Determinism and Causation Examples

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ABSTRACT

In studying causation, many examples are presented assuming that determinism holds in the world of the example such as the notoriously difficult to resolve preemptive and preventative situations. We show that for deterministic examples that this conditional preemptive situation is either (i) vacuously true, (ii) contradictory, or (iii) implies indeterminism. Along the way we formulate a specific block space-time definition of determinism, and suggest that commonsense causation theories need focus on unphysical quantities and indeterminism.

I. INTRODUCTION

The examples used to demonstrate the inadequacies of various theories of causality have been enormously helpful in shaping our view of cause and effect. Just like proceeding in physics, for instance, in philosophical debates one develops a theory to try and explain our notion of cause and effect in clearer terms. This theory is then put to the test by exposing it to a collection of critical thinkers, many of whom create hypothetical situations (thought experiments or *gedanken*) that expose potential flaws in the theory. In general, if a logical or commonsense contradiction is suggested, then either the theory must be abandoned or reformulated. The process repeats with a new theory and the hope that the new theories are progressing toward a formulation that can stand up better to various thought experiments.

While it is important to analyze the theory and understand exactly where the contradiction arises with respect to the particular thought experiment, it is also important to analyze the thought experiment to make sure that it does not include any presuppositions or inherent contradictions that would otherwise confuse any comparison of theory to thought experiment. To this goal, we will examine the wording and premises of one particular example in depth. We will suggest that the conclusions drawn from this example extend to other examples of the same form. I worry that some of the discussion will sound of needless semantic arguments that do not have any real relevance to the problem at hand. However, the incompatibility that I am attempting to expose seems to be subtle in that it has not been addressed before.

II. EARLY CONFUSION

The problem involves posing a causation situation in a deterministic world, and then proposing an alternative situation at the end of the example whose realization contradicts the events that supposedly occurred in that deterministic world. Our canonical example will be that of so-called late-preemption. In these sorts of thought experiments, the conditional situation is assumed to be true a priori in the sense that it is defined to be true according to the set-up of the example; one does not need to apply any procedure to derive its truth. This conditional is essentially a counterfactual that is defined to be true in the world of the thought experiment. We will show that for deterministic examples, this conditional is either (i) vacuously true, and adds nothing to the example, (ii) requires us to consider a completely different world whose analysis creates a contradiction, or (iii) implies indeterminism. In this paper we will first draw an analogy to a word problem in algebra that has essentially the same form as a causation example and show that (i) or (ii) must follow from this example. We then explain the misunderstanding in causation examples as arising from an unspecified perspective. In the last part we question the meaning of determinism and provide an unambiguous definition that potentially eliminates the above confusion and shows that the traditional deterministic example of late-preemption is better considered a poorly specified indeterministic example. Before we begin let us look at an early example.

It appears that confusion regarding a deterministic causation example can be seen in Lewis's influential 1973 paper on counterfactual causation (Lewis [1973]). In this work, Lewis defines determinism as:

> "The prevailing laws of nature are such that there do not exist any two possible worlds which are exactly alike up to some time, which differ thereafter, and in which those laws are never violated"

He then acknowledges that he will be ignoring indeterminism in that work, although he goes on to discuss a preemption example and states, "Suppose that *c1* occurs and causes *e*; and that *c2* also occurs and does not cause *e*, but would have caused *e* if *c1* had been absent." Now, if we are working in a deterministic world, and we do not explicitly acknowledge that there may be indeterminism in this example in the form of probability or otherwise, it seems that under no circumstance could *c1* ever be absent. What sort of determinism allows events to go one way or the other? In the language above, are we to assume that before event *c1*, there were a set of possible worlds that were precisely identical in state and natural law, but in some way right before some time, event *c1* had the opportunity to occur or not in these identical worlds? This sounds much more like an example of indeterminism, or at least it does not fit the definition of determinism above. Perhaps *c1* being absent does refer to a completely different world; a different world where determinism also holds, but how could this totally different world have anything to do with the causal situation in the world I care about? In one world *c1* always occurs; in the other it never occurs, yet these possible worlds never influence each other. If that were not confusing enough, somehow we also know that *c2* deterministically would have caused *e* without a doubt. Given that this these sorts of examples flourish in counterfactual theories of causation under determinism, it seems important to clarify the state of affairs.

