From *Metaphysica* 3(1): 87-119, 2002.

Causal Production as Interaction

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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 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

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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 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.

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. 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*. The third is the *principle of lawfulness*, which says that the world changes in a regular way, i.e. according to general laws.[3] These principles form the metaphysical framework on which the standard picture rests.

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.[4]

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

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

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 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.[5] 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,

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

[5] 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.

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 explaining the necessity of the connection between cause and effect. The genetic principle is often taken to be an obvious and trivial aspect of causal production, a mere boundary condition, despite that it is what above all distinguishes *natural* causation from what might be called supernatural causation, or 'magic', e.g. production *ex nihilo*. That is, the cause-effect relation has been considered to be necessary in the sense that certain kinds of causes always and invariably produce certain kinds of effects, in accordance to a general law of the form 'if *C* happens, then (and only then) *E* is always produced by it'. On this account, the necessity is a general feature of causation, manifest in type-type relations.

Surely causation has some general features that can be expressed by general laws, I do not dispute that, but, because I think the standard picture is mistaken, I have serious doubts that those features have to do with a one-way link between certain types of actions by 'extrinsic motive agents', and certain types of changes in 'patients'. However, I will not dwell on the problems of general causation. I think it is possible to give a coherent account of how something produces something else so that the two are necessarily connected, independently of general laws.

The account comes in two parts. The first part contains an analysis of causal production in terms of a certain kind of *interaction* between things. Briefly, I suggest that causal production always involves an interaction between things, and that the causally relevant relationship between the interacting entities is in a specific sense symmetrical. In other words, contrary to what the standard picture tells us, I suggest that causal production does not just involve an action of an 'agent' upon a patient, but a *mutual* and in a certain sense *equal* action of two things upon each other. Further, that this mutual action occurs *simultaneously* in both directions. In other words, I suggest that interactions are thoroughly *reciprocal*. Consequently, I suggest that the conception of cause should be modified to encompass the actions of both 'agent' and 'patient' together, i.e. that interactions should count as causes, and that the conception of effect be modified to encompass the changes produced in both 'agent' and 'patient', when they interact.

The second part suggest that there is a necessary connection between an interaction and the state produced by the interaction, notably a *genetic link* between token states of affairs, as

opposed to a lawful connection between certain types of actions by 'extrinsic motive agents', and certain types of changes in 'patients'.

The idea that the relationship between interacting entities is in a certain sense symmetrical, is not new in philosophy, nor in physics. In classical mechanics, it is generally accepted that interactions between material bodies are reciprocal, i.e. simultaneous, mutual, and with respect to forces quantitatively equal, but not so in philosophy. Among philosophers, Mario Bunge and Wesley Salmon, are two of the very few who have taken interaction seriously.

Bunge argues that the reciprocity of material interactions shows that the dichotomy of substances into 'agents' and 'patients', on which the standard picture depends, is ontologically inadequate ([1959], p. 149). He draws the conclusion that the standard picture of causality is merely a methodologically useful approximation, but still rejects the idea that interaction provides a better account of causality. He rejects interaction because he thinks it displays the relationship between cause and effect as being symmetrical and therefore cannot possibly involve production of the effect by the cause ([1959], p. 162).

Salmon, in his attempt to formulate a radically different approach to the problem of causality, suggests that an explication of the concepts of *production* and *propagation* is the key to coming to understand the nature of causality. He suggests that production should be explicated in terms of interaction ([1980]; [1984], Ch. 5-8).

I think Bunge is wrong to reject interaction as a possible account of causal production, and I think more needs to be said about the way interactions involve production than is provided by Salmon's analysis. I think philosophers have been prevented from accepting an interaction-model of causality, because the term 'cause' has since long been restricted to what Aristotle called the 'efficient cause'. That is, causes have come to be considered as essentially something external to the changing thing, as if by definition, and that has prevented the thing acted upon from being even considered as a part of the cause, or to be more precise, to consider the interaction of 'agent' and 'patient' as being the cause to the effect. I suggest, somewhat in the vein of the agency view proposed by F.P. Ramsey [1929], R.G. Collingwood [1940], D. Gasking [1955], and G.H. von Wright [1974], that the conception of cause in terms of 'extrinsic motive agent' is biased by our conception of agency.

The agency view states that we could not *know* causality, or could not form the *concept* of causality, unless we knew from ourselves and our actions what it is to act as a cause. The agency view might then be taken to claim that the concept of *efficient cause* is derived from our knowledge of ourselves as active agents. This is indeed the view of Evan Fales. Fales accepts Hume's thesis that knowledge of *necessity* and *forces* are not given in outer

experience, but claims against Hume that knowledge of *action* and *force* is given in our inner experiences of the effort exercised by our bodies ([1990], pp. 11-14). The question is: to what extent does our nature as intentional agents, with all the cognitive capacities we have, memory, prediction, etc., bias our view of the objective workings of causality in the world of inanimate material objects? Is our conception of ourselves as 'efficient causes' really applicable to how changes are produced in inanimate material objects by other inanimate material objects? I think not, but I also think that it is possible to abstract the component of intention from our notion of efficient cause, to derive a more objective notion.

Some further comments on my approach to the issue of causality will, I think, be helpful to the reader. Firstly, my intention here is not to defend the thesis that causal production is an objective feature of reality against those who deny its reality.[6] I take the reality for granted. I want to present a new analysis of causal production which I think can be given considerable empirical support, and which tries to make sense of the idea of a necessary connection between causes and their effects. I nevertheless hope that my analysis will be interesting not only to those that already agree that there is such a thing as necessary causal production, but also to those that have rejected its reality because they have found the standard picture of causal production inadequate. I hope they will find reasons to at least reconsider their position.

