Strong Proportionality and Causal Claims

Jennifer McDonald

Abstract

There are several supposedly lethal objections to the view that causation is essentially proportional. The first targets an account of proportionality in terms of causal models, pointing out that proportionality is too easily satisfied in causal model accounts of causation through manipulation of the range of values that a variable can take (Franklin-Hall, 2016). The second argues that proportionality legitimizes only the most general things as causes, and proportionality thereby contravenes causal intuitions (Bontly, 2005; Franklin-Hall, 2016; McDonnell, 2018, 2017; Weslake, 2013). The final, and perhaps most intractable, objection holds that proportionality counter-intuitively legitimizes disjunctive causes (Shapiro and Sober, 2012; Weslake, 2017; Woodward, 2018). This paper provides a unified response to these objections, which is best formulated in a causal model framework. I first articulate two independently plausible principles of variable selection – *exclusivity* and *exhaustivity*. I then show how the adoption of these principles responds to Franklin-Hall's objection, and dissolves the remaining two.

1. Introduction

Imagine that a pigeon named Sophie is trained to peck at red things and only at red things. Sophie then pecks at a paint chip, which is a particular shade of red – scarlet. Is the chip's being red or its being scarlet the cause of Sophie's pecking? Intuitively, we want to say, the cause is the chip's being red. For, had the chip not been red Sophie would not have pecked, whereas had it not been scarlet she still might have – had it been burgundy or crimson or some other shade of red.[1]

The example of Sophie illustrates Stephen Yablo's principle of proportionality. Proportionality holds that something counts as a cause of some effect just in case its description includes enough but not too much causal information relevant to the description of that effect within the given context (Yablo, 1992). Such a principle has been put to various philosophical uses: for example, as a proposed solution for the causal exclusion argument against non-reductive physicalism, and as a justification and explanation of the privileging of higher-level causal explanations in the special sciences. However, the precise formulation of proportionality, and the role it should play (if any) in the metaphysics of causation, has proven to be controversial.

---

[1] Sophie has been borrowed directly from (Yablo, 1992).

The primary aim of this paper is to defuse three objections to proportionality. One objection, put forward by Laura Franklin-Hall, (Franklin-Hall, 2016), argues that the formulation of proportionality within a causal model framework is easily satisfied without successfully privileging intuitively proportional causes such as red in the Sophie example. It's therefore inadequate for capturing the kind of causal explanation we're looking for. I take this objection to apply equally well to any causal model account of causation. The second objection, separately put forward by Thomas Bontly (2005), Brad Weslake (2013), Franklin-Hall (2016), and Neil McDonnell (2018, 2017), can be called *the problem of generic causes*. It begins with the claim that proportionality legitimizes only the most general or abstract things as causes. However, it seems as though many of our common-sense causal claims involve non-proportional causes. The requirement that causes be proportional would therefore render many causal intuitions false. Finally, Larry Shapiro and Elliott Sober (2012) demonstrate that proportionality counter-intuitively legitimizes disjunctive causes. This is particularly evident with things like non-monotonic functions.

My response to these objections takes the following form. For the purposes of this paper, the most useful way to frame causation is in terms of causal models. This is because a causal model framework is explicit about what features of the situation are assumed to be held fixed, and about the range of alternatives for how variable features could have possibly been different. A brief overview of this background framework is laid out in the next section. With this framework in place, I articulate two independently plausible and widely assumed principles of variable selection. Although pervasive, these principles have not been named or explicated. I therefore christen them *exclusivity* and *exhaustivity*. Exclusivity ensures that a variable take at most one of its values. Exhaustivity ensures that a variable take at least one of its values. Crucially, these principles are relative to the modal profile of the target causal situation.

I then defend a causal model formulation of strong proportionality against Franklin-Hall by showing that it works fine so long as exhaustivity is in place. Next, I answer the problem of generic causes. When translated into causal models, and with exclusivity and exhaustivity in place, it can be seen how the examples from the literature are indeed proportional. The objection that proportionality contravenes causal intuitions therefore doesn't go through.

Finally, I address the objection that proportionality counter-intuitively legitimizes disjunctive causes. I point out how much of what's compelling about this objection is dissolved in the same way as the problem of generic causes. However, something troubling remains. I argue that this is not as troubling as it seems.

2. Causal Models

In the last few decades, several accounts of actual causation in terms of causal models have sprouted up (Halpern, 2016a; Halpern and Pearl, 2005; Hitchcock, 2001; Pearl, 2000; Weslake, 2015; Woodward, 2003). This new development in the causation literature has proved fruitful and "exciting", to quote Christopher Hitchcock (2001, p. 273). Indeed, the causal model framework will be crucial for my purposes, as it brings to light precisely how the objections to strong proportionality go wrong.