III. PREEMPTION WITH BILLY AND SUZY

We will now discuss in more length the popular example of late preemption given by Hall (2002) which goes essentially as follows – Billy and Suzy throw rocks at a window. Suzy throws first so that her rock arrives first and shatters the glass. Without Suzy's throw, Billy's throw would have shattered the window. Late preemptive examples like this one have been useful for understanding causation because they seem to cause a bit of trouble for many theories. For instance, with regard to Lewis's 1973 counterfactual theory of causation, it is felt that his theory cannot explain the commonsense belief that Suzy caused the shattering, since even if Suzy did not throw her rock, Billy would have shattered the glass anyway, and there would have been no causal chain connecting Suzy to the shattered window (Menzies [2001]). Let us look at the pieces.

1) Billy and Suzy throw rocks at a window
2) Suzy throws first
3) Suzy's rock arrives first and shatters the window
4) If Suzy's rock hadn't shattered the window, Billy's rock would have shattered the window[1]

As above, according to Lewis's old theory, there is no causal dependence between Suzy's throw and the shattering, since even if Suzy had not thrown her rock, the window would have shattered due to Billy's throw. Now here the problem arises. In the analysis we are quick to think that if

[1] The first 3 points are rather innocuous, although the third is slightly worrisome in that the verb 'shatters' could easily be replaced with 'causes the window to shatter.' It may be preferable to say "Suzy's rock arrives first, then the window is found shattered" or something like that, so that we do not imply what causes what, although I am just being picky.

Suzy did not shatter the window, then Billy would have. However, our original thought experiment mandated determinism, and it states that Suzy's rock shattered the window. We do not need even consider 4) above because 3) is guaranteed to be true by definition. If you assume that this is a deterministic example, then we are not permitted to ask *what if* in the everyday sense according to this thought experiment, so any analysis that does is nonsensical. In order to ask what if we require a completely new thought experiment or a possibility that 3) is not true. While you may argue that one can conceive of a possible world in which Suzy does not shatter the window, we will show that any argument that demands us to consider such an alternate world in order to draw a conclusion about causation creates a logical contradiction under determinism.

So why are we so quick to ask what if in this thought experiment even though we take it as a deterministic example? The easy answer would be say that it is not a deterministic example, or to acknowledge that even though the world of the example is deterministic, we act as though it is not. But I do not think this is the reason, and the writers of these examples have not hinted at probabilities for the alternative outcomes. I believe it is the language of possible worlds and counterfactuals that has somehow diluted the meaning of determinism. In a deterministic world, events can happen in only one way.

IV. COMPARISON TO ALGEBRA

We can readily make a comparison between causation thought experiments and word problems in basic algebra. It seems natural to compare the word problem, a set of propositions, to the thought experiment in a typical causation example. Further, a particular theory of causation, in other words, a rule for taking a thought experiment and computing the truth of a causal event can be compared to the arithmetic rules or theorems of algebra. Consider the following mathematical word problem:

> Billy and Suzy both run a 100 meter race. Each runner runs at the same constant velocity. Suzy starts slightly before Billy. However, had Suzy not started before Billy, Billy would have started before Suzy. Who will finish the race first?

This is not much of a word problem, but clearly by the rules of algebra coupled with implicit notions of length and velocity, we calculate that Suzy will finish the race first. Of course I can ask, "Well, what if Billy started before Suzy?" Then again, by the rules of algebra, I calculate that Billy would have won under that new premise. However, at no time do I consider both examples simultaneously and attempt to answer the question as to whom will win the race. Nor can I use conclusions from the latter to make arguments against the former. Considering both thought experiments simultaneously would be like following example. Billy and Suzy both run a 100 meter race. Each runner runs at the same velocity. Suzy starts before Billy. Billy starts before Suzy. Who will finish the race first?