Secondly, I am not trying to work out a *concept* of causal production that will encompass all *logically* possible alternatives. That is, I am not arguing that the idea of a deity creating the world out of nothing by an act of will is logically incoherent in itself, just as it is not logically impossible that things just emerge out of thin air, that fortune tellers really see the future, or that telepathy is real. I just do not see that there is any reason to consider such logical possibilities in one's theory of causality. There is no clear empirical evidence to the effect that anything has ever been created by an act of divine will, or emerged out of thin air, and even if empirical evidence were found to support e.g. *creatio ex nihilo* by a deity, this would only call for a need to distinguish between natural causation and supernatural causation. I argue under the assumption that it is the primary role of a metaphysical theory of causality to explain the *de facto* nature of causality as it appears in this world, not of every conceivable world, and therefore I restrict the scope of my discussion of causality to production of natural effects by

[6] For critiques of the Humean view of causality, according to which causation is merely a correlation between types of events, see Bunge [1959], Ch. 3, and Armstrong [1983], part 1.

natural causes. Here I find myself to be in perfect agreement with what Sally Haslanger says about the relation between metaphysics and rational explanation in [1989].

Thirdly, I take myself to be suggesting a crude picture of a novel alternative within the realm of classical mechanics, rather than presenting a fully developed theory of causality. Therefore, I will not be too much concerned with establishing the universal validity of my account. To repeat, since I am not a physicist, nor a philosopher of physics, I cannot discuss whether my suggestion is compatible with, or refuted by, relativity and quantum theories of physics, which deal respectively with the extremely big and fast moving, and the extremely small entities in the universe.

2. CAUSAL PRODUCTION: A RELATION OR A PROCESS?

There is a tension between the standard picture of causal production, as I have presented it above, and what I take to be the received view in philosophy today, namely the view that causation is *primarily* a relation between temporally distinct events. The standard picture depicts the relation between cause and effect as a product of a more fundamental process, the action of something on something else. Of course, the standard picture does not deny that temporally distinct events are causally related, but it does depict those relations as something that comes into being as a *result* of a more fundamental process, causal production. The standard picture is an attempt to reconcile the idea that causality involves a relation between two temporally distinct events with the ideas: (i) that the former event brings the latter into existence, i.e. produces it in accordance with the genetic principle, and (ii) that this production involves some sort of action of something on something else. It is impossible to puzzle these ideas together with only a cause, an effect, and a relation between them as components, if only for the simple reason that the cause cannot produce the effect by acting on it. If the effect only comes into existence by being produced by the cause, i.e. by the action of the 'efficient cause', the effect cannot be subject to the very same action that is supposed to produce it. This would require that the effect already existed when it is acted upon, and could therefore not have been produced by that very same action. Some account of what acts upon what is required, in order to introduce action into causality, and the cause and effect, construed as 'the event which produces' and 'the event produced' respectively, cannot be those things. So, if causation involves production through action of something on something else, the relation between cause and effect cannot be the most fundamental aspect of causality. On the standard picture, it is the things involved in the events that act upon each other, and thereby produce a change, i.e. an effect.

The standard picture implicitly depicts the relation between cause and effect as being itself a product of causation. The relation only comes into being as a result of the production of the effect. On this account, the so-called 'causal relation' is not causal in the sense that it is a relation that causes anything, but in the sense that it comes into being as a result of causal production. This is important, because it implies that the nature of causal production is not available by analysis of causal relations, *considered as accomplished feats*. The relations must themselves be considered as 'products' of the process to be investigated, and it is the investigation of the process that will explain the relation, and not vice versa. The question is, what kind of process produces the causal relation by way of producing the relata on the other end of the relation? According to the standard picture it is the 'extrinsic motive agent' that produces the effect by acting on the 'patient', i.e. some given state of affairs.

The peculiar kind of asymmetry involved in the causal relation, when causation is assumed to involve production, is not in general recognised by philosophers. Bunge is one notable exception. Asymmetrical relations, e.g. larger than, are determined by the characteristics of both relata, but the relation between cause and effect, in terms of 'producer' and 'product', is *one-sided* in the sense that only one of the relata, the cause, is assumed to determine the relation between the cause and its effect, by being what brings the other end of the relation into existence; the relation comes into existence with the production of the effect. The relation between cause and effect is thus asymmetrical, or unidirectional, in the sense that the existence of the effect is entirely determined by the cause alone. The effect does not exist until the production is finished, and so cannot have any part in the actual producing. We may then say that the conception of effects as being brought into existence by a cause implies that there is a relation of *one-sided existential dependence* between cause and effect, i.e. *e* because of *c*, but not vice versa.[7]

3. CAUSAL PRODUCTION AS INTERACTION

On the macro level, paradigmatic examples of causation involve the action of things upon other things, e.g. when a window is broken by being hit by a brick. According to the standard picture, it is the action of the brick upon the window that produces the breaking of the window. What is meant by 'action' requires some comment. Here it is intended to mean 'influence exerted by one object upon another', but this may not conform to all uses of the term. Actions of intentional agents are typically composed of a movement of the limbs,

[7] For an attempt to further explicate the concept of *existential dependence*, see Eugenie Ginsberg's paper [1931], with an introduction by Peter Simons.

performed with the intention to achieve a certain goal, e.g. when a tennis player swings his racket to return a ball. We may use the terms 'striking the ball' as a description of the whole swing. But, the swing is strictly speaking only in part an action upon the ball. It is only when the racket comes into contact with the ball that it has any influence on it. We may unreflectively think of the whole movement as an action upon the ball, because the swing is initiated and guided by the intention to strike the ball. I suspect, that in an unreflective stance one may be prone to think of the way inanimate objects act on each other in a similar way, e.g. to think of the movement of a brick, prior to its collision with a window, as a part of its 'action' upon the window. But, of course, prior to actually touching the window, the brick exerts no influence upon it.

Does the brick even act at all prior to its encounter with the window? After all, to be in movement is not in itself an action, not if one is to take the law of inertia seriously, which says that material bodies continue in their motion in the absence of forces. A moving object, unaffected by anything else, continues in its motion without having to 'do' anything about it. At the very least, that kind of motion is not an action of the moving thing upon any other thing. In a sense, non-accelerating motion is really a state, a state of motion. We may say that the stone we threw, 'flies through the air', as if it was performing a miraculous stunt, but of course this is just a figure of speech. So, when considering a brick acting on a window, we can only consider as an action the actual influence of the brick upon the window, and that influence only begins when they come into contact with each other.