There are a number of different types of models, but I'll focus on the use of structural equation models, in particular. I take there to already exist a satisfactory number of useful articulations of such models in the literature (Greenland and Brumback, 2002; Halpern, 2016a, 2016b; Halpern and Pearl, 2005; Harary et al., 1965; Hitchcock, 2018, 2009, 2001; Pearl, 2000; Spirtes et al., 1993). As a result, and in tandem with the fact that many of the formal details won't actually matter for the purposes of this paper, I won't burden the reader with yet another detailed overview. Suffice it here to say that a structural equation model essentially represents causal relations between things in the world as functional equations between variables in a model. The variables on the right-hand side of an equation are all and only those variables for whom interventions on their values result in a change in the value of the left-hand side variable.[2] The form of the equation specifies the precise nature of these correlated changes, and can be in terms of Boolean logic, probability logic, arithmetic, etc. For example, say that a binary variable, $Z: \{z_1, z_2\}$, is such that it will take z_1 whenever two other binary variables, $X: \{x_1, x_2\}$ and $Y: \{y_1, y_2\}$, take x_1 and y_1, respectively, and Z will take z_2 otherwise. This could appear in our structural equation model as any of the following: $(Z \coloneqq X \wedge Y)$; $(Z \coloneqq \min(X, Y))$; $(Z \coloneqq X + Y)$.[3]

Variables represent the causal relata, whether they be events, property instantiations, or whatever. I'll assume that the causal relata are property instantiations. The set of values of a particular variable will therefore represent a set of properties – constrained by a given property type – that are possibly

[2] An *intervention* on a variable in a model is an operation that forces a variable, X, to take a certain value in such a way that breaks any dependence X had on any 'upstream' or 'parent' variables – variables that figured in the equation for X prior to the intervention.

[3] These functional equations can be taken to represent either counterfactual relationships between relata, and therefore reducible to counterfactuals (see Hitchcock, 2007; Woodward, 2003), or primitive, sui generis relationships, which generate various counterfactual claims (Hiddleston, 2005; Pearl, 2000). I remain neutral on which position is correct.

instantiated by some particular thing. It's worth noting, though, that the variables of a model can be taken to represent a variety of things, and my argument relies on the basic framework of models, rather than the particular choice of causal relata. So, nothing should turn on this assumption.

A model has two kinds of variables: exogenous and endogenous. Exogenous variables have stipulated values within the model. Endogenous variables have their values determined by the other variables within a model, in the way specified by the relevant equation.

There are two categories of rules for model construction.[4] The first are formal in nature – constraints internal to the model as a mathematical entity. The main constraint of this kind is that a variable be capable of taking more than one value. This is widely recognized. The second are principles that serve to ensure that the relationship between the model and the situation that it represents is of the right sort. Although of greater philosophical interest, these have yet to be made satisfactorily explicit. I address this in the next section.

One thing is causally related to a second just in case it figures in the equation for the second thing in at least one apt model.[5] This core criterion of causation is at the type level. Accounts of actual, or token, causation then build up from something like this core criterion using two key additions. First is added an actuality condition, which ensures that actual causes and effects will only be things that actually occur. Second is added a condition specially designed to accommodate the infamous problem cases of overdetermination and preemption. I remain neutral on how all these details shake out. In what follows I will refer to the analysis above as *the core criterion* for type-level causation, and I will assume that further analysis of actual causation will somehow deliver *the basic requirements of actual causation*. I would be obligated to precisify these details if I were attempting to provide an account of causation or actual causation. But I'm not. Instead, I'm arguing that a proportionality condition on causation gets our intuitions right, and that this is especially illuminated when considering the causal model framework. I'll therefore leave this overview here.[6]

---

[4] Thanks to Jonathan Schaffer, in discussion, for articulating this distinction.

[5] The choice of *at least one* apt model is widely made, but not logically required. One could define causation as a relation that holds across all apt models, some majority of apt models, some significant subset of apt models, etc. One could also avoid talk of apt models altogether by making the causal relation model-relative. But the sheer volume of possible models, and variation between them, makes this unsatisfactory.

[6] See (Halpern, 2016a; Halpern and Pearl, 2005; Hitchcock, 2001; Pearl, 2000; Weslake, 2015; Woodward, 2003) for complete accounts of causation in terms of causal models.

3. Exclusivity and Exhaustivity: Principles of Variable Selection

A causal model definition of cause relies on a notion of an *apt model*. I hold that a model is apt in the relevant sense only if its variables respect two principles: what I call *exclusivity* and *exhaustivity*.[7] Take exclusivity first. There is a non-controversial formal constraint that requires that a variable not take more than one value at a time. *Exclusivity* is a representational principle that ensures this. It holds that the values of a single variable should represent mutually exclusive things, so that the occurrence of any particular thing represented by a value of this variable excludes the occurrence of any of the others. If two things are not exclusive – if they could occur together – then they should be represented by distinct variables. In terms of property instantiations, if two properties can be instantiated by the same object at the same time – such as its being round and red – then they should be represented by different variables.

Exclusivity is universally assumed. As an example, take Hitchcock:

> [W]e must ask what it means to represent two events (such as *a* and *b*) as different values of the same variable, or as values of different variables. When we represent two events as different values of the same variable, we are representing those events as *mutually exclusive*. A variable is a function (over possible worlds, if you like), and hence it must be single-valued. (2004, p. 145)

While exclusivity ensures that a variable takes *at most* one of its values, exhaustivity ensures that a variable takes *at least* one of its values. *Exhaustivity* is the representational principle that requires that a variable's values capture the entire range of relevant possibilities for whatever type of thing the variable represents.[8] In terms of property instantiations, exhaustivity holds that a variable's values must jointly represent the range of possibilities of property instantiation by the given object for the given property-type. If the property-type is a color, for example, then the values must exhaust the color spectrum. This can be done quite simply with a binary variable that can take the values: {*being some particular color*, *not-(being that particular color)*}.

---

[7] Note that this is only a necessary condition, and not a sufficient one.