Of course this question is trivially nonsense. The theorems of algebra cannot resolve this problem 'en bloc' because the problem is logically inconsistent. Symbolically, if A is the theorem of algebra (coupled to notions of length and velocity) and H_1 and H_2 are sets of premises in the form of word problems, the first with Suzy starting first and the second with Billy first; then both $A(H_1)$ and $A(H_2)$ have answers. However, $A(H_1H_2)$ cannot be resolved – not because the theorems of algebra are deficient but because H_1H_2, which has Suzy and Billy both starting first, does not make sense. Causation examples are equally troublesome because the conditional premise is a logical negation of the original premise. A theorem of causation must be able to resolve a particular thought experiment 'as is'. A hypothetical conditional situation is often used as an argument to refute a particular theorem of causation. Again, the typical argument is as follows with regard to late preemption – Lewis's theory of causation suggests that Suzy caused the glass to shatter; however, if Suzy missed and Billy's rock caused the shattering, then Suzy's actions would have no connection to the shattering; therefore, Lewis's theory cannot be correct. This argument carries no weight for the reasons above. The detractor is talking about a totally different thought experiment. With regard to the algebra example, it is similar to arguing that the theorem of algebra cannot be correct because, if Billy started before Suzy, then Billy would have been first; but we have already calculated that Suzy finished first, so algebra is not correct. We cannot posit both worlds and apply the theory en bloc.

In considering other possible hypothetical worlds; specifically, worlds which logically contradict the truth value of the original thought experiment, we create a contradiction at the level of the thought experiment itself. In symbolic form, if T represents a theory of causation, H_1 represents a thought experiment with a specific set of premises and H_2 represents another thought experiment with a different set of premises espoused in the conditional scenario, then our theorem must apply simultaneously to the premises of both H_1 and H_2, represented as $T(H_1H_2)$. However, quite often H_1H_2 creates a logical contradiction under analysis, e.g. Suzy shatters the window and Billy shatters the window. While one may argue that at no time $T(H_1H_2)$ is the case, and that $T(H_1)$ is the focus of analysis, this would imply that the theory could resolve causation questions for H_1 and H_2 independently, and at no point would we need to posit the alternate world. Another way out would be to say that we really are considering $T_2(T(H_1)T(H_2))$, where T_2 is another theory and that $T(H_1)$ and $T(H_2)$ do not contradict each other; however, no theorist has suggested that this strategy is being undertaken. Perhaps we are to assume that the conditional situation in a causation example has a unique meaning that differs from the sense in the word problem? I do not see an obvious difference, and if one exists it has not been clarified.

The implication here, if we are to accept the preceding argument, is that under determinism the conditional counterfactual statement at the end of each thought experiment above is either completely irrelevant to the problem or creates a logical contradiction in further analysis. How is it then that numerous modern causation examples have been analyzed in this manner and no one has seen any problem? Perhaps the writers did not really mean to say that the examples were deterministic – but then they should have mentioned something about the likelihood of the opposing events. Maybe there are other implicit assumptions within causation thought experiments that are typically made that I have not presumed or vice versa.

V. A LAYERING OF PERSPECTIVE

I believe one source of conflict arises in viewing the thought experiment as a set of events that actually took place within the actual physical world, rather than viewing it as an abstraction of information divorced from all other knowledge. In the latter view, we could replace the words 'Suzy' and 'shatters' with letters such as *C* and *E*, and no information would be lost from the original example. In the former case, if I were to replace the concept 'Suzy' with the letter *C*, I would be suffering a great loss of information as I presume that Suzy is a human female with mass, a genetic code, and feelings. Now this is the confusion. It seems that most causation analyses assume the former viewpoint, that the events described in the example take place in the actual physical world, and that Suzy does have all of the properties of a human. My mistake above in deriving the contradiction of the conditional world was to assume the latter, that events are pure abstractions with no contact to the actual physical world. Therefore, perhaps the contradiction is avoided by assuming that the hypothetical events take place in an actual world, and that 'Suzy' and 'shatters' cannot be replaced by abstracted variables. [2]

Suppose that we are in the backyard of Ms Smith's house. Suzy and Billy are standing in the yard. There is a window about 15 feet away from both Suzy and Billy, and you are nearby so that you have a good view of them both and the window. You watch Suzy pull her arm back over her shoulder and launch the rock at the window. At the moment you notice the rock at the window, the window shatters with pieces falling to the ground. You conclude that Suzy's rock shattered the window, although in the actual world such an observation would not be sufficient to prove causation. Nonetheless, after witnessing Suzy's action you sit back and think, well, if Suzy had not shattered the glass, then Billy would have done so anyway. There are two problems with this

