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PETER FORREST

# Sets as Mereological Tropes

Either from concrete examples such as tomatoes on a plate, an egg carton full of eggs and so on, or simply because of the braces notation, we come to have some intuitions about the sorts of things sets might be. (See Maddy 1990) First we tend to think of a set of particulars as itself a particular thing. Second, even after the distinction between set-theory and mereology has been carefully explained we tend to think of the members of a set as in some sense parts. And third we tend to think that there is something represented by the braces. Now if there were experts who got their intuitions from elsewhere then we could discard these rather crude ideas about egg cartons and so on. But I suspect the intuitions of experts are, just like those of the rest of us, based on notation and simple examples.

Doing full justice to our homely intuitions about sets might well require that we abandon classical mereology and treat the members of a set as quite literally parts of the set. In this paper, however, I explore an alternative, in which sets are identified with mereological tropes. To motivate this account let us first ask what is the difference between {a,b} and a + b, as it might be the set whose members are two volumes of a dictionary and the dictionary itself which is the sum of the two volumes? One difference is that we might think of the braces {,} as somehow standing for something. But more important is that initially at least when we divide up {a,b} a and b remain intact, whereas a + b can be divided up directly into the parts of a and b, say the 1,200 pages.

This suggests the following intuitively appealing account of sets: a set is something considered as having *these* parts (its members) rather than as having *those* parts. Of course, considering it a certain way

cannot stop it having other parts, but we are to ignore its other parts. This account might be worth developing as a substitute for realism about sets, but a realist theory it is not, for what we "consider" is mind-dependent. So for a realist theory of sets we should seek something real corresponding to something, c, considered as having characteristic F. There seem to be two candidates, the states of affairs *that c is F* or the trope *c's F-ness.* I am suggesting, then, that a set whose members are a, b etc is c-with-a-b-etc-as-parts for some c which has a, b etc as parts. And we have yet to decide if c-with-a-b-etc-as-parts is to be taken as the state of affairs *that c has a, b etc as parts* or as the trope *c's having a, b etc as parts*

Let us consider again {a,b}. In this paper I shall follow Lewis (1991) and take {a,b} to be {a} + {b}. The singleton {a} is the abstract particular c-with-a-as-a-part, and {b} the abstract particular d-with-b-as-a-part. {a,b} is the abstract particular e with-a-and b-as-parts. Whether they are tropes or states of affairs the Lewis equation {a,b} = {a} + {b} holds if and only if c = d = e. There is then only one plausible candidate for c, namely the sum of everything — call it Ω — and we may think of the braces as referring to the sum of everything disjoint from every member of the set.

The hypothesis, then, is that a singleton {a} is either to be taken as the state of affairs *that* Ω *has a as part* or as the trope Ω*'s having a as part.* What is the difference between the *that b is F* and *b's F-ness*? One difference, perhaps the only difference, is this: *that b is F* has b as a constituent, whereas *b's F-ness* is itself a part of b. So now let us consider sets of sets, such as {{a}}. Ω would be a constituent of the state of affairs *that* Ω *has a as part.* Hence this state of affairs cannot itself be proper part of Ω. For any part is a constituent and the only way in which x and y can be constituents of each other is if x = y. Therefore there could be no such entity as {{a}}. However this problem does not arise in the case of tropes. For tropes of the form Ω*'s being F* are parts of Ω. We reach the conclusion then that this intuitively motivated account of sets requires sets not to be identified with states of affairs but rather with mereological tropes which are sums of ones of the form Ω*'s having z as a part*, where z ranges over all members of the set in question.

If we adjoin the null element ø, classical mereology becomes a complete Boolean algebra, so whether or not we are realists about ø it is convenient to adjoin it. In that case ø will also perform the role of the null set Ø and {Ø} will be Ω's having ø as a part.

Do we have a set {Ω}? That would be Ω's having Ω as a part. So do we mean "part" or "proper part"? We could stipulate either way, but there is something peculiar about allowing tropes of the form: x's having x as a part. So take "part" to mean "proper part".

## *Problems*

The first and most obvious problem with treating sets as mereological tropes is that there seem to be necessitation relations between tropes, so that Ω*'s having b as a part* necessitates Ω*'s having c as a part* if c is part of b, for nothing can have b as a part without having c as a part too. But sets with b as a member do not always have c as a member. Likewise the sum of the tropes Ω*'s having b as a part* and Ω*'s having d as a part* necessitate, the trope Ω*'s having (b + d) as a part.* But sets with b and d as members do not always have b + d as a member too. The solution to this problem is to grant that one trope x can necessitate another trope y without y being part of x. If b is part of c then the existence of Ω*'s having b as a part* entails the existence of the trope Ω*'s having c as a part.* But all this shows is that the existence of {b} implies the existence of {c}, as it should.

