs with opposite senses. If such vector displacements are

¹² A form suggested by David Lewis, see Armstrong, *A World of States of Affairs*, p. 91.

reckoned as part of reality, then it is an example of a real relation and its converse relation that are necessarily instantiated together.

4. Velocities as Vectors

The purpose of this next section is to give an argument for vector displacements being real relations on account of their connection with velocities. The argument is that velocities are real attributes and since a velocity is the rate of change of a vector displacement, not a rate of change of the other two types of dyadic spatial relation, this strongly suggests that vector displacement is a real relation. The rest of this section is a summary of an argument given by Bigelow and Pargetter that instantaneous velocity is a real attribute.¹³

¹³ John Bigelow and Robert Pargetter, *Science and Necessity* (Cambridge: Cambridge University Press, 1990), pp. 62-74. Cf. Armstrong, *A World of States of Affairs*, pp. 76-80, who discusses velocity as his primary example of vectors and then extends the conclusions to other vectors, including forces. Peter Forrest has argued that vectors are not universals, since on account of the curvature of space each vector can only be instantiated by one particular at a given time. On the other hand, it can be argued that each vector maintains its intrinsic potential to occur at many places at the same time even if space is curved, but is prevented from exercising that potential by the local curvature of space. If the space were to become flat in the neighbourhood of a particular instantiating a vector, the vector would at once be able to exercise its potential for multiple location within that neighbourhood. That matter curves space has to do with physical necessity, while a vector's potential for multiple location is a matter of logical necessity. Peter Forrest, "Space Curvature and Repeatable Properties: Mormann's Perspectival Theory", *Australasian Journal of Philosophy* 74 (1996), pp. 319-323,. See also "New Problems with Repeatable Properties and with Change", *Nous* 24 (1990), pp. 543-556.

They defend what they call the doctrine of flux, which is that at an instant of time in addition to a position a body in motion possesses an instantaneous velocity, which is a real attribute and not a mathematical fiction, and that velocity explains the sequence of positions and not vice versa.¹⁴ There is an obvious relation between velocity and position in that a velocity can always be calculated from a sequence of positions. If a particle a has position \mathbf{x} with respect to a particle b , and \mathbf{x} is a function of time, $\mathbf{x}(t)$, then the velocity of a relative to b is defined as:

$$\mathbf{v} = \lim_{\delta t \rightarrow 0} \frac{\{\mathbf{x}(t + \delta t) - \mathbf{x}(t)\}}{\delta t}.$$

This is the standard way of “defining” velocity as a vector, using the notation of the physicists, in terms of the derivative with respect to time of the position of a point that changes its position continuously. Given a continuous sequence of positions that vary with time, a velocity can at least always be related in this way to the sequence of positions. In this definition position has to be understood as vector displacement.

It appears from the definition that the series of displacements explain velocity. In order to argue that it is velocity that explains the series of displacements, it must *first* be shown that the two are independent of each other to some degree. Bigelow and Pargetter argue for a degree of independence as follows. (1) It is possible for there to be a continuous sequence of positions at different times without there being a velocity vector as a real attribute. This is shown by the fact that a velocity can be calculated for a moving spot of light; but in this case the velocity is just a mathematical fiction and not a real attribute because no body is moving. (2) It is possible for there to be a velocity

¹⁴ Bigelow and Pargetter, *Science and Necessity*, p. 65.

vector as a real attribute without there being a continuous sequence of positions at different times. This is shown by the fact that the middle ball in Newton's Cradle possesses an instantaneous velocity even though it does not move at all and therefore does not move through a continuous sequence of positions.¹⁵

Secondly, they argue that velocity is a real attribute, because if a sequence of positions is occupied by the same body, then the only explanation is that the object must have been moving if it was to get from one position to the next.¹⁶ This they say makes it a matter of logical or metaphysical necessity that velocity is a real attribute. The argument assumes that bodies continue in existence through time (endurantism) and it assumes that God does not create the very same body over and over again each instant — Bigelow and Pargetter consider this last possibility to be a counter example, but I am not so sure. In any event, I am happy to make both these assumptions. They also argue that given the laws of nature as we know them, instantaneous velocity is the only way of getting a body from place to place, making it merely a matter of physical necessity that