[2] If Suzy throwing rocks took place in the actual world, and our thought experiment posits that "Suzy's rock shattered the glass", then I first must assume that someone observed her throw the rock at some past time, and that this person observed what he saw 'correctly' without confusion and did not miss anything. Of course he might have seen it incorrectly with some small probability. You might like to disagree, and state that we are talking about a hypothetical 'abstract' Suzy that doesn't really exist, and that no one really witnessed anything because it's an abstracted example, then I must question how abstracted is it? If we are no longer talking about actual events in the world, then your example might be subject to the logical contradiction above. Let us bypass this argument by assuming that you actually observe, in the actual world, Suzy throwing a rock at a glass.

thinking. First, as an observer of Suzy in the actual world, for you to wonder if Suzy had not shattered the glass requires the possibility that events could have gone a different way. This requires you to specify a probability that Suzy shatters the window. If you demand that Suzy could not have done otherwise, then the probability was equal to 1, and it makes no sense to hypothesize what Billy would have done because Suzy was never going to miss. If you concede that Suzy did have a chance, however small, to miss the window then you should specify this probability in the thought experiment. But let us assume that this chance to miss was implied but not specified (I do not think this chance is typically implied as determinism is assumed, but it is the only way to save the example). Now the second problem arises once we consider Billy's actions. As an observer in Billy's world, you have no way of knowing with absolute certainty that Billy would have indeed shattered the window if Suzy missed. How could you possibly have this information in advance? You may have some degree of probability, but it strains logic to assume that you could predict the future perfectly. Is there not some small chance that Billy will miss too?

It seems that the typical late preemption example assumes a layering of perspectives within a single example – the perspective of hypothetical Suzy and Billy and possible observers at that same layer, and the perspective of external observers, us, who can observe the world of Suzy and Billy but also observe external truths that they do not have access. Let us call our perspective the actual layer and Suzy's perspective the example layer. As residents of the actual layer, you and I have full knowledge of the example layer. The problem arises with the conditional statement usually posed at the last line of the example such as "had Suzy missed, Billy's rock would have shattered the glass." The common analysis of causation examples assumes that this statement has relevance in the example layer, although as we have just shown that unless the antecedent has a possibility of being true in that layer, then we need not even consider it as part of the original example. If you maintain that the example is strictly deterministic, then either the conditional statement is irrelevant because it resides in the example layer and can never be true in the everyday sense, or you are implicitly assuming that the conditional statement resides in the actual layer. However, if the conditional resides in the actual layer, and you assume that the example is deterministic, then any use of the conditional will result in the contradiction as in the algebra example above. It is interesting that in the algebraic word problem we distinguish the actual and example layers clearly, yet in the causation example we mix them together.

By adding a probabilistic language to Suzy's actions we can make the conditional statement have relevance within the example layer and avoid any contradiction. By this I mean it would make sense for an observer of Suzy in her layer to ask "What if Suzy missed?" Here is an example. Billy and Suzy throw rocks at a window. Suzy throws first. Suzy has a 0.75 probability of shattering the window before Billy throws. If Suzy's rock didn't shatter the window, Billy's rock would have shattered the window. In this thought experiment Suzy has 0.75 probability of shattering the bottle and Billy has a 0.25 probability. We know Billy's probability because we demand that the bottle gets shattered in our thought experiment, so his probability is 1 - 0.75. In this example it makes perfect sense to raise questions about Suzy acting one way or the other, but the world in not deterministic. What happens in this example if we ask "What if Suzy had a 0.25 probability of shattering the bottle?" Of course you would reply that that would be a completely different thought experiment with different probabilities, and that you would not use conclusions from the second experiment to make conclusions about causation in the first. However, this type of argument is made almost uniformly when talking about preemptive type causality examples.

Although we eliminate the host of problems that arise by assuming that Suzy indeterministically shattered the bottle, the force of this example of late preemption dissipates. Further, the dilemma that the bottle must shatter at the end of the experiment remains. Who is it that has the knowledge that the bottle must shatter? Certainly this knowledge only exists in the actual layer where you and I suppose that it is true, for how could Billy or Suzy know this in advance? But then the example is again ill-posed as it is not a self-contained set of premises. Suppose I wished to know what would happen to the bottle if neither Billy nor Suzy shattered it. This question has no answer in either layer. Perhaps the bottle just shatters by itself when no one is around. If I do not know what happens to the bottle when both Billy and Suzy are not influencing it, then how can I make any claim about causation? In the above example our commonsense notion of causation fails. While you may blame the probabilistic component, I believe that the remaining determinism is the source of confusion.