Another problem faced by a trope theory of sets is that we might have to use sets as a tool in trope theory. We should check that this results in neither confusion nor absurdity. Thus if we identify a universal with a set of tropes we will find that the universal itself becomes a rather special trope, and instantiation has a mereological interpretation. Consider the universal *being a sphere*. This would be identified with a set of resembling tropes, *a's being a sphere, b's being a sphere* etc. That in turn is to be identified with the sum of: Ω*'s having as part a's being a sphere,* Ω*'s having as a part b's being a sphere* etc. If Ω were replaced in this analysis by something smaller, such as the sum of all spheres, then this would be a counter-intuitive identification. It is, however, perfectly appropriate that Ω — everything — should be the

"locus" of the trope which we identify with a universal. So there seems to be no problem here either.

The third problem is both a threat and an opportunity. An ontology of sets should resist paradox without ad hoc manoeuvres. If it does then this supports the account given. And in this case we are able to resist paradox by appealing to philosophical intuitions which pre-date set theory. For mereological tropes exist *in virtue of* other tropes, that is they are both entailed and explained by other tropes. For instance {b}, that is the trope of Ω*'s having b as a part,* exists in virtue of the tropes of which b is the sum. To avoid paradox we may state a general Well Founding Principle, namely that the existence-in-virtue-of relation must be well-founded. Assuming the Axiom of Choice this amounts to denying an infinite regress of $x_1$ existing in virtue of, among other things, $x_2$ which exists in virtue of, among other things, $x_3$ etc. Such a rejection of an infinite explanatory regress is independently plausible and predates set theory. It is for instance a premise used in cosmological arguments for the existence of God. Sets considered as mereological tropes are subject to this requirement, which prevents there being paradoxical sets.

## *Comparisons*

We may conclude by comparing the identification of sets as mereological tropes with other recent accounts of sets. If we aim to follow Lewis (1991) in treating subsets as parts of sets and if we aim to treat sets as particulars then there are two other accounts available. First there is Lewis's own primitivism about the singleton operator. If we can avoid such primitivism we should do so and hence if we are otherwise inclined towards a trope theory we should prefer the mereological tropes thesis.

The other recent account is Armstrong's (1991). On it sets are states of affairs, whose atomic parts are the singletons, where {b} is the state of affairs of b having unithood, where *unithood* is the property of having some unit-determining property and where a *unit-determining* property is one such that 'a thing falling under the property is just *one* thing of that sort …' (Armstrong, 1991, p. 197.) Now any non-class

L. NATHAN OAKLANDER

# McTaggart's Paradox Defended

No argument has done as much to stimulate debate in the philosophy of time as McTaggart's argument for the unreality of time.[1] On the one side are A-theorists who believe McTaggart's positive thesis that time involves the A-series and temporal passage, but deny his negative thesis that the A-series and temporal passage are contradictory.[2] On the other side are B-theorists who believe that McTaggart's positive conception of time is mistaken, but that his negative thesis is true.[3] At least part of the reason why McTaggart's paradox has failed to convince defenders of passage is because they fail to appreciate his positive thesis and thereby misunderstand the rationale behind his negative thesis. The purpose of this paper is to prove that point. I shall proceed by first explicating what I take McTaggart's positive and negative theses to be. I shall then show how and why one recent response to McTaggart's paradox, which is representative of many, is unsuccessful because it misunderstands it. And finally, I will explain how a subsidiary benefit of my account of McTaggart's paradox is that it can provide a clear criterion for distinguishing passage from non-passage views of time.

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[1] J.E.M. McTaggart, "Time," in C. D. Broad (ed.), *The Nature of Existence*, vol. 2 (Cambridge: Cambridge University Press, 1927; reprinted Grosse Pointe, Michigan: Scholarly Press, 1968): 9-31. All page references will be to the 1968 edition. J.E.M. McTaggart, "The Unreality of Time," *Mind* 18 (1908), pp. 457-74 , reprinted in S.V. Keeling (ed.), *Philosophical Studies* (London: Edward & Arnold & Co., 1934): 110-34. All page references will be to *Philosophical Studies*.

[2] See for example, Quentin Smith, *Language and Time* (New York: Oxford University Press, 1973). William Lane Craig, *The Tensed Theory of Time: A Critical Examination* (Dordrecht: Kluwer Academic Publishers, 2000). William Lane Craig, *The Tenseless Theory of Time: A Critical Examination* (Dordrecht: Kluwer Academic Publishers, 2000). Michael Tooley *Time, Tense and Causation* (Oxford: Clarendon Press).

[3] See for example, Robin Le Poidevin, *Time, Cause and* Contradiction: *A* Defense of the Tenseless Theory of Time (Basingstoke: Macmillan, 1991). D. H. Mellor, *Real Time* II (London: Routledge, 1998).