[8] Note that although inspired by it, this is not the notion of exhaustivity discussed in (Franklin-Hall, 2016). Franklin-Hall proposes and dismisses an exhaustivity condition that "requires that the cause variable's values collectively exhaust the…range of circumstances by which the explanandum event – as well as its contrast – might be brought about." (2016, p. 566)

It's not clear how controversial exhaustivity is. But it is widely taken to be a natural principle of variable selection. Woodward writes,

> We also want our variables to take a range of values corresponding to the full range of genuine or serious possibilities that can be exhibited by the system of interest. (2016, p. 1064)

In addition, Judea Pearl in his seminal text assumes both exclusivity and exhaustivity in his description of a variable. He writes, "B_i, i = 1, 2, …, n, is a set of exhaustive and mutually exclusive propositions (called a *partition* or a *variable*)…" (2000, p. 3) Several pages later, he continues,

> Likewise, each variable X can be viewed as a partition of the states of the world, since the statement X = x defines a set of *exhaustive* and *mutually exclusive* sets of states, one for each value of x. (2000, p. 9, emphasis my own)

Finally, in their discussion of interventionist counterfactuals, Ray Briggs assumes both exclusivity and exhaustivity,

> Each V∈V comes with a range R(V) of possible values ‑ that is, answers to the question posed by the variable. I assume that the answers to any given question are *mutually exclusive* and *jointly exhaustive*, and that *no answer to one question entails an answer to any other*. (2012, p. 142, emphasis my own)

I take there to be more representational principles for models than the two I've enumerated here. For example, we may need something like *distinctness* – a principle that holds that things which are represented by distinct variables should be metaphysically distinct. But only the two principles of exclusivity and exhaustivity are needed for my current argument, so I leave a more comprehensive discussion of representational principles for another work.

4. Relativizing to Modal Context

As I've mentioned, exclusivity and exhaustivity are widely assumed, but rarely articulated. This may explain why the following has not been registered. Once articulated, we can see that each principle makes reference to *possibilities*. Exclusivity holds that every value of a variable should exclude – as in, render impossible – any of its other values. Exhaustivity holds that a variable's values must jointly represent the entire range of relevant possibilities. These principles therefore call for an explication of the nature of this possibility.

I propose that the range of possibilities presupposed by exclusive and exhaustive variables is determined by what I call the *modal context*. The modal context is the set of initial conditions of the system under inquiry. The notion is essentially the same as the traditional notion of *causal field*.[9] But the term 'modal' is meant to draw attention to the fact that these initial conditions include both how things actually are as well as how things could have been. So, the modal context is constituted by the actual particular facts – about what things exist and what properties these things have – and the possible particular facts – about what properties the existent things could have had, what things could have existed, and what properties these possible things could have had. The modal context for Sophie's case, for example, will include the range of possible colors that the chip might have been.

To illustrate how exclusivity and exhaustivity are relative to a modal context, take the causal claim, 'The chip's being scarlet is the cause of the pigeon pecking.' I'll assume that the claim refers to a concrete situation in the world, with an actual scarlet chip and an actual red-pecking pigeon. Note that this claim alone leaves out some details. The shape of the modal context depends on how these details are filled in. The situation to which this claim refers may be one in which the chip could have possibly been any other color. In which case, the modal context would include the possibility that the paint chip takes any color within the color spectrum. A variable, *C,* that can take the values {*cyan, scarlet*}, is not exhaustive relative to this modal context. *C* would therefore be an inappropriate variable. But the variable *T:* {*taupe, scarlet, cyan, mauve, crimson,* etc.} is exhaustive. An exhaustively appropriate model of this situation will therefore include *T,* rather than *C*.

Alternatively, this claim may refer to a situation near a local paint chip factory that specializes in just the colors scarlet and cyan, and no others. In this case, the scarlet chip could only have otherwise been cyan. The modal context will therefore include that the chip is scarlet and only could have possibly been cyan. Relative to this context, *C* is an exhaustive variable, and so a model which includes *C* will be exhaustively appropriate.

5. Proportionality as Relational Property between Variables

I now have the framework with which to define proportionality. As a first pass, proportionality can be represented as a relational property holding between a cause variable and an effect variable. Two variables will be *proportional* just in case changes in one of them (the cause variable) line up in the right way with changes in the other (the effect variable). This captures the intuition that the

---

[9] (Anderson, 1938; Mackie, 1974, 1965)

paint chip's being red is proportional to Sophie's pecking because changes in the chip's shade from red to otherwise will correspond to changes in whether Sophie pecks. But this is not a definition – more needs to be said about what it is to 'line up in the right way'.

To motivate the definition I eventually adopt, I'll first translate Yablo's example into causal model terms. Take the variable, P, to be a variable representing whether Sophie the pigeon pecks or not. It can take the values: {*peck*, *not-peck*}. Now consider two alternative variables for representing the property-instantiations of the paint chip: the variable, R, which can take the values {*red*, *not-red*}, and the variable, T, which can take the values {*taupe, scarlet, cyan, mauve, crimson,* etc.}, where 'etc.' stands for all other physically possible colors at the same grain as those already made explicit. These two variables are equally good in a number of ways. First, variables R and T each respect the exclusivity and exhaustivity principles. Second, each of R and T counts as causally related to P according to the core criterion of causation given above. The variable P will change values whether you intervene to change the value of R from *red* to *not-red*, or intervene to change the value of T from *crimson* to *taupe*. But the relationships that R and T respectively bear to P are different. *All* of the changes in R line up with changes in P – every intervention on R corresponds to P taking a different value. There is a one-to-one correspondence between the values of R and those of P. But only *some* of the changes in T line up with those in P – only certain interventions on T correspond to P taking a different value. If the value of T is *taupe*, say, then the intervention that assigns T the value *cyan*, for example, does not so correspond. So, there is not a one-to-one correspondence between the values of T and P.