The forgoing argument has been focused on causation examples, how we analyze them, and the assumptions we make. I have not claimed that any particular theory of causation is flawed; rather, the examples themselves are problematic. From a pragmatic standpoint, why else would such a simple example of late preemption be so difficult to reconcile unless the problem was with the example and not the theory?

VI. DETERMINISM

In the end, the fundamental flaw with this example of causation is the assumption that determinism holds and that the antecedent of the conditional situation has the possibly of being realized in the exact same world. It is implied that we assume a deterministic example of causation when we describe an example without assigning chance to various events. But determinism dictates that events can only happen in one way. If you are observing Suzy shatter a window in the actual world, and you assume that the world is deterministic, then asking what would have happened had Suzy not shattered the window is irrelevant in the actual world because the situation you are inquiring about could never have happened. Your inclination then is to ask what would have happened "in theory" if Suzy did not shatter the window. In doing this you are imagining a different deterministic world, a world in which Suzy in fact misses; a separate world where she could have done none other. In both worlds Suzy's actions are precisely dictated. In the first world she was the cause; in the second she was not. Neither world influences the other. We can restate the problem in one more way:

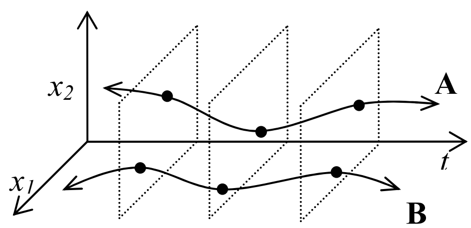
> H_1: 'Suzy must shatter the window and Billy must not'
> H_2: 'Suzy must not shatter the window and Billy must'

The 'must' is added to emphasize determinism and implies nothing more. These statements essentially summarize the example at hand after abandoning the conditional. Since determinism holds, either H_1 or H_2 is true but not both. With what likelihood are they true or not? It appears that we implicitly assign a particular chance to each premise being true or not, at least in some sense, yet this probability is strictly outside of the original deterministic thought experiment. We want to assume that determinism holds, yet we also want to assume that events have some chance of going a different way. We have gotten around this in causation examples by making the world of the example deterministic, and then allocating the probability outside of the example so that we can meaningfully talk about deterministic events going one way or the other. Instead of stating that Suzy has some probability of shattering the glass or not in a single consistent example, the example writer implies that one or the other deterministic worlds (H_1 or H_2) is true or not with an unspecified probability. I believe that the best anyone can say is that Suzy causes the window to shatter under H_1 and Billy causes the window to shatter under H_2. We might add probabilities for which these are true, but at no time does this example create the confusion that has been traditionally associated with it. The algebra example can be resolved in a similar manner.

VII. A BLOCK SPACE-TIME DEFINITION – BILLY AND SUZY OBSERVED

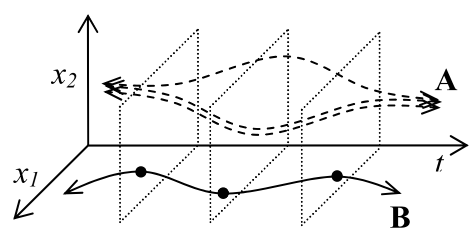
Let us question once more what is meant by determinism in these examples. A common definition states that a world is deterministic if and only if, given a specified state at time *t*, the way things go thereafter is fixed as a matter of natural law (Hoefer [2004]). This is similar to the possible worlds definition given in the beginning of this paper. It follows, if Billy and Suzy inhabit a world with determinism, then a given time *t* before they engage in rock throwing should sufficiently fix their future actions. At no point could they have done otherwise. Here we offer another definition of determinism that illustrates what is at stake. This view of determinism is not new but only a re-specification of the block universe put forth by Einstein and Minkowski and argued against by William James (Einstein et al. [1952]). We will say that *world w is deterministic if and only if the world lines of all objects **A** in w are non-probabilistic (fixed) functions of space **and** time*. *World w is not deterministic if one or more world lines in w are a probabilistic function* *of space* ***or*** *time*. An object **A** is anything for which a space-time distance between **A** and an arbitrary space-time point *P* can be measured (baseballs, cars, and puddles count; the thought of a peach does not – although the originating neurons do). By measure we mean in the empirical sense. The position of an electron can be measured – but not with the unaided eye. There is a healthy distinction to be made between objects such as shadows and those such as chairs which we will mention below (Dowe [1997]).