L. Nathan Oaklander, Temporal Relations and Temporal Becoming: A Defense of a Russellian Theory of Time (Lanham: MD: University Press of America, 1984).

According to McTaggart, we ordinarily (or commonsensically) conceive of time as involving the notions of past, present and future (A-determinations) and earlier than/later than and simultaneous with (B-relations). Although McTaggart claims that the A-series (defined in terms of A-determinations) and the B-series (defined in terms of B-relations) are both essential to our *ordinary* concept of time, he believes that A-determinations and the A-series are more fundamental, more ultimate and more essential to the *ontological* nature of time than B-relations and the B-series. In fact, his view is that the B-series is dependent on the A-series, not only because there would be no B-relations unless there were A-determinations, but more fundamentally, because the B-series is ontologically reducible to the A-series and the non-temporal C-series. The C-series gives the B-series its permanent *order*, and since the C-series contains a genuine (non-temporal) relation, when it is conjoined with the A-series the two series together give time a *direction* by providing a metaphysical basis for the temporal B-series.[4] In other words, the A-series and the C series are jointly necessary and sufficient for, and thereby the ontological ground of, B-relations.

The evidence that McTaggart does in fact hold the positive view of time that I am attributing to him is both textual and structural. That is, on the one hand, he basically says what I say he does, and on the other, by interpreting him as I do we can make sense of his argument that the A-series is contradictory and that therefore, time is unreal. I shall consider the textual evidence first. McTaggart says that the A-series and the C-series are jointly *sufficient* to constitute the B-series:

> We can now see that the A series, together with the C series, *is sufficient to give us time*. … Thus to our previous conclusion that there can be no time unless the A series is true of reality, we can add the further conclusion that *no other elements are required to constitute a time-series except an A series and a C series* …[5]

Furthermore, the C-series and the A-series are jointly *necessary* for the B-series.

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[4] Whatever its virtues or vices, McTaggart offered the following definition of "earlier than": "The term *P* is earlier than the time *Q*, if it is ever past while *Q* is present, or present while *Q* is future" (McTaggart 1927, 2, p. 271).

[5] McTaggart, "The Unreality of Time," *op. cit.*, p. 118; emphasis added.

> The C series, however, is as ultimate as the A series. And this — the B-series — cannot be got out of the A-series alone. It is *only when* the A-series, which gives change and direction, is combined with the C series, which gives permanence that the B series can arise. (p. 118, emphasis added.)

The words "only when" signify that the A series and the C series are necessary for the B-series, and his claim from the previous quote that "no other elements are required to constitute a time series except an A series and a C series" (p. 118) implies that they are sufficient for the B-series as well.

Finally, McTaggart claims that while the A-series and the C-series are each ultimate,

> The B series, on the other hand, is not ultimate. For given a C series of permanent relations of terms, which is not in itself temporal and therefore is not a B series, and given the further fact that the terms of this C series also form an A series, and it results that the terms of the C series become a B series, those which are placed first, in the direction from past to future, being earlier than those whose places are farther in the direction of the future. (p. 118)

I think that these passages make it clear that for McTaggart there are no ontologically primitive or simple temporal relations. Metaphysically, time is entirely constituted by the A-series, and it together with the non-temporal but ordered C-series ground the commonsense view of time as involving *both* A-determinations and B-relations.

My interpretation is not only textually sound, but it also enables us to clearly bring into view the central issue in McTaggart's paradox, namely, the ontological status of *succession*, the B-relations of *earlier/later than* and *simultaneity*, and the *direction of time and change*. To see what is involved consider that time and change not only have an *order* they also have a *direction*, or what C. D. Broad referred to as an "intrinsic sense" in *Scientific Thought*[6] and as an "*intrinsic* direction" in his *Examination of McTaggart's Philosophy*[7]. If we have three objects M, N and O, then either M is between N and O, or O is between M and N, or N is between M and O, and this is so from any point of

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[6] C. D. Broad, *Scientific Thought* Broad, (London: Routledge and Kegan Paul Ltd., 1923). Reprinted in (Patterson, New Jersey: Littlefield, Adams & Co. 1959). The phrase "intrinsic sense" is quoted from the 1959 edition, p. 61.