This is the feature we're looking for to define proportionality. Variable R is *proportional* to variable P, while T is not, because the values of R counterfactually line up one-to-one with those of P, while those of T do not. This insight can first be translated into an account of what it is for a variable to be proportional to some other variable. A variable, C, is a *proportional variable* to some other variable, E, just in case *every* intervention on C that changes it from any one value to any other will correspond to a change in the value of E. More precisely:

> ($\boldsymbol{P_V}$) C is a proportional variable relative to E, given a model $\mathfrak{M}$, just in case every intervention that is on C, and on no other variable in $\mathfrak{M}$, corresponds to E taking a different value.[10]

[10] This is perhaps what Woodward means to pick out with his Principle P (2010, p. 298), but perhaps not. His principle is too vague to tell.

A cause, then, is *proportional* to an effect just in case there is an apt model in which it can be represented by a proportional variable relative to the effect. This provides for the following definition of proportionality in terms of causal models.

> (***P***) A cause, A, is proportional to an effect, B, just in case (i) A satisfies the core criterion of causation relative to B; and (ii) there is an apt model $\mathfrak{M}$, where A is represented by the value of some variable, C, and B by the value of some other variable, E, according to which C is a proportional variable to E.[11]

There are three positions on the significance of a principle like ***P***. First, so-called *strong proportionality* takes proportionality to be a necessary feature of causation.[12] So, one thing is the cause of something else only if it satisfies ***P***. It's worth noting that this view allows that there still be merely causally sufficient and causally relevant relata for a given effect. It's just that these are distinguished from the proportional cause, which is *the* cause of that effect. Yablo writes,

> What distinguishes causation from these other [causal] relations is that causes are expected to be *commensurate* with their effects: roughly, they should incorporate a good deal of causally important material but not too much that is causally unimportant. (1992, pp. 273–274)

In line with this plurality, it need not be a commitment of the strong proportionalist that causal models must only represent proportional relata. Causal models can still be used to model merely causally sufficient and/or relevant relata. It's just that these relations are not *causation*, but mere causal sufficiency or causal relevance.[13]

Against this, a second position – *weak proportionality* – takes proportionality to be a merely pragmatic constraint on causation.[14] Weak proportionality denies

---

[11] The definition specifies that *there is* an apt model, rather than *for every* model, to allow for the possibility that there may be an apt model in which the proportional cause doesn't even appear.

[12] See (List and Menzies, 2009; Menzies and List, 2010; Papineau, 2013; Yablo, 1992).

[13] This point is overlooked in the literature. It's worth belaboring it. It's open to a strong proportionalist to argue that our causal talk can pick out not only proper causation – which is proportional – but also causal sufficiency and causal relevance. Plausibly, the term 'causes' in natural language is ambiguous between these various relations. The important intuitions, then, against which to check the plausibility of strong proportionality are about claims of the form 'This *is the cause of* that,' rather than those of the form 'This *causes* that.'

[14] See (Blanchard, 2018; Bontly, 2005; Maslen, 2017; McDonnell, 2018, 2017; Weslake, 2017, 2013; Woodward, 2015; Yablo, 2003).

that genuine causation requires proportionality, while admitting that proportional causes are at least sometimes better than non-proportional ones for pragmatic reasons. For example, it's perhaps often the case that causes satisfying ***P*** are more explanatorily useful than those failing to so satisfy.

Finally, there is the position – we can call this view *no proportionality* – that denies the value of a proportionality principle altogether.[15] It argues that there is no real privilege of causes satisfying ***P***, or that even if there were it does no real theoretical work. This paper defends strong proportionality.

Note that proportionality is defined in terms of proportional variables within *apt* causal models. And the previous two sections explain how a causal model is apt only if its variables respect exclusivity and exhaustivity relative to the relevant modal context. So, something will be proportional only relative to some modal context – in addition to being relative to some particular effect. Refer back to the previous section's comparison between the modal context where the paint chip could be any other color and the local factory context where the paint chip could only have been scarlet or cyan. In the former, the causal claim that 'The chip's being scarlet is the cause of the pigeon pecking' is *false* because T is not proportional to P in this context. Sophie will peck in response to shades of red other than scarlet, so an intervention on T that changes its value from *scarlet* to *crimson* will not correspond to a change in P. In the latter context, however, the causal claim is *true* because C is proportional to P relative to that context. Any intervention on C given the context of the local paint chip factory will correspond to a change in P.

This relativization to modal context does not undermine the objectivity of proportionality. It's true that some things are determined pragmatically, such as which effect and which modal context we're talking about. But, once an effect and modal context are fixed, features about the world are solely responsible for what counts as proportional relative to that effect within that context.

6. Proportionality Does the Trick

Franklin-Hall contends that the interventionist formulation of proportionality doesn't successfully prioritize intuitively proportional causal relata, such as red in the pigeon example (Franklin-Hall, 2016).

---

[15]See (Franklin-Hall, 2016; Hoffmann-Kolss, 2014; Menzies, 2008; Shapiro and Sober, 2012). I'm ignoring this position at present.

Refer back to Sophie and her paint chip. Franklin-Hall introduces a comparison between the causal variable, *R*, that can take the values: {*red*, *not-red*}, (as above), and a variable, *C*, that can instead take the values: {*cyan, scarlet*} (as above). *R*, as before, is proportional to, and therefore a genuine cause of, *P*. But, she argues, *C*, too, is proportional to *P*, since *C* seems to satisfy $\boldsymbol{P_V}$ relative to *P*. An intervention on *C* that changes its value from *cyan* to *scarlet* changes *P* from *not-peck* to *peck*, and an intervention that changes *C*'s value from *scarlet* to *cyan* changes *P*'s value from *peck* to *not-peck*. Thus, the changes in *C* line up with the changes in *Y* just as well as the changes in *R* do. The problem, then, is that proportionality, as formulated, is insufficient to its intended task. It fails to privilege a variable like *R* over one like *C*, and so fails to prioritize a causal model that uses *R* over one that uses *C*.