¹⁵ Newton's Cradle with rigid spheres shows that it is physically possible in worlds governed by Newtonian Mechanics for a body to have a finite velocity for only an instant of time and not move through a related sequence of positions. It also shows that it is logically possible, even though Special Relativity does not allow for rigid bodies. Newton's Cradle consists of three (or more) balls with collinear centres, usually suspended in some way; two are touching and the third moves towards them and strikes the nearer ball; the incoming ball and the nearer ball stop still while the farther ball continues with the velocity that the incoming ball had. The middle ball, even though it does not move, transfers momentum, and therefore it possesses momentum just for an instant; if it possesses momentum just for an instant then it possesses velocity just for an instant.

¹⁶ Bigelow and Pargetter, *Science and Necessity*, p. 69.

velocity is a real attribute. They conclude that a sequence of positions plus numerical identity of an object through time entails that the instantaneous velocity is real attribute.¹⁷

Some explanations are in order. In the case of a moving point of light, the velocity will be a mathematical fiction and the sequence of positions will explain the velocity, whereas in the case of a moving particle or body the velocity will be a real attribute and will explain the sequence of positions. However, in this case the vector displacements are also fictions, because a vector displacement is a relation and as such must be instantiated by two particulars, and whatever a moving spot of light is it is not a particular. In the case of the middle ball of Newton's cradle, the velocity that it possesses for only an instant would have given rise to a sequence of positions, but the ball simply did not possess the velocity long enough to realize this potential.

5. Forces as Vectors and Relations

In two fundamental cases, gravity and electrostatics, the force that causes a body to

¹⁷ Because of its role in physics, momentum is clearly a real attribute, and, therefore, velocity should be a real attribute. If a particle changes its spatial relations with other particles, then it is possible to define the velocity of the particle as the rate of change of any of those spatial relations, and in each case the components of the velocity vector would be different. All those different values for the components of the particle's velocity are merely different ways of presenting the same thing. In the same way that a particle can have only one position at a given time, so also a particle can have only one velocity at a given time. In tensor calculus when there is a transformation of coordinates the velocity will have different components in the new coordinate system, but there is an underlying assumption that it is the same vector whichever system of coordinates it is expressed in. But the fact that a velocity must be expressed in terms of relations with other particles does not imply that velocity is a relation.

accelerate lies in the direction of another body and either points towards it or away from it, with the magnitude of the force depending on the distance between the two bodies. Generally, there are forces only when two different bodies interact; when there is only one body there may be a field, and though some may call it a force field, it exerts a force only when a suitable particle is present. If two bodies interact there must be a relation between them, and in the case of gravitation attraction and electrostatic attraction and repulsion the force between them seems the most obvious candidate for being that relation. These considerations suggest that forces are relations.¹⁸ Now the force that makes a body accelerate is something with magnitude, direction, and sense, in other words a vector. And because of their causal significance forces should be regarded as metaphysically real, in fact, as real, vector relations.

Forces originate in the interactions between pairs of bodies, and occur in *converse* pairs, according to Newton's third law of motion — if body *a* exerts a force *F* on body *b*, then body *b* exerts a force $-F$ on body *a*.¹⁹ Now it could be suggested that the necessary

¹⁸ Resultant forces are not relational, since they do not have to point at some other body, and on this view they are constructions, since they are always formed by combining forces that are relational. The parallelogram law does not tell us how to calculate what other force comes into being, but merely how to calculate the effect of a number of forces acting together, see Andrew Newman, *The Physical Basis of Predication* (Cambridge: Cambridge University Press, 1992), pp. 150-4.