One should also avoid confusing 'action', as used here, with the definition denoted by the term 'action' in classical mechanics. In mechanics, 'action' denotes the time integral of the kinetic energy of a material object, as taken between two times. On this account, an action is the summation of the kinetic energy of an object existing at different times, whether that object influences anything else or not. This may allow talk of pure motion as an 'action', but as Heinrich Hertz observed:

> the name 'action' for the integral in the text has often been condemned as unsuitable[…] these names suggest conceptions which have nothing to do with the objects they denote [*in mechanics, RI*]. It is difficult to see how the summation of the energies existing at different times could yield anything else than a quantity for calculation[…] ([1956], p. 228)

Let us then return to our example, and point out that whenever a brick hits a window, the breaking of the window is not the only change resulting from the interaction. At the same time as the window breaks, the brick loses velocity, momentum and kinetic energy; it drops flat to the ground. It does this because of the resistance offered by the window, and this resistance is

called a 'reaction'. In fact, whenever anything acts upon anything else, that thing always suffers a change in itself, because the thing acted upon always reacts to the action. When a brick collides with a window, the window breaks, *and* the brick loses momentum and velocity. In other words, what is often conceived to be an action of one thing upon another thing, is really an *interaction* between the things.

There are some possible confusions, due to ordinary language use, that must be sorted out here. The first is, that sometimes the term 'interaction' is used about communication, where the communicating entities take turns at affecting each other, e.g. in conversation, or, to use a somewhat construed example of communication, when I slap you in the face and you slap back. This kind of interaction is not being discussed here. What is being discussed here is the collision between hand and face; between brick and window. The second is that sometimes, e.g. in the 'communicative' situations mentioned, 'reaction' is used for the ensuing response to some event, e.g. when someone 'reacts' to a slap in the face by slapping back. In this use, 'reaction' is used more or less as equivalent to 'effect'. But, by 'reaction' I mean the physical resistance immediately offered by a thing when it encounters another thing, e.g. the resistance offered by the face being slapped, or by the window being hit by a brick. That is, the breaking of the window is *not* a reaction, in this sense, but an effect; it is the resistance offered by the window *before it breaks* that is a reaction. In the same way, the pain, or humiliation, or anger, of being slapped in the face, is not a reaction, but an effect. It is the immediate resistance offered by the face to the hand that slapped it, that is a reaction, and this is a reaction that can be felt in the hand of the person that did the slapping, and may feel as painful as a slap in the face.

In what follows, the most important points of the argumentation will be presented in the form of numbered proposals, for the sake of clarity, at the end of my argumentation for that particular point. The argumentation will then continue assuming the truth of that proposal. The first proposal will be the lesson already described, and taught by classical mechanics, that whenever a material thing acts upon another thing, the thing acted upon reacts to that action:

P 1: There are no actions without reactions.

The reaction of the thing acted upon, and the change suffered by the thing acting on it, are often neglected in discussions about causality. And yet it has been noted that the fact that there is always a reaction seriously threatens the standard picture of causality:

> A severe shortcoming of the strict doctrine of causality is that it disregards the fact that all known actions are accompanied or followed by reactions, that is, that the effect always reacts back on the input unless the latter has ceased to exist […] In other words, the polarization of interaction into cause and effect, and the correlative polarization of interacting objects into agents and patients, is ontologically inadequate[…] (Bunge [1959], pp. 170-1).

The existence of a reaction undermines the standard picture because it shows that there are no strictly passive substances, i.e. substances who only receive influence but do not themselves influence other things, nor are there substances who influence other things without being themselves affected in any way. It threatens the supposed unidirectionality of actions.

It is clear that the standard picture needs to be modified in order to include the reaction of the 'patient', although it is still unclear whether this changes anything much, since it is still possible to hold that the reaction is only an effect of the action. That is, even if it is admitted that there are no actions without a reaction, then it can be argued that the reaction itself is produced, or provoked, by the action, and therefore counts as part of the effect produced by the action. Let us be very clear on this modified picture. When a brick collides with a window, there is supposed to be an action on behalf of the brick upon the window, a reaction on behalf of the window upon the brick, and there are the two changes in the two things: (i) the breaking of the window, and (ii) the loss of momentum and velocity by the brick. The question is, does the action of the brick, produce the reaction in the window, and so in effect produce both the breaking of the window and the loss of momentum and velocity in the brick itself?

The action of the 'agent' has been considered to have causal priority mainly for two different but interrelated reasons: (i) because it has been assumed that there is a distinction to be made between active and passive substances, and (ii) because the action has been thought to be temporally prior to the reaction. Now, the first reason partly depends upon the second, at least when it has been pointed out that there are no genuinely 'passive' substances, i.e. substances that merely receive influence, but do not themselves influence other things. Ultimately the causal priority of actions over reactions depends on showing that the action is in some way temporally prior to the reaction, either because the action begins prior to the actual encounter, or because the reaction is temporally retarded in relation to the encounter.

The first possibility requires us to treat the motion of the 'agent', prior to the encounter, as part of its action upon the 'patient', and this, as I argued above, is to see it acting with a purpose, a purpose inanimate objects are incapable of having. Whatever a motion through space is, it is something different than the influence exerted by a thing upon another when

they encounter one another. The second possibility requires that the thing acted upon initially 'gives way' to the intrusion of the other, without offering any resistance. Perhaps like a rubber band initially offers little or no resistance when it is stretched, but successively the resistance increases. This way of thinking of the relationship between action and reaction may have some appeal when considering a rigid object in motion, colliding with a soft, elastic body at rest, but none when considering a soft elastic body in motion colliding with a rigid body at rest. In the latter case it is obvious that the resting body resists the moving body from the first instant they gain contact with each other. And, on closer inspection, the former example is not as convincing as it may first appear to be. In order for the reaction to be temporally retarded, it is not enough that it is initially very small, but must be entirely absent, because if the reaction is initially very small, so is the action. It requires no large effort to make an impression in a pillow.

We may perhaps not acquire decisive answers on this issue, by considering common-sense examples. What, then, does science tells us about the relationship between action and reaction? According to classical mechanics, which is that part of physics that deals with the collisions of middle-sized material things, the reaction is always equal to the action, and occurs *simultaneously* in the opposite direction. This relationship is expressed in Newton's third law of motion, which says that the force by which object 1 acts on object 2 is equal to the oppositely directed force by which object 2 acts on object 1:

$$F_{1\,2} = - F_{2\,1}$$

Classical mechanics depicts the action and reaction as being thoroughly reciprocal. Action and reaction, or force and counterforce, as they are also-called, are reciprocal "in the sense that we are free to consider either of them as the force or the counterforce" (Hertz [1956], p. 185). Now, firstly, if classical mechanics would have found that the reaction was temporally retarded in relation to the action, it could not consider them to be reciprocal in this sense. Secondly, classical mechanics does not consider interactions as being composed of ontologically different kinds of influences, an 'action' and a 'reaction', of which one kind is only a response to the other.