In response to this problem, a natural move would be to find a way to disqualify variables like *C* from the arena. Intuitively, *C* is not the right kind of variable. But, why not? I propose that our aversion to variables like *C* is due to their failure to exhaustively represent the implicit modal context of the situation. The background possibilities relative to the paint chip include the full color spectrum. Unless the possible color of the paint chip is restricted in some special way – by the local factory, perhaps – then the target object can fail to take one of *C*'s two values. There are other possible colors that the paint chip could have had – such as beige or olive green – and *C*'s values fail to represent these possibilities.

Relative to the implicit modal context, then, *C* is not an exhaustive variable. The variable, *R*, on the other hand, is exhaustive, since the object must take one of *R*'s two values. By requiring exhaustive variables, *C* is discounted as a candidate variable *relative to the implicit modal context*, and *R* takes privilege as the proportional cause. More formally, the model relative to which *C* satisfies $\boldsymbol{P_V}$ is not an apt model in this situation.

In general, two variables are in proper competition with each other over which is proportional to some effect variable only when they are exhaustive relative to the same modal context. *C* and *R* are not competitors for proportionality relative to *P*, since only one of them can contain an exhaustive set of possibilities relative to any given modal context.

7. The Problem of Generic Causes

The primary objection pitched against strong proportionality is what I call *the problem of generic causes*. The objection begins by pointing out that only very general or abstract causes will satisfy a principle of proportionality. If proportionality is required of something to be a cause, as strong proportionality claims, then many things that we would naturally call causes don't actually qualify. But surely common sense is not as deeply misguided as strong proportionality requires. Strong proportionality, then, must go. (Bontly, 2005; Franklin-Hall, 2016; McDonnell, 2018, 2017; Weslake, 2013).

To illustrate, I'll work with one of Bontly's examples, but Weslake's and McDonnell's are of the same kind. Take the case where Socrates drinks hemlock and then dies, and the corresponding causal claim, 'Socrates's drinking hemlock is the cause of him dying'. The objection is that drinking hemlock is not actually proportional to Socrates dying. If Socrates had not drank hemlock but still consumed it – by eating a dozen leaves, perhaps – then he still would have died. This seems to show that the changes in the variable that represents Socrates drinking hemlock don't line up in the right way with the changes in the variable that represents Socrates dying. The first variable could change values from *having-drank-hemlock* to *having-eaten-hemlock* and the second variable would retain the value *dies*. This causal claim is therefore not proportional. The proportional cause should be, instead, Socrates's consuming hemlock.

One might run this objection even further. The above of course assumes that no other lethal forces are at play. But, Socrates also would have died had he performed seppuku, or had he refused food and drink for several days. So, the real proportional cause should be, instead, something like *having-had-a-lethal-experience*. For only something as general or abstract as this could genuinely satisfy proportionality.

However, if we assume a causal model framework with exclusivity and exhaustivity, then the problem of generic causes is mistaken on two counts. This can be demonstrated by first pointing out that the formulation of the problem doesn't respect the exhaustivity principle of variable selection and fails to attend to the modal context. As a result, it equivocates between different background modal contexts. Moreover, though, it doesn't respect exclusivity, and as a result runs together what should be different variables. Once you set up a model in a way that respects exclusivity and exhaustivity, the problem dissolves.

8. How Exhaustivity Preserves Causal Intuitions

Take the hemlock example just outlined. Importantly, this example and corresponding claim are under-defined.[16] Translated into causal model terms, all that this description provides is that there is some variable that takes at least one value that represents Socrates drinking hemlock, and an intervention on this variable changes the value of some other variable to one that represents Socrates

---

[16] This is not a new observation. See (Franklin-Hall, 2016; McDonnell, 2017; Weslake, 2017)

dying. But, a number of different variables could represent the purported cause, and a number of different models could represent its relationship to the effect of Socrates' dying. Which of these is representationally accurate depends on what the relevant alternatives to drinking hemlock are. How these details get filled in will also determine whether or not the variable that represents Socrates drinking hemlock is proportional.

The causal claim that drinking hemlock causes Socrates's death implicitly takes the relevant alternative to be Socrates's *not* drinking hemlock. I hold that the default context is taken to be that hemlock was the only possible poison, and drinking it the only possible means of consumption, for reasons I'll provide shortly. Given such a context, the exhaustive variable representing Socrates drinking hemlock has the values {*having-drank-hemlock*, *not-having-drank-hemlock*} – call this *D*. The exhaustive variable representing Socrates's death has the values {*having-died*, *not-having-died*} – call this *F*. But, *D* is indeed proportional to *F*. When an intervention sets the value of *D* to *having-drank-hemlock*, *F* takes the value *having-died*. When an intervention sets the value of *D* instead to *not-having-drank-hemlock*, *F* changes value to *not-having-died*. Thus, the common sense cause is, in fact, proportional.

Such a defense first requires that causal claims be implicitly relative to a modal context. This kind of relativity, however, is explicitly denied by both McDonnell and Weslake (McDonnell, 2017; Weslake, 2017). They each claim that if causal claims are indeed relative to a context, then we wouldn't be able to agree on the truth value of the claim before settling the context. The very fact that we have strong and convergent intuitions about these examples, despite their being under-determined, demonstrates that the intuitions are not sensitive to filling in modal details.