This view of determinism is best appreciated when considering the block space-time illustration in Figure 1.[3] Two spatial dimensions are represented by x_1 and x_2 and one of time by t. Assume that there are two worlds, both consisting of only two particles **A** and **B**. In the first world, the world line of each particle is fixed within the world. In the second world, the **A** particle may be found on one of three world lines with a particular probability, where possible paths are represented by dashed lines. The indeterminism may be spread across time or space or both. We can imagine



A deterministic world

Figure 1



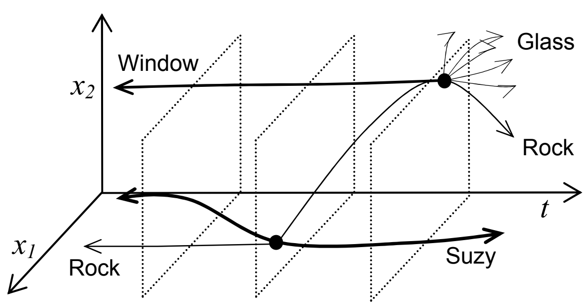
A non-deterministic world

an arbitrary volume representing the indeterminate path of any object. An electron would have a probabilistic path according to the Copenhagen interpretation of quantum physics. This conception of determinism side-steps much confusion spawned by other definitions by considering block space-time. Briefly, there is no need to consider a particular state of the universe at a given time t, and it becomes clear that determinism refers symmetrically to the arbitrary past and future. Nor do we confuse prediction with determinism. The world line of a particle may entail an incredibly

[3] Our diagrams are not technically Minkowski space-time diagrams in that we do not assume that the Minkowski space-time metric holds. This means that the world lines we draw will have arbitrary paths through space and time; paths which would not be possible according to our current understanding of our universe.

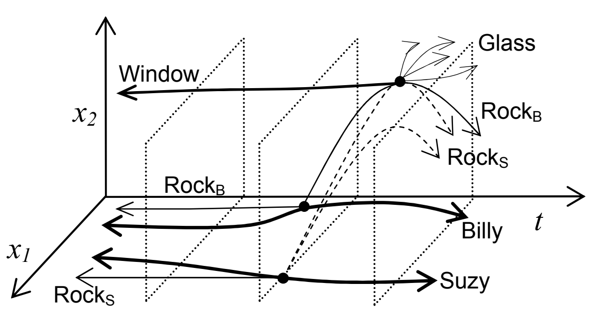
complicated path through space-time and be extremely difficult to predict given the history of the particle, but this would in no way imply indeterminism. There is no need to assume that the laws of physics are identical in different regions of space-time. So long as a particle is restricted to one path, it matters not what laws that particle experiences. Finally, the formulation above is quite general and applies to all other possible worlds that exist in arbitrary *n*-dimensional space-time containing a well-defined measure of distance.

While this definition and its relation to previous definitions is a matter of debate; the block-space time view of determinism is not new. In accordance with commonsense, our definition makes a clear deterministic difference between classical and quantum physics under the Copenhagen interpretation. The utility of our definition is in its ability to cleanly specify what we mean by a deterministic causation example, and to make clear the distinction we are to make from indeterminism. Further, at no point do we need to consider the so-called prior causes deterministically causing everything else that is to follow. All particles have their own path to follow in the universe, whether they run into other particles or not. In a deterministic world that concerns itself with physical objects, causation appears to be no more than asking if two particles overlap or oppose each other in any region of space-time. Under determinism, one kind of causation is identical to physical interaction – well, almost. Those philosophers who concern themselves with causal process theory and more specifically the conserved quantity theorem have convincingly argued that under determinism in block space-time, one sort of causation is to be understood in terms of world lines and intersections of these lines accompanied by an exchange in conserved physical quantities (Dowe [1992]; Salmon [1994]).