In mechanics, the terms 'action' and 'reaction' are indeed considered only to reflect the subjective aspect under which the scientist considers the interacting objects, i.e. as depending on which changes the scientist is interested in; the changes in the window, or the changes in the brick. This point comes out clearly in a passage by Maxwell:

> The mutual action between two portions of matter receives different names according to the aspect under which it is studied, and this aspect depends on the extent of the material system which forms the subject of our attention. If we take into account the whole phenomenon of the action between the two portions of matter, we call it Stress[…]But if[…]we confine our attention to one of the portions of matter, we see, as it were, only one side of the transaction—namely, that which affects the portion of matter under our consideration—and we call this aspect of the phenomenon, with reference to its effect, an External Force acting on that portion of matter. The other aspect of the stress is called the Reaction on the other portion of matter ([1877], p. 26-7)

In classical mechanics, as paraphrased by Bunge, "physical action and reaction are, then, two aspects of a single phenomenon of reciprocal action."([1959], p. 153). I will now present as the second proposal what classical mechanics takes to be an empirical fact that:

P 2: Interactions are thoroughly reciprocal.

Bunge is one of the very few philosophers who have acknowledged the ontological significance of the fact that there are no actions without reactions. He takes it to show that the standard picture cannot be anything but an approximation of causality, and yet Bunge rejects the idea that causality could be explained in terms of interaction, "if only for the simple reason that material objects are in a state of flux, so that generally the action has over the reaction the definite 'advantage'—to use an anthropomorphic expression—of priority in time."([1959], p. 162) He adds:

> The frequent asymmetry of interactions, as well as the fact that processes in which the antecedent disappears altogether cannot be described as interactions (although they involve reactions upon different objects), renders interactionism inadequate as a universal doctrine. Causation cannot be regarded as a particular case of interaction because the latter lacks the essential component of irreversible productivity. ([1959], pp. 170-1)

To sum up, Bunge has four objections against interaction as a universal doctrine of causality: (i) that when we consider the fact that things are in a state of flux, actions are temporally prior to the reaction, (ii) that interactions are often so asymmetric that the reaction and its effect can be quantitatively neglected, (iii) that some processes, e.g. the spontaneous decay of various kinds of micro-particles, cannot be described as interactions, and (iv) that if the action does not give rise to the reaction then interaction contains no element of productivity, which he, like I, considers an essential component of causality. However, as I hope to show, these objections are really directed against a very different conception of interaction than the one I present here.

I will discuss the objections in a different order than they appear above, but begin with the first objection that the action is temporally prior to the action. I am afraid that this objection is based on a mistake, namely of not separating the reaction from the effect. When talking

generally about interaction Bunge says that "the effect always reacts back on the input" ([1959], p. 170), when discussing gravitational interaction he says that "[e]very change produced by m_1 on m_2 reacts back on m_1" ([1959], p. 150), and when discussing the sense in which interactions are reciprocal, he only states that there is a reaction to every action, and that the reaction is equal to the action, but does not say that they occur simultaneously. In fact, he says that every action is accompanied or *followed* by a reaction ([1959], p. 170).

Indeed, Bunge's third objection that interaction cannot handle processes where the antecedent ceases to exist, is only intelligible if one assumes that he does identify the reaction with the effect. Bunge uses an example of spontaneous decay of a micro-particle to illustrate his point, notably the conversion of a pion, into a muon with the emission of a neutrino:

> In this case, the parent particle (π) is unstable; it decays spontaneously (that is, without any known extrinsic cause, though presumably as a result of an inner process)[…]This is an irreversible, typically genetic process, the thing furthest from interaction–despite which meson theories usually treat this process as if it were a mutual action between coexistents. More exactly, the parent-child connection existing between the pion and its descendants is described as an interaction eliciting that very transition–despite the fact that the products are not yet born. ([1959], p. 163)

If the muon and neutrino are 'products' of the decay of the pion, Bunge argues, then there cannot be talk of interaction *between* them and the pion. There cannot be an action by the pion on the products since they are 'not yet born', nor a reaction from the products on the 'parent particle' since it no longer exists. Note that Bunge does not object to the possibility of products reacting back on what produced them, but only to the possibility of such reaction in cases where the 'producer' ceases to exist in the process of producing the effect. I agree that the decay cannot be described as an interaction between the pion and its descendants, but for the simple reason that I do not think that interactions occur between the product and the producer.

I think that the example is really a worse anomaly for the standard view, than it is for the interaction-view I present. If the decay is spontaneous, in the sense that there is no external cause to it, then it cannot be considered as a case of causation at all on the standard picture, because this picture defines causes as being external to the changing entity. On the standard view, if there is no external cause to the decay, and the possibility that the product of the decay reacts back on its own production is excluded, then we are dealing with a spontaneous event; an uncaused change. In that case the example really falls outside the category of phenomena being discussed, namely causal production. However, if the decay is a result of an inner process, as Bunge suggests, then it can possibly be treated as a product of an interaction between the parts of the unstable pion that become the muon and neutrino respectively. This

would however require that the pion be treated as a compound substance, which is an issue best left to physicists to answer. What matters here is, firstly, that Bunge identifies the reaction with the effect and therefore thinks that if the 'agent' ceases to exist in the process of producing the effect, then there is nothing for the effect to react back on. Secondly, he cannot see a process internal to the pion as being the cause to its decay, because he restricts the meaning of the term cause to 'extrinsic motive agent':

> Efficient causes are, by definition, extrinsic determinants[…] As understood in modern times, causal determinism asserts the universal operation of efficient causation. Now, by definition, of all kinds of cause, the efficient cause is the motive or active one, it is, moreover, an agent acting on things *ab extrinseco* and one that cannot act on itself. The efficient cause is, in short, an *external* compulsion, hence, an essential mark of (efficient) causation is externality ([1959], pp. 173-4).[8]

It would seem as if the possibility of understanding the inner process of a pion as being the cause to its decay, require us to reject entirely the idea that efficient causation involves external compulsion, but I think this would be an exaggeration. Even on the interaction model, efficient causation involves external compulsion, namely the external *and* reciprocal compulsion that interacting things exert on each other. A brick is of course external to the window, and vice versa, but sometimes, an interaction may take place between the parts of a unity, producing the destruction of the unity. The interaction is then internal to the unity that is destroyed, but nevertheless involves external compulsion, namely the compulsion that the parts of the unity exert on each other. Interaction is not incompatible with the notion of external compulsion, it just does not *identify* the notion of 'cause' with external compulsion. Interaction requires that the notion of 'cause' as meaning the unique producer of a change, must be separated from the notion of external compulsion, because there cannot be a compulsion without a 'countercompulsion'.