[7] C. D. Broad, *An Examination of McTaggart's Philosophy,* vol. 2, pt. 1 (Cambridge: Cambridge University Press, 1938), p. 269.

view. But regardless of what order a series has, that still leaves two different directions. If, say, N is between M and O, then the *sense* or *direction* of the series can be either MNO or ONM. To say that time and change have an intrinsic sense means that if MNO is the direction of change, then that is the direction from any point of view. Thus, for example, if an apple is *successively* green, red and brown, then it is green *before* it is red and it is red *before* it is brown. The direction of change from green to red to brown is intrinsic to the series since it changes in that direction from any point of view. The intrinsic direction of time is that feature that distinguishes a temporal series from a spatial series, since the direction of a spatial series is extrinsic to the terms since it depends on a point of view outside the series.[8] What, then, is the ontological basis for the direction of time and change, that is, for the *succession* of one event/thing/time coming *after* another? Giving the A-theory answer to that question leads us directly to McTaggart's paradox.

On the A-theory, according to McTaggart, the direction of time is grounded in the application of the A-series to the C-series. That is, if there is a C-series in which A is related to B is related to C in that order, and if A is past, B is present and C is future, then we have a temporal series with an intrinsic direction: A is earlier than B is earlier than C from any point of view. The direction of time is from A to B to C and not the other way around. It is important to emphasize that McTaggart does *not* being by assuming that every event is (timelessly or simultaneously) past, present and but, but rather he denies it. Thus, the common critique of McTaggart that he errs at the first step by *assuming* every event is past, present and future is a *non-sequitor*. On the con-

[8] Broad sums this up in the following passage that I shall quote at length:

In the temporal series of experiences that constitutes a person's mental history there is a genuine dyadic relation that is intrinsic to the series and involves no reference to any term outside the latter. This is the relation of "earlier than". … In the temporal series there are two intrinsically opposite directions, earlier-to-later and later-to-earlier. In the linear spatial series there is no *intrinsic* direction. If direction is to be introduced, this must be done *extrinsically*, either by reference to motion along the line (and therefore to time), or by reference to the right and left hands of an external observer, or in some other way. (*Examination of McTaggart's* Philosophy, *op.* cit. vol. 2, p. 269)

TOMIS KAPITAN

# The Ontological Significance of Variables

## *1. Introduction: The Issue*

The use of single letters in displaying patterns, functions, generalizations, and unknowns, dominates mathematical expression, and for that reason, appears in every domain of theoretical and technical discourse employing even the slightest bit of mathematical language. These *variables*, as they have come to be called, are the very mark of abstract power and precision, ingenious tools for expressing functionality and valid formulae and, thereby, for providing solutions to *types* of problems as well as facilitating the calculation of unknowns. Compare, for example, the ease with which we grasp and work with the formula,

(1) $(x - y)^2 = x^2 - 2xy + y^2$

over its more cumbersome counterpart,

(2) The square of the difference between one number and another is equal to the difference between the square of the first number and twice the product of the two numbers plus the square of the second number.

As with mathematical symbolism generally, the advantage of variables is the brevity with which a clear and concise representation of relationships and patterns is achieved — "they have invariably been introduced to make things easy" (Whitehead 1911, 549-60). The letters 'x' and 'y' in (1) perform more efficiently the work of expressions like 'one number,' and 'another' in (2), and unlike 'the first number' and 'the second number,' they secure a semantic difference without suggesting a distinction of values. Moreover, by combining with constants into functional terms such as '2xy', they permit a speedier grasp of what is expressed by lengthier descriptions such as 'twice the product of the two numbers.' The same efficiency is evident when they substitute for the pronouns in,

(3) The cube of a number equals the product of itself and its square.

to yield,

(4) $x^3 = x \cdot x^2$.

Russell could not have been far from wrong when he wrote that the variable is, "from the formal standpoint, *the* characteristic notion of Mathematics," nor Tarski who remarked that "the invention of variables constitutes a turning point in the history of mathematics."[1]

Despite these credentials, variables have been largely ignored in philosophical discussions of language. There are various reasons for this neglect. *First*, as abbreviations, variables represent no semantic novelty. Anything that can be said by their means can also be said with pronouns and descriptive phrases, illustrating that natural language devices serve equally the relevant linguistic role. The use of single letters achieves a laudable economy of expression and ease of comprehension, but their *raison d'être* is purely pragmatic. *Second*, viewed separately, variables lack the autonomy of constants or referring expressions, leading some to conclude that they are syncategorematic and "do not have a meaning by themselves," or, "have no meaning," or, that each is "ambiguous in its denotation and accordingly undefined."[2] The important semantic and representational issues concern what the larger linguistic structures containing variables express. *Third*, even if we allow that variables are meaningful bits of discourse, their semantics is thoroughly understood in terms of the semantics of quantification. Variables are simply devices for speaking generally about domains of entities. Combined with quantifier expressions, they are convenient vehicles for predicating distributively of entire domains and for expressing ontological commitments in accord with

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[1] Russell 1964, p. 90, and Tarski 1941, pp. 13-14. Benson Mates reminds us that the variable graces the non-technical arena as well; witness the *Mikado*: "See how the Fates their gifts allot, for A is happy — B is not. Yet B is worthy, I dare say, of more prosperity than A." (Mates 1965), p. 20.