In response, I argue that we do tend to settle on a context for causal examples, but we do go about this in the same way that we would go about filling in missing context in standard conversations.[17] According to Grice, communication generally is governed by a set of unspoken but presupposed conversational maxims (Grice, 1989). The maxims most relevant to how an audience engages with these under-defined causal examples are the maxims of *quantity* and *relation*. Taken together, these maxims enjoin an interlocutor to,

[17] A similar point is made, to different effect, by Bontly (2005). It may also need saying that this move bears resemblance to that made by any view that takes causal claims to be sensitive to contrasts, where the contrasts are set by conversational context (Schaffer, 2012; Shapiro and Sober, 2012).

> Make your contribution as informative as is required (for the current purposes of exchange)….[and no] more informative than is required,….[and b]e relevant. (1989, pp. 26–27)

Thus, the conversationally natural way to fill in the modal context of these examples is to take each fact as informative and relevant, and to assume that all informative facts have been provided.

My defense further requires that the implicit modal context is as I've specified. My reasoning follows. The only information provided by the hemlock example is (i) that Socrates drinks hemlock; and (ii) that Socrates dies. If we assume that Gricean maxims have been obeyed, which we do in standard conversations, then we can assume that this is all the information needed, and nothing significant has been left out. Any unspecified details will get filled in as continuous with everyday life. The modal context will be taken as having a similar environment, a biologically similar Socrates, etc., to everyday life.

The main emphasis in the example is on Socrates's drinking hemlock. This means that in evaluating the causal relationship, everything else is held fixed and the fact of the drinking hemlock is varied. Due to the absence of any other details, the only real alternative to Socrates's drinking hemlock is his not drinking hemlock. There's nothing to suggest that there are alternative means of consuming the hemlock, let alone that had Socrates not drank the hemlock he would have consumed it in some other way (or consumed some other poison, or etc.). Further, it's not a common occurrence in everyday life to have alternative means of consuming a given poison. Treating his eating hemlock, for example, as a relevant alternative would be to arbitrarily introduce something that wasn't otherwise specified, and whose presence can't be justified by everyday experience.

The problem of generic causes seems to get off the ground because it stipulates a range of relevant alternative possibilities to Socrates's drinking hemlock, and then argues that given these other possible alternatives, the causal claim is not proportional. However, I have argued that the common sense cause is implicitly relative to a context that doesn't include these other alternatives. To introduce these other alternatives is to introduce a different context than what is implicitly in play, and thereby to change the subject. Relative to the context that I take to be implicit, the common sense cause is proportional.

9. How Exclusivity Preserves Causal Intuitions

However, even given the possible alternatives raised by the objectors, the common sense cause would still be proportional. This can be seen when we respect the principle of exclusivity.[18] The problem presupposes that there is some relevant alternative to Socrates's drinking hemlock that preserves his consuming it. Take as an arbitrary alternative his eating hemlock. But, Socrates could both drink and eat the hemlock – he could wash down a hemlock salad with a full glass of hemlock milk, for example. Since these possibilities can occur together, exclusivity dictates that they should be represented by distinct variables – say by the variable *D:* {*having-drank-hemlock*, *not-having-drank-hemlock*} from before, and a new variable, *E,* that has the values {*having-eaten-hemlock*, *having-not-eaten-hemlock*}.

Fortunately, there is still no problem for proportionality. If the case in question is one in which Socrates doesn't also eat the hemlock, then *D* satisfies $\boldsymbol{P_V}$ with respect to *F*. If the case in question is one in which Socrates also eats the hemlock, then we simply have a case of symmetric over-determination. Causal accounts diverge in their response to these cases. But precisely how one responds to symmetric overdetermination is irrelevant to my argument. Insofar as the common sense cause is taken to be a cause at all, it is also proportional.

There is, however, a way to manufacture a proportionality problem. If the situation is such that Socrates's drinking hemlock is indeed mutually exclusive with his eating hemlock, then *having-drank-hemlock* and *having-eaten-hemlock* should be values of the same variable. Imagine that Socrates's jailor only has enough money to purchase either hemlock leaves or hemlock milk, but not both. The context therefore constrains Socrates's options so that his drinking hemlock excludes his eating it, and vice versa. Call the representative variable *H:* {*having-drank-hemlock, having-eaten-hemlock, having-neither-drank-nor-eaten-hemlock*}. *H* does not satisfy $\boldsymbol{P_V}$ relative to *D*, since an intervention on *H* that changes its value from *having-drank-hemlock* to *having-eaten-hemlock* will not correspond to a change in *D*. Thus, neither Socrates's drinking nor his eating will be proportional. The proportional cause is instead something like his consuming hemlock. The proportional variable would instead be something like *N*: {*having-consumed-hemlock*, *not-having-consumed-hemlock*}.

Notice, though, that this modal context is non-standard. It requires that we abstract away from normal everyday circumstances, and instead fix the situation in an arbitrarily constrained way in which the unique manner of Socrates's hemlock consumption is decided by his jailor's decision at the shop. When, given this background, we're asked what was the cause of Socrates's death, we are arguably forced to concede that it was his consuming hemlock. After all, it isn't the drinking in particular nor the eating in particular that makes a difference to whether Socrates dies, since a salient reason for him not doing one is that he in

[18] This is a similar move as that made in (Woodward, 2018).

fact did the other. What makes a difference is whether he consumed hemlock, generally. I claim, therefore, that this final case does not in fact conflict with common sense.