Let us now turn to Bunge's second objection, that interactions are often so asymmetrical that the reaction can be neglected. This objection is really an argument in favour of the standard picture, not an objection to interaction, i.e. it is a justification of the application of what Bunge calls the *causal approximation*. He makes a point of the fact that interacting things always affect each other mutually with equal force, but then points out that when there are large quantitative differences between the things, the larger thing will hardly be affected at all by the interaction. Bunge uses gravitation, which is both considered to be a paradigm of

[8] Bunge notes that external causes are insufficient to determine all kinds of changes, but he does not take it to imply that there is anything wrong with the thesis that causes are essentially external to the changing thing. Rather, he takes it to show that causality is but an approximation.

causality and thoroughly reciprocal, to illustrate his point: "Only if one of the masses is much smaller than the other (for example, a stone as compared with the whole Earth), can the greater mass be regarded as the *cause* of the acceleration of the smaller one, and the reaction of the latter's motion be *quantitatively* neglected" ([1959], p. 150).[9] That is, even though the interaction really is reciprocal, then sometimes the effect produced by the reaction is so small that it can be *neglected*, and the interaction be treated as being approximately causal in the standard sense. Bunge argues that "[i]n some cases this involves no error at all" ([1959], p. 150). It is justified to ask: according to which standards is the reaction negligible? The answer is 'in accordance with the explanatory interests of the observer': "by a suitable choice of the reference system (change from laboratory system to center-of-mass system) [...] an interaction problem is thereby transformed into an ideal causal problem" ([1959], p. 151).[10] That is, Bunge argues that when the effect on one of the things is for all practical purposes negligible, then we are methodologically justified to do the kind of aspect-shift that Maxwell described so well, i.e. sometimes we are justified to neglect those aspects of reality that we have no explanatory interest in.

I will not argue that the application of the standard picture is not *methodologically* justified in many or most cases in scientific practice. I think Bunge does satisfactorily argue that it is so justified, as a useful approximation. But, the fact that interactions can always be approximated to fit the standard picture, by a suitable choice of which effect is to be neglected, is not an *ontologically* valid argument against interaction. There is clearly a tension between Bunge's ontological and methodological considerations. He makes a point of the ontological inadequacy of the standard picture, regarding the relation between the action and reaction, but he prefers the standard picture, both for its methodological utility in cases where there is a large quantitative difference between the effects produced in an interaction, and because he thinks interaction does not involve production. I have no methodological considerations. I am looking for an ontologically adequate account of causal production, and I think, contrary to Bunge, that interaction does involve production.

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[9] Note again, that Bunge does not distinguish clearly between reaction and effect.

[10] Bengt Molander also considers briefly the suggestion that the standard conception of causality should be replaced by a conception based on interaction. He dismisses it with the motivation that explanations of what happens in a given system in terms of interaction does not make causal statements of the form '*E* because *C*' about what happens in that system inappropriate or false ([1982], pp. 140-3). That is, it will still be true that the brick breaks the window, although at the same time the window causes the brick to lose momentum. This is a motivation I find to be similar to Bunge's reasoning. I would agree with them to the point that causal statements are not inappropriate or false *as*

Bunge's fourth objection, that interaction does not involve production, is the most serious objection to interaction, but it is clear that it is directed against a completely different conception of interaction than the one I advocate, namely against the view that the relation between cause and effect, then meaning action and reaction, is symmetrical. In Bunge's words: "Let us agree to call interactionism, or functionalism, the view according to which causes and effects must be treated on the same footing, in a symmetrical way excluding both predominant aspects and definitely genetic, hence irreversible, connections." ([1959], p. 162) This view, he claims, may be regarded as a "hasty extrapolation of the mechanical principle of the equality of the action and the reaction" ([1959], p. 162). Now, I agree that on my view there is not a relation of one-sided existential dependence between the action and reaction, rather a mutual dependence, but I take that to show that the reaction cannot really be an effect, and that the action alone cannot really be a cause. I do not take it to show that there is a symmetrical relation between cause and effect, rather I take it to show that we must re-examine the standard conception of 'cause'. I suggest that by abandoning the idea that causes are essentially what Aristotle called the efficient cause, i.e. something external acting one-sidedly on the changing entity, then it is possible to conceive of the interaction as a whole as the cause, and the change in the compound whole of interacting things as the effect. According to this view, the relation between action and reaction is symmetrical, but it does not follow from this that the relation between the interaction and the change it produces is symmetrical. Indeed I will argue that it is asymmetrical and that the interaction can therefore be considered to be the cause to the change. Bunge completely overlooks this possibility because he considers causes to be *by definition* external to the changing entity.

It is not impossible to conceive of interactions as involving production, when one considers not the reaction as being the product, but the effects produced in the interacting things themselves by their own interaction. It is in fact difficult to conceive of interactions without thinking of them as the production of changes in the interacting things, when, as here, interaction refers to the mutual influence of two things upon each other. The notion of force has always been understood in terms of production of changes. Newton defined it as "an action exerted upon a body in order to change its state, either of rest or of uniform motion in a straight line" ([1953], p. 13), and Hertz defined it as "the independently conceived effect which one of two coupled systems[…]exerts upon the motion of the other" ([1956], p. 185). If

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explanatory statements, in relation to what we want to explain. But it does make the individuation of causes and effects dependent on a subjective choice of reference.

force, meaning the action of one thing upon another, cannot be separated from the changes it produces, then neither can interaction be separated from the production of changes, since an interaction consists in two reciprocal forces. That the forces are reciprocal means that neither can exist without the other, and that, therefore, neither can produces the other. However, together they can produce a new state of affairs.