[2] These quotes are, respectively, from Tarski 1941, p. 4; Leonard 1967, p. 444; and Whitehead and Russell 1962, p. 4. That variables are ambiguous is also mentioned in D. Hilbert and W. Ackermann 1950, p. 168, and in Brody 1967, p. 77, which defines a variable as "an ambiguous name of any one of a class of things." See also Eaton 1931, p. 60: "The *x*'s, *y*'s, and *z*'s are *variables* because they have no determined meanings."

the "to be is to be the value of a variable" formula. Their presence within true quantified sentences points to nothing beyond the items in their ranges, in which case there is really no interesting question about what variables commit us to ontologically that is in any way different from what their substituends represent.

Yet these considerations do not settle the issue about the ontological significance of variables. To the first, even if we grant that the pronouns and descriptive phrases of natural languages can do the work of variables, questions can be raised about the meanings of such pronouns and descriptions. Obviously these "indefinite indicators," as Frege called them (1960, p. 72), are not singular referring expressions that designate particular numbers, nor are they general terms for properties, functions, and the like. Like variables, each has the remarkable feature of behaving syntactically like a singular term while conveying the generality of a common noun. What is their ontological significance? How do we understand Frege's claim that each "indefinitely indicates" (*andeuten*) any item of a certain sort (p. 181)? As for the second reason, it seems odd to characterize variables as meaningless or ambiguous given that variables are the principal vehicles for demarcating form from content, and that their emergence paved the way for the dramatic developments of 17th Century mathematics. It is doubtful that justice is served by describing them as ambiguous, undefined, or worse, meaningless; variables achieve what they do because they are so efficient and precise in conveying information, and this is not something we usually associated with ambiguity and meaninglessness. Finally, the semantics of generality do not solve the ontological problems of what variables represent. This is not only because of Russell's famous point that generality is ineliminable in setting forth truth-conditions of quantified formulae, but also because generalizations over empty domains challenge extensionalist reductions of quantifiers. More importantly, in displaying patterns, variables have representational uses quite apart from their roles in expressing generalizations.

If these points are correct, serious questions remain. Just what information do variables and their natural language counterparts convey? How exactly do they differ from "constants," and what do they reveal about the subject-matters they are used to talk about? What do

these expressions indicate about the structure of reality? In this paper I will attempt to answer these questions by developing an account of what variables and their counterparts represent.

## *2. Some Data on Variables*

Let us focus on variables as a source for speculating about for the broader class of indefinite indicators. Individual letters are used in different ways in mathematics. Some, like '$\pi$' and 'i', are routinely treated as constants, but, since the times of Francois Viète and Descartes, at least four distinctive uses of letters *as* variables have become standard:

*Proxies*: Variables are used as proxies for terms designating what is unknown and to be discovered, and also as proxies for fixed yet undetermined parameters.

*Generalizability*: Variables are used to express generalizations.

*Term Forming*: Variables are used in the construction of complex terms (e.g., functional, property, and class abstracts).

*Abstractive*: Variables are used to depict patterns, the orders of structured complexes.

Informally, a *structured complex* is any complex entity constituted by an arrangement, ordering, or relationship of entities. For every structured complex there are various ways in which its components are ordered or interconnected so as to constitute that complex. Each such way is a complex relation, or, as I shall speak, a *structuring* of those components (see section 7 below). A *pattern* is a property that a structured complex exhibits by virtue of being constituted by certain kinds of components in a given manner. Since variables are used to represent both the kinds and the structurings, then they are devices for representing abstractions.

This diversity of funciton raises the question whether there is just one syntactic or semantic category — the *variable* — that achieves all these tasks. Frege, for one, used different sorts of signs to function as placeholders in functional expressions on the one hand, and to complete quantificational formulae on the other (see note 6). He cautioned

MAX KISTLER

# The Causal Criterion of Reality and the Necessity of Laws of Nature

I propose an argument for the thesis that laws of nature are necessary in the sense of holding in all worlds sharing the properties of the actual world, on the basis of a principle I propose to call the Causal Criterion of Reality (CCR). The CCR says: for an entity to be real it is necessary and sufficient that it is capable to make a difference to causal interactions. The crucial idea here is that the capacity to interact causally — or to contribute to determining causal interactions — is not only the ultimate metaphysical ground for the *existence* of an entity, but it also provides a criterion for determining the *nature* of that entity, i.e. its properties.