Deterministic example of shattering

Figure 2



Indeterminate example

Figure 2 is perhaps the clearest argument against the compatibility of a deterministic world and the traditional late preemptive examples; as well it shows that any complicated theory of causation under determinism is unnecessary to explain it – the conserved quantity theorem handles it neatly. Here we represent the world lines of a rock, Suzy, a window, and shattered glass. I ignore Billy for now. This is the world of the thought experiment viewed en-bloc through space and time. At some time Suzy (the thick bottom world line) interacts with the rock; the interaction is represented by the intersection of their respective world lines. The rock flies off toward the stationary window and then interacts with the window. The physical interaction of the rock and window results in glass fragments. Intersecting world lines are called causal interactions, but it seems like calling them physical interactions would suffice. Under determinism it makes no sense to ask what would have happened if Suzy missed. She cannot do so.

In the bottom diagram we can ask intelligibly about alternative scenarios because the path of Suzy's rock is not determined. This is the example that I suspect all discussions in the literature are attempting to answer regarding the Billy and Suzy 'late' preemption example. If I am wrong, then one should be able to represent this example in a single diagram without introducing any indeterminism. This rendition of the example is clearly non-deterministic, which makes it an interesting example for causation analysis. Here we assumed that the timing of shattering would have been identical for both throwers. To assume different timing would require a completely different diagram. We gave Billy's rock a deterministic path because the example is often stated in such a way that his rock could do no other. Suzy is often given the chance to miss, and so the path of her rock is indeterminate. We could have made Billy's rock path indeterminate as well; it does not change the argument. In this example we require that the window is shattered deterministically. We might ask, given that the window is shattered, who exactly is responsible for this outcome? In our example the answer is at least Billy and perhaps both Billy and Suzy because we provided no additional information in which to differentiate them. You could further complicate the example, and assume that Billy and Suzy shatter the glass in different ways, describing different numbers of glass fragments and velocities, but then you must create new indeterminate paths for the glass shattering. Given that the glass shattered in a particular way (choosing one indeterminate path over another), you could trace the path back to the associated thrower by following the intersecting lines. If you assume that shattering can take place in a number of different ways, you are adding more indeterminism to a so-called deterministic example. Some of the current theories of causation suggest that considering finer details regarding the shattering solves the example of late preemption (Lewis [2000]). This is incorrect. More detail simply adds more paths to the world line diagram. It would be helpful to assign probabilities to make this example tractable.

VIII. CONCLUSIONS

Any question about causation that involves a deterministic world as described above, that does not allow for probabilistic alternatives, and concerns itself solely with objects carrying conserved physical quantities can be reduced to a world line diagram without any mystery. No matter how complicated the example, should it include levers going on and off, preemptive potential causes, and double preventions; if the example mandates a deterministic world and conserved quantities, then it is solved easily – ignore all conditional statements and draw the diagram. You can also appreciate that a sort of transitivity can be readily assigned in these examples. If the rock interacted with Suzy, and the rock interacted with the window, then Suzy interacted with the window (through the rock). Simply follow the intersecting world lines. Space-time objects are connected through chains of symmetric interaction. Interaction is transitive.

The mystery of causation is far from resolved, although for a class of causation problems involving determinism as defined above and concerning itself with conserved physical quantities, most of the ends are tied. The late preemption example of Billy and Suzy either contains a contradiction in its assumptions or has a trivial solution; problematic examples do not likely end with those two. All neural-type diagram examples are likewise physical, and if we ignore the conditionals there should be no confusion. Even though we introduced a specific definition of determinism for clarity, it seems most common definitions lead to the same conclusions as our initial arguments did not depend upon this view. The interesting questions regarding causation spring from two sources – indeterminism and objects not composed of fundamental particles. There is no single robust concept of indeterminate causation that coincides with commonsense and leads to acceptable results in all cases. The second problem has been addressed in the casual process literature, at least for so-called pseudo processes like shadows, reflections, television images and other patterns of light. However, focusing on these physical epi-objects seems to minimize the notion that thoughts, ideas, and states seem to be just as causative as more physical phenomena. If our deterministic example considers events to be fact or ideas, I am far more intrigued. Certainly I do not know what it means to draw the world line of a fact or an idea. Can an idea interact with another idea or a physical object? Ideas seem to pop into my mind from nowhere, interact with other ideas, influence my physical behavior, and then disappear – like these.

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