P 3: Interaction involves production.

I have so far argued that inanimate material objects cannot be objectively distinguished into 'agents' and 'patient', and thereby that the distinction between causes and effects *in terms of* 'actions of an agent' and 'changes in a patient', respectively, is ontologically inadequate. It involves a neglect of the reaction of the 'patient' and change produced in the 'agent'.[11] The causal production of a state of affairs involves the interaction of things, and this interaction is reciprocal.[12] That is, in explaining the causal relation between events, there is always a story to be told about the interaction between the things involved.

I do not deny that we often experience interactions as being asymmetrical, but I suggest that this experience of asymmetry is purely subjective. It does appear to be more 'fatal' for a window to be smashed to smithereens than for a brick to lose momentum. But, surely, the sense in which the breaking, or destruction of objects in general, is 'fatal', is a subjective evaluation. Is it perhaps because a smashed window is inconvenient to a house-owner in a way that the loss of momentum by a brick is not, that we attend to the breaking of the window as an 'important' effect of the interaction, while the loss of momentum by the brick is a

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[11] Someone may find my talk of causes and effects in terms of the action of 'agents' and changes in 'patients' ill fitted to contemporary discussions about causality, where causes are usually formulated in terms of conditions of various sorts. I chose this terminology to avoid confusion with accounts of causality where production has no place. But, I take it that the basic idea behind the polarisation of interacting entities into 'agents' and 'patients', has affinity with the idea behind distinguishing between conditions that are merely necessary, and conditions that are both necessary and sufficient. The idea is that there is some special part of a given state of affairs, whether that part is an object or event, which has an especially important function in the production (or determination) of a subsequent state of affairs. I argue that this idea is mistaken. It may anyhow be pointed out that in terms of conditions, my account comes closest to being compatible with Mackie's analysis of causes in terms of insufficient but necessary parts of a condition which is unnecessary but uniquely sufficient for the effect (INUS condition) [1965]. Except, because I think of effects in terms of tokens, not types, and of the genetic link between cause and effect as grounding the necessity of the connection, then I think the 'action' and 'reaction' are each an insufficient but necessary part of an interaction which is *necessary* and uniquely sufficient for the effect (let me call that an INNS-condition).

[12] I am here using 'state of affairs' as the unity of a substance with properties, whether or not the substance is a compound or a simple, and whether or not the compound is an aggregate or unity of substances. For reference, see I. Johansson [1989], Ch. 3. For a recent discussion of the ontology of states of affairs, see E. Runggaldier & C. Kanzian [1998] pp. 198-218.

negligible 'side-effect'? If this is the reason, and I think it is, then the experienced asymmetry of the interaction is purely subjective, i.e. dependent on our explanatory interests.

To be sure, different things change in different ways when entering into interactions, and these differences can be quite dramatic, but does not justify giving one of the interacting things, e.g. 'the flying brick', the privilege of being the sole producer of the subsequent change, e.g. that the window breaks and that the brick loses momentum and velocity. The objective character of the subsequent state of affairs as a whole is determined jointly, and reciprocally, by all the things involved. I suggest the difference in how things change in interactions is due to differences in the intrinsic properties of the things themselves, not to asymmetry between the influences they are subject to. Different things change differently when they interact, because they are different, not because of an asymmetry between their respective actions.

If it is correct that causal production always involves interaction between coexisting things, then it follows that interaction is ontologically prior to the cause-effect relation believed to hold between temporally distinct events. I think this is something we can observe in our everyday practices, when we reflect upon it. We know we cannot accomplish anything without acting upon things in some way or another, and we always feel their resistance (reaction) when we do. We always suffer a change ourselves when accomplishing a change in something else, but as long as this change is negligible to our purposes, then it will go by unnoticed. It is indeed because we feel the resistance of the things we interact with, that we can adjust the effort we make to their resistance. Our effort is always proportional to their resistance. We also know we value different consequences of interactions in various ways, indeed, different people value the same consequences differently, and we know that the mechanical forces involved have little or nothing to do with their value. A tiny little push on the edge of a cliff can have dramatic consequences, while a full body tackle in the ice-hockey rink does not matter a jot. We even disagree on what is to be considered as the 'agent', i.e. the efficient cause, e.g. in deciding questions of responsibility. That interactions are thoroughly reciprocal, is maybe not intuitively given at first glance, especially when it comes to intentional acts, but I think it is convincing on second reflection in light of everything that has been said.[13]

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[13] Perhaps intentional beings could in some sense be examples of 'extrinsic motive agents', in accordance with the standard picture. That is, I am prepared to leave it open whether individuals with the capacity to a) perceive themselves in relation to other objects, b) have preferences and desires, c) predict various consequences of various actions before they are performed, d) choose the action that is

> P 4: Interaction between coexisting objects is ontologically prior to the one-sided existential dependence relation between two temporally distinct events.

Now, in what sense can a state of affairs produced by an interaction be *necessarily* connected to the interaction that produced it? Perhaps it is possible to argue that if the character of the interaction is entirely determined by the properties of the interacting things, then the outcome of that interaction is entirely determined by the interaction. On the assumption that properties are universals, then whenever two objects of a certain kind interact in a certain way, the very same kind of effect is always produced. We would then have, in principle, constant and invariable type-type relations, i.e. a necessary connection. I will however argue that there is another kind of necessary connection to be found, a genetic token-token link.

Assuming, as I do, what appears to be an empirical fact, that nothing can be produced *ex nihilo,* then we must consider *out of what* a new state of affairs is produced. A potter cannot produce pots without clay, factories need raw material out of which they can produce ready products. Without raw material that can be altered into a new shape, nothing can be produced. What is the raw material out of which a new state of affairs is produced, and where does it come from? I propose that a new state of affairs is produced by the interaction of things, out of the very substance those interacting things are made of, i.e. the state which is produced is made of the same substances as were involved in the interaction. It is the same substance that constitutes a window and then a pile of broken glass. It is the same brick that comes flying through the air and then lies in that very pile of broken glass.