The alternative is to conceive of laws of nature as contingent[1]: they could be different from what they are like in the actual world, where that possibility is understood to be metaphysical, not only epistemic. For the sake of this paper, I shall accept Armstrong's (1983; 1997) thesis that laws of nature are relations between universals. I also follow Armstrong in the view that both the existence and the properties of *particulars* are metaphysically independent of the existence and identity of other particulars[2]. However, what is controversial and what I shall challenge is his thesis that *universals* are like particulars in the following respect: according to Armstrong, each universal is a logically distinct entity whose existence and identity is independent of the existence and identity of other universals. My aim in this paper is to show that the identity of a universal is entirely determined by its lawful relations to other universals. The crucial premise I use is the thesis that the CCR is a universal criterion, which applies both to particulars and universals. From the thesis that the identity of a uni-

[1] Cf. Armstrong (1983, chap. 11), Armstrong (2000), Lewis (1986b, p. 163).

[2] Their existence and properties are of course *causally* dependent on other things, but it is metaphysically possible that they exist and have the properties they actually have even if their actual particular causes and effects don't exist. In other words, the causal relation between particular events is an external relation.

versal is exclusively determined by laws, it follows that laws are necessary in the sense that they cannot differ without the universals they link also being different. This creates a difficulty for those authors who, as Armstrong, accept the CCR but nevertheless defend the view that laws are contingent.

## *1. The Causal Criterion of Reality*

According to a traditional metaphysical principle, all and only those entities exist which make a causal difference. Armstrong has called it the "Eleatic principle" by reference to its formulation by the Eleatic Stranger in Plato's *Sophist*[3]. In Armstrong's words, "everything that exists makes a difference to the causal powers of something" (Armstrong 1997, p. 41), and conversely, I should add, everything that makes a difference to the causal powers of something, exists[4]. This Causal Criterion of Reality can serve as a justification of the postulation of the existence of both particulars and universals. It can be justified by the claim that it is a central part of scientific methodology. One version of scientific realism consists in extending its validity to cover even metaphysics[5].

First, the postulation of the existence of *particulars* has a causal background: Particulars are needed to make the existence of universals compatible with the acceptance of the CCR, for universals cannot interact causally by themselves but only through their instantiation in particulars. Conversely, just as there cannot be causal interactions without particulars that interact, there cannot either be particulars that do not, in principle, interact. Accepting the CCR forbids the postulation of particulars that are absolutely causally idle — the probability

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[3] Plato, *Sophist*, 247d-e.

[4] Armstrong himself insists that the CCR is only methodological but not metaphysical. See discussion below, in the conclusion. Jaegwon Kim has called it "Alexander Dictum" (Kim 1992, p. 134), in honour of Samuel Alexander (1920) who has defended it as a metaphysical principle: "*To be real is to have causal powers*" (Kim 1992, p. 135; Kim's italics).

[5] According to scientific realism the postulation of universals is justified by the need to explain the way things interact with each other and, through perception and action, with us.

of a neutrino interacting causally with anything may be extremely low, but if it were zero, we wouldn't be justified in postulating the existence of the neutrino in the first place.

Second, and most important for us, the ultimate justification for the existence of a *universal* is that the best explanation of the fact that a set of (elementary) particulars exhibits a specific pattern of causal interaction is that those particulars instantiate a specific universal responsible for that type of interaction. For each primitive type of interaction, there is a simple universal. The dependence goes both ways: just as there is no type of interaction without its universal, similarly there is no universal without its specific type of interaction. The reason for this is that, in an analogous manner to the case of particulars, it would contradict the CCR to postulate a universal whose instantiation by a particular does not make any difference at all to the causal interactions of that particular[6].

Two general remarks before we put the CCR to work. The first concerns the epistemological status of the CCR: Is it purely conceptual or is it rather empirical notwithstanding its generality? As a generalization from a principle derived from the criteria which science uses to justify the postulation of entities, it might seem that the CCR is not entirely a priori, and that it would have to be abandoned in its full generality if it turned out not to be respected in science. Let us conceive a situation in which physics would postulate, say for considerations of symmetry, a perfectly idle universal whose instantiation by a particular would not change at all that particular's capacity to interact. There are two reactions to such a situation that seem to be more plausible than to conclude that it refutes the overall validity of the CCR. First, one might conclude that the fact that a scientific theory leads to the postulation of an idle universal pleads against the theory

[6] It is important to note that the acceptance of the CCR does not necessarily lead to denying the existence of such entities as possible worlds, possible or necessary states of affairs, or of such allegedly non spatio-temporal entities as numbers and classes. Rather, in order that the type of entity in question can be acknowledged within the overall metaphysical scheme, what has to be shown in each case is that these entities are either identical or at least supervene on entities which obey the CCR. On the condition that the subvenient entities obey the constraints of the CCR, so do the supervenient, even in such a controversial case as that of numbers.

rather than against the universal validity of the CCR. Second and more importantly, even if the theory is accepted, one can interpret the idle property as a "mere Cambridge", or merely relational, property, just as the property of being a widow: The acquisition by Xanthippe of the relational property of being a widow right at the moment of Socrates' death, leaves her unchanged from a causal point of view. Being a widow is a merely relational property, and not a real universal. I conclude that if the CCR is not purely a priori, it seems to be a principle that is more central to our conceptual scheme (and in particular to the part of the scheme used in science) than the most general empirical principles[7].