10. The Problem of Disjunctive Causes

Shapiro and Sober (2012) have a related objection. They also argue that strong proportionality will delegitimize many common sense causal claims. But, their reasoning behind this merits its own response.

Shapiro and Sober provide the example of a non-monotonic function in which both the input values 3 and 22 will produce the same effect of an output value 6. This is one instance of the general phenomenon of some effect being caused by two different things. The truly proportional cause in these cases seems like it must be a disjunction. In this case, the disjunction of being 3 or being 22. They argue that strong proportionalists could bite the bullet and concede disjunctive causes. But, doing so will lead them away from common sense, and "will mean rejecting almost all the causal statements we think are true." (Shapiro and Sober, 2012, p. 90).[19]

Fortunately for the strong proportionalist, this conclusion is too quick. The kind of disjunctive causes that would be responsible for contravening many of our causal intuitions are those that disjoin independent properties. These take a form similar to the disjunctive cause in the following claim: 'The cause of Sophie's pecking is that "[she was] presented with any red target, [*or* she was] provided food, [*or* she was] tickled, and so on."' (Franklin-Hall, 2016, pp. 566–577) But we've already seen how exclusivity can rule out this kind of disjunction as a possible cause. The target's being red and Sophie's being tickled should be values of different variables. This simply loops back to my earlier response to the problem of generic causes.

However, there is a kind of disjunction that seems to pose an actual threat to proportionality – the kind where the disjuncts are mutually exclusive properties. For example, if Sophie pecked at all and only blue or red things. Proportionality would dictate that the cause of Sophie's pecking would therefore be the disjunctive property of the chip's being red or blue.

The best response on behalf of strong proportionality may indeed be to bite the bullet and accept disjunctive causes of this kind. But this is barely a case of biting the bullet in many cases, where there is even an appropriate single term for the relevant disjunction. An example of this is the final Socrates case from section 8.

[19] The fatality of this problem is agreed to in (Weslake, 2017; Woodward, 2018)

There, due to the oddly constrained circumstances, we had as explicitly mutually exclusive properties Socrates's having eaten and his having drank hemlock. As a result, I conceded, the principle of proportionality legitimizes as the cause the property of Socrates having consumed hemlock. The reason is that the real proportional cause here is the disjunctive property, Socrates's having eaten or drank hemlock. And 'Socrates's having consumed hemlock' is the most accurate term for such a disjunction.

Sometimes, however, there is no neat, single term. This is the case for the earlier property of being red or blue. This very limited kind of case is the real issue for the strong proportionalist. I argue, though, that it's not such an issue. It's merely an accident of language in these cases that we can't refer to the disjunction with a single term.[20] One possible explanation of this calls upon the utility of an economical language – one which doesn't multiply terms unnecessarily. We could have introduced a single term for things that are red or blue, which would then allow us to pick out the cause in the example case with a single term. But the utility of such a term fails to justify its introduction. The example case is a weird one, and for cases like this we can simply employ the 'or' operator, albeit sacrificing whatever utility is produced by being able to identify causal relata with single terms.

11. Conclusion

I have defended a causal model formulation of strong proportionality by explicating the exclusivity and exhaustivity principles of variable selection, and stipulating that proportionality requires that variables obey these principles. I then responded to Franklin-Hall's objection and the problem of generic causes, each of which dissolves once the principles are honored. While much of the problem of disjunctive causes similarly dissolves, the strong proportionalist does need to concede the kind of disjunctive cause where the disjuncts are mutually exclusive properties. Sometimes we have a single term for such a disjunct, but sometimes not. I've argued that it's merely an accident of language when not.

As mentioned, these principles have been defined on the assumption that a variable represents a particular object's instantiation of a particular type of property. But they are easily generalized to cover alternate objects of representation. Take events, for example. If variables represent particular kinds of events occurring or failing to occur, then exclusivity would require that the values of a variable be event occurrences such that no two could occur simultaneously. Exhaustivity would require that the values of a variable cover

[20] Thanks to David Papineau, in discussion, for this point.

the entire range of possibilities of event occurrence for whatever type of event the variable represents.

12. References

Anderson, J., 1938. The Problem of Causality. Australas. J. Psychol. Philos. 16, 127–142.

Blanchard, T., 2018. Explanatory Abstraction and the Goldilocks Problem: Interventionism Gets Things Just Right. Br. J. Philos. Sci. https://doi.org/10.1093/bjps/axy030

Bontly, T.D., 2005. Proportionality, causation, and exclusion. Philosophia 32, 331–348. https://doi.org/10.1007/BF02641629

Briggs, R., 2012. Interventionist counterfactuals. Philos. Stud. 160, 139–166. https://doi.org/10.1007/s11098-012-9908-5

Franklin-Hall, L.R., 2016. High-Level Explanation and the Interventionist's 'Variables Problem.' Br. J. Philos. Sci. 67, 553–577. https://doi.org/10.1093/bjps/axu040

Greenland, S., Brumback, B., 2002. An overview of relations among causal modelling methods. Int. J. Epidemiol. 31, 1030–1037. https://doi.org/10.1093/ije/31.5.1030

Grice, P., 1989. Studies in the Way of Words. Harvard University Press.

Halpern, J.Y., 2016a. Actual Causality. MIT Press.