Since interaction requires at least two things, then the production of a new state of affairs requires an aggregate of things or substances, and we can speak of that aggregate as a *compound substance*. If the state of affairs produced by the interaction is produced out of the substance of the interacting things, then the state of affairs produced by an interaction consist in the very same compound substance as were engaged in the interaction. On this account, the relationship between two different but in this sense causally related states of affairs is

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perceived to lead to a desired effect, e) adjust the effort and direction of the action to the reaction of other objects, may perhaps be capable of *initiating* actions, and not just interact with the environment in the sense described above. This list of capacities is not complete, nor do the distinctions aim to represent logically, or otherwise, independent capacities, but rather interdependent capacities. I just want to make a sharp distinction between how *we* calculate, and perhaps initiate, our actions in the world, and how physical objects in general actually interact in the course of real events. To what extent intentional actions differ from interactions is beyond the scope of this paper, but I do think our cognitive abilities biases our understanding of the nature of causal production in the world of inanimate material objects. For a recent overview on the topic of mental causation, see Loewer [1998].

necessary in the sense that they are necessarily constituted by the very same compound substance. Causally produced change is then an alteration in the state of a compound substance, brought about by that very substance itself, through the interaction of its aggregate parts. This brings another feature of change into focus, namely that every production of a state of affairs is always at the same time a destruction of an existent state of affairs. The coming into existence of a state of affairs, that does not come into existence out of a state that is destroyed, must be creation *ex nihilo*.

> P 5: Two causally related states of affairs are necessarily constituted by the very same compound substance.

It might be objected that I am here assuming without argument an *endurance* view of the persistence of things, as opposed to a perduring view of persistence, but this would be mistaken. That things persist by enduring, as opposed to perduring, is a conclusion of my argument, from the initial premise that causality does in fact involve production. It seems to me that this premise is only compatible with endurance.[14] If it were assumed that things persist by having temporal parts, each part being a distinct and independent substantial entity, i.e. by perduring, then I fail to see what could be produced, by what, and out of what.[15] If one temporal part of a thing is broken and an earlier part is whole, without the part being whole having changed into being broken, then out of what was the broken part produced? The broken part must either (i) always have existed, in which case it was not produced, (ii) be produced by being brought into reality from outside reality, (iii) be produced out of the substance of the 'agent', in which case a brick would have to be able to change into a pile of glass and the problem would shift to the production of the brick lying in the pile of glass, or (iv) be produced *ex nihilo*. Indeed most perdurantist would agree and say that since things perdure, there is no production, everything simply exists, albeit at different times. I want to make as good sense as I can of the idea that causality involves production, but reject the possibility of creation *ex nihilo*, and will then have to conclude that if causality involves production then substances persist by enduring.[16]

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[14] I have elsewhere argued in greater detail that the notion of causal production requires endurance [2001].

[15] Like Haslanger [1989], I have argued that the perdurantist position commits to a Humean interpretation of causality, i.e. to a correlation view of causality, in which production has no place [2001].

[16] It is widely argued that change *per se*, not just causally produced change, necessarily requires endurance of the substances involved. For reference see, Aristotle's *Metaphysics*, Bk. XII, Ch. 2, Haslanger [1989], and Lowe [1998].

If one is forced to assume that substances persist by enduring, one is arguably also forced to assume that time is tensed. The idea that substances endure through a succession of incompatible states, requires that substances may exists in just one state at a time, and, objectively speaking, cease to exist in the state they change from, when they change into another state. That is, in order for an entity to cease to be in a state and begin to be in another, objectively speaking, that entity must be 'wholly present' at many times in succession, i.e. be at present in one state but in another state in the future. This is a possibility that is denied by the so-called tenseless view of time, which claims that all moments of time are equally existent and real. On the tenseless view, things just appear to exist at different times in succession, when in fact they are at all times equally existent and real at all the times they exist. This view, it is argued, is only compatible with the view that things perdure, i.e. exist at various times by having different temporal parts located at those various times.[17]

Two states of affairs that are causally related, in the sense given above, will be different states of the very same compound substance, which has changed from one state to the other due to the interaction of its parts. The production of changes cannot then really be construed as involving an external influence on the changing entity (although the parts of that entity act mutually and externally on each other), but to influences *internal* to a changing compound, or aggregate of substances. That is, on this account, causally produced change is always a change within a system.

P 6: Causally produced change is always internal to a compound substance.

If causation is the production of a change in an aggregate by the interaction between the coexistent parts of that aggregate, that interaction being considered as the cause to the change, it follows trivially that causes are existentially prior to their effects. The causal production of a new state of affairs, presupposes the existence of an aggregate whose parts interact. On the further assumption that time is tensed, it follows trivially that interactions always precede their effects in time.

P 7: Interactions always precede their effects in time.

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[17] In [2001], I argue that endurance, tensed time and causal production are essentially linked to one another in what I call the *dynamic view* of reality, while perdurance, tenseless time and the correlation view of causality essentially belong together in what I call the *static view* of reality. In that paper I also argue that what has hitherto been considered the most serious objection to the dynamic view, the charge that tensed change in enduring entities is contradictory, is invalid because circular.

I must stress that this is an account of causal change that is completely independent of the particular qualitative character of the states of the compound substance before and after the interaction. Surely, what happens in an interaction is determined by the properties of the substances involved, and the way they interact, but my account does not depend on it being the case that any two interactions are exactly alike; my account is compatible with the possibility that every single interaction in the history of the universe is unique. It is also compatible with the possibility that there are general laws, it just does not give a criterion that can be used to identify types of effects that are always and invariably produced by certain types of interactions; that, I think, is a task for empirical science.

I have said that I will not defend the reality of causal production against those who deny its reality, and I will not. But, I will point out what I think is an interesting contrast between Hume's account of causality and mine. According to Hume, the objective components of the causal nexus are three: contiguity, succession, and constant conjunction. I have argued that there is also reciprocity between the contiguous objects. I have no qualms with Hume's view that there is no logical necessity in the conjunction of the motion of a billiard ball *A* and subsequent motion of a billiard ball *B*, when *A* and *B* collide. We are free to *think* of the collision of *A* and *B* as being succeeded by anything whatsoever. We can *conceive* of *A* approaching *B*, and their contact resulting in a third ball *C* (or whatever object you like) emerging from *B*. We can even think of ball *A* simply passing through ball *B*, without anything happening to *B* or to *A*. What we cannot do, or *will* not do, I submit, is to think of the passing by *A* through *B* as being a case of causation, *however many times this type of event recurs*. Rather, we would think of it as the absence of causality, because, I suggest, it completely lacks any sign of reciprocity. The appearance of reciprocity is present in every instance of causation in the realm of ordinary middle-sized objects. Whether this appearance of reciprocity is explained in terms of production or not, any adequate account of causation will have to be able to account for it.