The second remark concerns the reference to capacities or dispositions in the above formulation of the CCR. For particulars, I think it is plausible to suppose that all of them interact causally at least twice: when they come into existence and when they disappear. These causal interactions affect even a particular neutrino that does not at all interact with anything between the events of its creation and its annihilation. Still, our formulation of the CCR would allow for the possibility that the universe has neither a beginning nor an end in time and that there exist eternal particulars that never interact. (This is not actually the case if the big bang theory is true). Their existence is nevertheless in agreement with the CCR as long as their probability of interaction differs from zero[8]. For universals, the reference to capacities is more important. Think of a universal which is instantiated by very few particulars and which bestows a very low probability of interaction on these particulars. Is it possible that the universal exists even if, by accident, it does in fact never influence any actual causal relations at all? It seems to me that the answer should be yes. It is metaphysically possible because its existence would be a scientifically legitimate hypothesis which can be evaluated in accordance with the CCR (our leading principle is the generalisation of the domain of legitimate ap-

[7] I follow Quine in thinking both that the distinction between what is a priori or analytic and what is a posteriori or synthetic is one which admits of degrees, and that this fact does not make the distinction useless or meaningless.

[8] This implies that space-time points do not exist independently from what occupies them. Indeed the existence of space-time is dependent on the existence of the matter and radiation occupying it. The latter is grounded according to the CCR.

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# Causal Production as Interaction

## *1. Introduction*

The notion of causal production lies at the heart of the common conception of the nature of causality, i.e. the belief that causes bring their effects into existence. But, in philosophy, there is controversy regarding the nature of this alleged production. Not only is there controversy regarding its nature, but also about its reality. However, in this paper, I will confine my discussion to the nature of causal production, on the assumption that it is real.

Discussions regarding the nature of causal production, like discussions about causality in general, usually turn on the notion of a necessary connection between cause and effect.[1] I will however focus as well on the more fundamental question: what is causal production? That is, the problem of causal production, as I discern it, revolves around two distinct but interrelated questions: (i) what is causal production, and (ii) is there a necessary connection between cause and effect? Of course, any answer given to the latter depends partly on how one answers the first, because the first gives us the answer to what causes and effects are. In this paper I will present what I think is a partly novel answer to these questions.

A standard picture of causal production has been around at least since Aristotle.[2] The general idea is that new states of affairs are

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[1] For reference, see Anscombe [1971]. There are accounts of causation that depict the causal relation as something a bit weaker than a necessary connection, e.g. probabilistic accounts of causation. For an overview on different approaches to causality, see Sosa and Tooley [1993].

[2] According to Aristotle, causal production requires four ingredients, (i) a material cause, (ii) a formal cause, (iii) an efficient cause, and (iv) a final cause (*Physics*, book II, Ch. 3). The first three kinds of causes are included as *components* in what I call the standard picture (I prefer to use the term 'components' because the term 'cause' has come to be used for the efficient cause only). The material cause is the substance of the given state of affairs on which the efficient cause acts, and which provides the substance out of which the effect is produced. The character of the effect (i.e. its form, as

brought into existence when an already existing material substance changes due to an external influence, without which the change would not have occurred and the new state of affairs never exist. The kernel of this view comes out clearly in the well known slogan 'whatever comes to be is necessarily born by the action of a cause'. Typically, the external influence, or cause, is depicted in terms of an '*extrinsic motive agent*', basically some object possessing causal powers, which *acts* upon another object, that object sometimes referred to by the term 'patient'. Accordingly, a *cause* is the action of some object upon another object, and an *effect* is the change produced in the object acted upon.

The standard picture depicts causal production as essentially involving three components: (i) that it requires a substance which can be altered, (ii) that the alteration is initiated by some influence external to the altering substance, and (iii) that the character of the alteration is determined by the form of the given substance and of the efficient cause. These three components relate to three basic metaphysical convictions about coming into existence in physical reality. The first of these principles is the old materialistic principle that nothing comes into being out of nothing or passes into nothing, the *genetic principle* for short, since it says that everything has a natural origin.[3] The second is the conviction that a distinguishing mark of causal changes in the natural world is that they occur as a result of some kind of action, basically any kind of influence exerted by one substance upon another, let us call that the *principle of action*.[4] The third is the *principle of lawfulness*, which says that the world changes in a regular way, i.e. according to general laws.[5] These principles form the metaphysical

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opposed to its substance), is determined by the character of the efficient cause and of the given state of affairs. These three components are needed to characterise production in the world of inanimate material objects while the issue whether the production is done in order to achieve a goal, or a good, is only relevant in cases where there are intentional beings involved, acting with a purpose.