Halpern, J.Y., 2016b. Appropriate Causal Models and the Stability of Causation. Rev. Symb. Log. 9, 76–102. https://doi.org/10.1017/S1755020315000246

Halpern, Pearl, J., 2005. Causes and Explanations: A Structural-Model Approach. Part I: Causes. Br. J. Philos. Sci. 56, 843–887. https://doi.org/10.1093/bjps/axi147

Harary, F., Norman, R.Z., Cartwright, D., 1965. Structure Models: An Introduction to the Theory of Directed Graphs. Wiley, New York.

Hiddleston, E., 2005. A Causal Theory of Counterfactuals. Nous 39, 232–257.

Hitchcock, C., 2018. Causal Models. Stanf. Encycl. Philos., Edward N. Zalta (ed.).

Hitchcock, C., 2009. Causal Modelling, in: Beebee, H., Hitchcock, C., Menzies, P. (Eds.), The Oxford Handbook of Causation. Oxford University Press, pp. 299–314. https://doi.org/10.1093/oxfordhb/9780199279739.003.0015

Hitchcock, C., 2007. What's Wrong with Neuron Diagrams?, in: Campbell, J.K., O'Rourke, M., Silverstein, H.S. (Eds.), Causation and Explanation. MIT Press, pp. 4–69.

Hitchcock, C., 2004. Routes, Processes, and Chance-Lowering Causes, in: Dowe, P., Noordhof, P. (Eds.), Cause and Chance: Causation in an Indeterministic World. Routledge.

Hitchcock, C., 2001. The Intransitivity of Causation Revealed in Equations and Graphs. J. Philos. 98, 273. https://doi.org/10.2307/2678432

Hoffmann-Kolss, V., 2014. Interventionism and Higher-level Causation. Int. Stud. Philos. Sci. 28, 49–64. https://doi.org/10.1080/02698595.2014.915653

List, C., Menzies, P., 2009. Nonreductive Physicalism and the Limits of the Exclusion Principle: J. Philos. 106, 475–502. https://doi.org/10.5840/jphil2009106936

Mackie, J.L., 1974. The Cement of the Universe: A Study of Causation. Oxford University Press.

Mackie, J.L., 1965. Causes and Conditions. Am. Philos. Q. 2, 245–264.

Maslen, C., 2017. Pragmatic Explanations of the Proportionality Constraint on Causation, in: Beebee, H., Hitchcock, C., Price, H. (Eds.), Making a Difference: Essays on the Philosophy of Causation. Oxford University Press, New York, pp. 58–72.

McDonnell, N., 2018. Transitivity and proportionality in causation. Synthese 195, 1211–1229. https://doi.org/10.1007/s11229-016-1263-1

McDonnell, N., 2017. Causal exclusion and the limits of proportionality. Philos. Stud. 174, 1459–1474. https://doi.org/10.1007/s11098-016-0767-3

Menzies, P., 2008. The Exclusion Problem, The Determination Relation, and Contrastive Causation, in: Hohwy, J., Kallestrup, J. (Eds.), Being Reduced - New Essays on Reductive Explanation and Special Science Causation. Oxford University Press, pp. 196–217.

Menzies, P., List, C., 2010. The Causal Autonomy of the Special Sciences, in: Mcdonald, C., Mcdonald, G. (Eds.), Emergence in Mind. Oxford University Press.

Papineau, D., 2013. Causation is Macroscopic but Not Irreducible, in: Gibb, S.C., Ingthorsson, R. (Eds.), Mental Causation and Ontology. Oxford University Press, p. 126.

Pearl, J., 2000. Causality: models, reasoning, and inference, Second edition., 3rd printing.. ed. Cambridge University Press, Cambridge, United Kingdom ; New York.

Schaffer, J., 2012. Causal Contextualism, in: Blaauw, M. (Ed.), Contrastivism in Philosophy: New Perspectives. Routledge.

Shapiro, L., Sober, E., 2012. Against proportionality. Analysis 72, 89–93. https://doi.org/10.1093/analys/anr135

Spirtes, P., Glymour, C.N., Scheines, R., 1993. Causation, prediction, and search, Lecture notes in statistics (Springer-Verlag) ; v. 81. Springer-Verlag, New York.

Weslake, B., 2017. Difference-making, Closure, and Exclusion, in: Beebee, H., Hitchcock, C., Price, H. (Eds.), Making a Difference: Essays on the Philosophy of Causation. Oxford University Press, New York, pp. 215–231. https://doi.org/10.1093/oso/9780198746911.003.0011

Weslake, B., 2015. A Partial Theory of Actual Causation. Br. J. Philos. Sci.

Weslake, B., 2013. Proportionality, Contrast and Explanation. Australas. J. Philos. 91, 785–797. https://doi.org/10.1080/00048402.2013.788045

Woodward, J., 2018. Explanatory Autonomy: The Role of Proportionality, Stability, and Conditional Irrelevance. Synthese 1–29.

Woodward, J., 2016. The problem of variable choice. Synthese 193, 1047–1072. https://doi.org/10.1007/s11229-015-0810-5

Woodward, J., 2015. Interventionism and Causal Exclusion. Philos. Phenomenol. Res. 91, 303–347. https://doi.org/10.1111/phpr.12095

Woodward, J., 2010. Causation in biology: stability, specificity, and the choice of levels of explanation. Biol. Philos. 25, 287–318. https://doi.org/10.1007/s10539-010-9200-z

Woodward, J., 2003. Making Things Happen: A Theory of Causal Explanation. Oxford University Press.

Yablo, S., 2003. Causal Relevance. Philos. Issues 13, 316–328.

Yablo, S., 1992. Mental Causation. Philos. Rev. 101, 245. https://doi.org/10.2307/2185535