Now there remains to describe the relation between the state destroyed in an interaction and the state produced by that very same interaction. Strictly speaking it is the interaction between the parts of the compound substance that produces a change in the compound from one state to another, the states themselves are always products. That is, the interaction is the process in which the effect is produced. But, I suggest that the relation between any state *from* which the compound substance changes and the state *to* which it changes, due to the interaction, nevertheless be characterised as being one of producer to product. Any given state of a substance, although merely a temporary form of the substance, cannot be separated from

the substance itself. The state cannot exist without the substance. If, as I have argued, the state to which the compound substance changes, is necessarily constituted by the very same substance as the state from which it changes, then the state to which the compound changes is for its existence dependent on the state from which the compound changes, because the state to which it changes 'inherits' both the substance, and the character, from the state the compound changes from.

The temporally distinct states of any such compound, related as producer to product through the interactions of the parts of the compound, will then hold a relation of one-sided existential dependence; the state to which a compound substance changes is for its existence dependent upon the state from which the compound changes, but the state from which it changes is not for its existence dependent upon the state to which it changes. That is, on my account, the so-called causal asymmetry between a cause and an effect, i.e. why it does not follow from '*x* caused *y*', that '*y* caused *x*', can be given in the following terms: *if x* produced *y*, *y* could not have produced *x*, because that would have required *y* to produce *x* prior to its own production, which is impossible.[18]

> P 8: The state produced by an interaction stands in a relation of one-sided existential dependence to the state destroyed by that very same interaction.

5. CONCLUSION

When the asymmetric relation between 'agent' and 'patient' is abandoned, and causal production of changes is taken to be the result of reciprocal action between parts of an aggregate (or system), a relation of one-sided existential dependence can be found to hold

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[18] I think this is a good time to point out a significant difference between my view and the *perspectival view* advocated by Huw Price [1996], who also argues that the standard picture of causality is biased by agency. I argue that the relation between interacting entities should be considered to be symmetrical, but the relation between the interaction and the state it produces as asymmetrical. Price argues that the relation between earlier and later stages of a process hold a symmetrical relation, i.e. he argues that the state which a system appears to have changed from, and the state which it appears to have changed to, when its parts interact, really hold a symmetrical relation. Price's argument is based on the fact that the mathematical formulations of the laws of nature in physics are time invariant. That is, because it makes no difference to exchange the time variable *t*, with its contrary *-t*, in the fundamental laws of physics, any process can be *described* as going either backwards or forwards in time, without violating those laws. Perhaps accounts of causality that rely *only* on the aspects of lawful connections between types of events in accordance with the laws of physics, will have to accept Price's conclusion, but then, I think, those accounts are incompatible with the conception of causality as involving production. If the relation between two states of one and the same system is symmetrical, neither could have produced the other. Admittedly, the genetic principle imposes no special direction to certain *types* of processes, but it excludes that the relation between two *token* stages of one and the same causal process is symmetric.

between the state produced in the aggregate by the interaction of its own parts, and the state destroyed by that same interaction. In other words, the interaction between the parts of a compound substances, destroys a state of affairs at the same time as it produces a new state of affairs, the produced state of affairs being for its existence one-sidedly dependent upon the state that was destroyed.

Thus conceived, the two states of affairs may be *logically* independent, in terms of being of a certain type each, but they cannot be thought to be made of distinct and independent substances. If it is assumed that they are distinct compound substances, then the question out of what they are produced is left unanswered, or it is answered that they were not at all produced, or it is answered that this effect was at least not produced by this cause. I suggest that in order to explain production of changes, and the existential dependence relation between the change and what produced the change, it is necessary to assume that things, or the substance they are made of, persist by enduring. Conversely it means that if endurance is abandoned, production must be abandoned too. Also, if endurance requires time to be tensed, and production requires endurance, then production requires tensed time.

When cause and effect are seen to be made of the same substance, it is impossible to think that any particular effect could just as well have been produced by some other cause than it in fact was. Any attempt to think of the effect as having been produced by some other cause, will necessarily involve thinking of it as having been produced out of some altogether different substance, and therefore as being a totally different effect. It is of course possible to think that a certain *type* of effect could have been produced by a number of different *types* of causes, or by different *token* causes of the same *type*, but not that a particular *token* effect could have been produced by any other *token* cause than it in fact was.

I hope I have made a good case for the claims that interaction, as I have described it (i) *can* be conceived to involve production, (ii) involves a necessary connection between an interaction and its product, and (iii) should be taken seriously as a possible hypothesis of the factual nature of causality. It is an hypothesis that fits the components of the common notion of causality, i.e. that causality involves *production* due to *causal influence* such that the producer and product hold a relation of *one-sided existential dependence*, although it combines these components in a somewhat different way than is usual. It also fits certain widely accepted metaphysical principles, i.e. the genetic principle and the principle of lawfulness, but requires that the principle of action be substituted for what may be called the principle of reciprocity. This, I believe is however only a minor modification, and which serves to correct the agency bias of the standard picture. My final suggestion is thus:

P 9: Interaction and necessary causal production is the same process

In short, my suggestion is that causally produced change is properly described in terms of changes in the state of a compound substance, produced by the interaction between the parts of that substance itself, i.e. that causally produced change is always due to influences internal to the changing entity. Causally related states of affairs are thus different states of the very same substance, one coming to exist out of the other, and that is, I suggest, the kernel of truth behind all talk of a necessary connection between causally related events.[19]

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[19] I would like to thank Phil Dowe, Jan Faye, Ingvar Johansson, E.J. Lowe, Jeff Malpas, Johannes Persson, and three anonymous referees, for their comments on earlier drafts of this paper, and those parts of it presented at the *Copenhagen Colloquium on Backwards Causation and Time*, in december 1999.

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