[3] The term 'genetic principle' is from Bunge ([1959], p. 24). Craig Dilworth calls it 'the principle of (the perpetuity of) substance', ([1996], p. 53).

[4] The principle of action is the 'production-version' of what is often called 'the causal principle', or 'the principle of causality' (Bunge [1959], p. 26; Dilworth [1996], p. 57).

[5] Again I borrow a term from Bunge ([1959], p. 26). Dilworth calls it 'the principle of the uniformity of nature' ([1996], p. 55).

framework on which the standard picture rests.[6]

Note that the principle of action does not state that all changes are causal, only that causal changes occur as the result of some kind of action. The metaphysical framework of the standard picture allows non-causal changes of a certain kind. For instance, if the law of inertia is correct, a thing will continue in its motion in the absence of forces, and then a configuration of uniformly moving objects may change without the configuration, or the objects, having being causally affected. Such change is in accordance with the genetic principle and it is lawful, but it is not causal. The standard picture of causal production should therefore not be identified with *causal determinism*, or *physicalism*, which is the view that no other kinds of determination exist than causal determination.[7]

It is also important to note that *logically* speaking these metaphysical principles are independent of each other with regard to the idea of coming into existence, i.e. of becoming. Everything may be thought to come into being in accordance with the genetic principle, but not in a lawful way, nor due to any action, and, it may be thought that something comes into being in a lawful way, a way that nevertheless violates the genetic principle and the principle of action. That is, it is possible to think that coming into being is always the coming into being of something out of something else, but nevertheless that every becoming is unique and spontaneous, and, it is possible to think of creation *ex nihilo* by a deity as falling under a general law, which is lawful becoming but violates the genetic principle and the principle of action. It is even possible to think of substance coming into existence for no reason at all, i.e. not out of anything else, not in accordance with any general law, and not because of any kind of influence, not even divine will; it is possible to think of becoming as violating all three basic principles. Consequently, the idea that nothing comes into being spontaneously out of nothing, but always out of something else in a lawful manner, and usually as a result of some kind of action, does not derive its appeal from any logical connection between the three basic

[6] My account of the 'standard picture' and its metaphysical base owes much to Mario Bunge's discussion of causality in [1959], in particular, Ch. 1.

[7] For a discussion of different kinds of determination, see Bunge [1959], pp. 6 ff.

convictions, nor between them and the idea of coming into existence. Its appeal must be derived from being confirmed by experience, and/or from its success in explaining experience.

I think it is safe to say that the standard picture and its metaphysical framework is the paradigm view of how reality works among laymen in western societies. It is believed that things just do not 'pop' into existence out of nothing, or alter in a random fashion without having been caused to do so. In physics, this view is thought to have its limits. It is thought to have considerable empirical support within the realm of classical mechanics, i.e. as applied to ordinary middle-sized objects moving at moderate velocities, but its validity is uncertain as applied to quantum phenomena.[8] Since I am not a physicist, nor a philosopher of physics, I am not in a position to discuss causal production on the quantum level, nor for very big, or very fast moving objects. Consequently, with respect to physics, my discussion will be restricted to the nature of causal production within the realm of classical mechanics. Or, more precisely, I will discuss whether an account of causal production can be given that is compatible with the metaphysical principles given above, and which makes sense of the conviction that there is a necessary connection between that which produces, and the product, i.e. between cause and effect? I think such an account can be given, with only minor modifications of the standard picture.

Traditionally, it is lawfulness that has been taken to be the important feature of the standard picture of causality, and the key to explain-

[8] I take it to be commonly accepted within physics that although classical mechanics have been shown to fail when applied to objects moving at extreme velocities and when applied to the realm of micro-particles, then it has been established to hold good for macroscopic objects moving with a speed much less than the speed of light. According to what is called the *correspondence principle*, the relativity and quantum theories are more general theories which must yield the same results as classical mechanics when applied to the conditions in which the classical theory is known to hold good. Consequently, whatever these theories predict about very small and very fast moving entities, they ought to predict that ordinary middle-sized objects moving at moderate velocities behave like classical mechanics say they do (Weidner & Sells [1968], pp. 13-4; Albert [1992], pp. 43-4). If what I will propose is compatible with classical mechanics as applied to the conditions in which they are known to hold good, then, according to the correspondence principle, relativity and quantum theories should yield the same result within those same conditions.