¹⁹ Referring us to Sections 5.5 and 5.6, Armstrong says “. . . the force *is* a property of the force-exerting body, though a property either semantically picked out via its potential effects (Categoricalism) or even essentially linked to such effects (Dispositionalism).” *A World of States of Affairs*, p. 93. Later he decides between these possibilities: “We argued in Ch. 5 that they [forces] are categorical properties of the things exerting the force, properties instantiated at the time the force is being exerted, but categorical properties

co-instantiation of a force and its converse is a matter of physical necessity, being required by Newton's third law, and not a matter of the metaphysical necessity, or broadly logical necessity, that is required for a true converse relation. On the other hand, it is conceivable that it is part of the nature of forces that they occur only in converse pairs, or more precisely, necessarily, if a force is instantiated between two particulars it is also instantiated between those particulars in the other direction. And so it is at least conceivable that forces provide an example of a relation necessarily being co-instantiated with one just like it but with opposite sense, and the relation and its converse having distinct causal effects. It could also be suggested that there were physical converse pairs of relations, which were always instantiated together as a matter of physical necessity, and that there were also logical converse pairs of relations, which were always instantiated together as a matter of logical necessity.

According to the linguistic view of converse relations, the true converse of a relation is whatever is described by the passive sentence, so that while the sentence '*a* exerts a force *F* on *b*' describes a relation force, the sentence '*b* is subject to a force *F* exerted by *a*' describes the converse force relation. If this were true then there would be four relations that necessarily occur together. But according to the metaphysical view of converse relations there would be just two relations.

described in terms of what they tend to bring about.", p. 214. He seems to allow that velocities could be relational, but that forces are not relational, despite the fact that his main arguments about vectors concern velocities.

6. The Independence of States of Affairs

For Armstrong each state of affairs is a contingent being and each state of affairs is independent of all other states of affairs. States of affairs are independent of each other if and only if no conjunction of states of affairs, including unit conjunctions, entails the existence or non-existence of any wholly distinct state of affairs.²⁰ He has to go to some lengths to preserve the independence thesis, by suggesting, for example, that time is atomic in order to deny that the temporal relation “before” is strictly speaking transitive,²¹ and by suggesting that time might be cyclical in order to avoid the inference if *a* is before *b* then necessarily *b* is not before *a*.²²

The *structural identity condition* for states of affairs, which is the one that he proposes, is that states of affairs are identical if and only if they have exactly the same constituents (particulars, properties, and relations) organized in exactly the same way.²³ According to this criterion of identity, a state of affairs involving a relation is different from the state of affairs with the same particulars instantiating the same relation going in the other direction (the converse), because according to the metaphysical understanding of the sense of a relation, the instantiation of a relation and the instantiation of the same relation with opposite sense, are distinct instantiations. According to this view sense is an objective feature of a relation. We have, therefore an example of two different states of affairs that necessarily occur together. However, the linguistic understanding of

²⁰ Armstrong, *A World of States of Affairs*, p. 139.

²¹ Armstrong, *op. cit.*, p. 141-2.

²² Armstrong, *op. cit.*, p. 144.

²³ Armstrong, *op. cit.*, p. 131-2.

converse relations, which we have had reason to reject, leads to the view, expressed by Armstrong, that there is only one state of affairs.²⁴

Armstrong also mentions the empirical identity condition for states of affairs, which declares that states of affairs are identical if and only if they necessarily co-exist.²⁵ He says that he regards it as a true identity condition for states of affairs but of secondary importance, though others, such as Kenneth Olsen and Kit Fine, regard it as the primary identity condition. The difficulty with the empirical identity condition is that it makes the thesis that states of affairs are independent true by definition.

Both Williamson and Armstrong in their discussions of converse relations claim that converse relations represents no increase in being. Indeed, if there were nothing more to the notion of a converse relation than the supposition that the converse relation is something described by linguistic expressions cast into the passive voice, why then of course there would be no reason to suppose there is any increase in being, and it would be obvious that the instantiation of the relation with opposite sense represented no increase of being. But the standard definition of a converse relation is not phrased in linguistic terms at all; it allows for the possibility that relations could be objectively, metaphysically distinct from their converses. The difficulty for Armstrong with having a relation and its converse differing in an objective, metaphysical way is that there would be two states of affairs that necessarily obtain together, so that it would not be the case that all states of affairs are independent.

²⁴ Armstrong, , *op. cit.*, p. 143.

²⁵ Armstrong, , *op. cit.*, p. 133.