Powers: The No-Successor Problem

ABSTRACT: *This essay considers the implications for the powers metaphysic of the no-successor problem: As there are no successors in the set of real numbers, one state cannot occur just after another in continuous time without there being a gap between the two. I show how the no-successor problem sets challenges for various accounts of the manifestation of powers. For powers that give rise to a manifestation that is a new state, the challenge of no-successors is similar to that faced on Bertrand Russell's analysis by causal relations. Powers whose manifestation is a processes and powers that manifest through time (perhaps by giving rise to changing through time) are challenged differently. To avoid powers appearing enigmatic, these challenges should be addressed, and I point to some possible ways this might be achieved. A prerequisite for addressing these challenges is a careful focus on the nature and timing of the manifesting and manifestation of powers.*

KEYWORDS: powers, manifestation, timing, Bertrand Russell, Aristotle

Introduction

In this essay, I consider the implications for powers of the no-successor problem employed by Bertrand Russell in his celebrated and influential attack on causation[1] (an attack taken up more recently by Michael Huemer and Ben Kovitz [2003][2]): As there are no successors in the set of real numbers, an effect (event or state) cannot occur just after a cause without there being a time gap between the two (provided that time is continuous)—such a gap seems problematic. I show how the no-successor problem sets challenges for various accounts of the manifestation of powers, and in particular the timing of such manifestations, and point to some possible routes to addressing these challenges. (For discussions of the manifestations of powers and their timing, see Fischer [2018: especially ch. 4];

[1] See, for example, Russell (1913: 193): 'The law of causality, I believe, like much that passes muster among philosophers, is a relic of a bygone age, surviving, like the monarchy, only because it is erroneously supposed to do no harm.' The law of causality is taken to establish a determination relation between a cause 'event' and an effect 'event'. 'An "event" may be defined as a complete bundle of compresent qualities' (Russell, 2009: 78), so that such events may be understood as states.

[2] Huemer and Kovitz (2003) like Russell attack a notion of causation that supposes a cause event is followed by an effect event. Unlike Russell, they support the notion of simultaneous causation. For discussion of this, see Cei Maslen (2018). Such simultaneous causation might be taken to be (at least roughly) compatible with an ontology of powers with *Aristotelian-timing*.

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McKitrick [2010]; Molnar [2003: especially ch. 12, section 12.1.3]; van Miltenburg [2015: especially ch. 6]; and Williams [2019: ch. 6, section 6.3]; as well as the accounts of powers referenced in section 4 of this essay.)

Many contemporary accounts of powers suppose that when a power is in some suitable state,[3] a manifestation occurs. For example, such a state may comprise the power being in stimulus conditions appropriate to that power (for example, Bird 2007), or the power being compresent with mutual manifestation partners (for example, perhaps Martin 2008; Mumford and Anjum 2011). I call such a state in which the power is in circumstances sufficient for its manifestation an *activation state*.[4]

On some such accounts, the manifestation is a further state (or perhaps a transition to a further state), the *manifestation* state, say. I call such powers *state-state powers*. As I explain below in section 1, state-state powers are subject to the no-successor problem: the manifestation state cannot occur just after the activation state without there being a time gap between the two (provided that time is continuous). If, on the other hand, the manifestation state occurs at the same time as the activation state, then we do not seem to have an account that underwrites change over time. This no-successor problem for state-state powers is very similar to that facing cause-effect relations outlined by Russell.

Other such accounts of powers suppose that the manifestation is a process. I call such powers *state-process powers*. In section 2, I note that some leading accounts of state-process powers are vulnerable to the no-successor problem as the processes posited comprise sequences of states. Powers that manifest in processes of other (perhaps more unified) kinds may, though, be better placed with respect to the no-successor problem. In any case, a careful account of the ontology of the posited process and how it addresses the no-successor challenge is requisite.

On Aristotle's account in *Physics*, by contrast, agent-patient powers obtain (that is, exist) through the period of their manifesting[5]—their manifesting through time typically yields the changing through time of the patient. Manifesting through a period (typically of changing) stands in contrast to giving rise to a manifestation when the power is in a certain state (that is, an activation state). I describe powers that obtain through the period of their manifesting as having *Aristotelian-timing*. As I outline below in section 3, it seems that powers with Aristotelian-timing may not be compromised by the no-successor problem. Nevertheless, such powers often presuppose changing through time. This presents a different challenge: changing is a problematic and controversial notion, so that a careful account of this changing and the associated ontology that licenses it is a prerequisite for the adoption of such powers.

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[3] I take it that during the obtaining of a state there is no change, so that typically a state obtains at a single instant. (An instant being the shortest duration of time, perhaps just a single point in time.) A process, by contrast, may (and typically does) involve change.

[4] On some accounts, the manifestation may be associated with more than one power that obtains in the activation state.

[5] Such power may also typically exist during periods when they are not manifesting, of course. Unless otherwise noted, references to Aristotle's *Physics* are to Robin Waterfield's translation (Aristotle 1996).
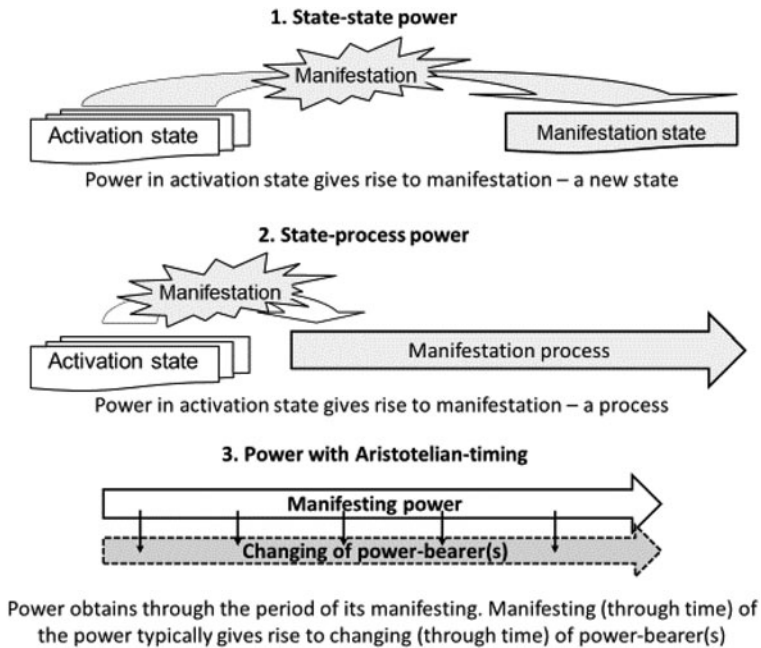
Figure 1. Characterization of three possible ways in which powers may manifest. Courtesy of the author.

Figure 1 pictures schematically each of these three types of powers. In what follows, I consider the nature of each manifestation type in greater detail, setting out the challenge of the no-successors problem in relation to each.

In section 4, I consider the nature of the manifestation set out in some of the leading contemporary accounts of powers—those of Stephen Mumford and Rani Anjum, C. B. Martin, Alexander Bird, and Brian Ellis—in order to explore how they fare in the face of the no-successor problem. These accounts differ significantly. Indeed, in many cases they are open to varying interpretations according to which the powers proposed may be *state-state*, *state-process* or *Aristotelian-timing* powers, or perhaps even other types of powers. But however interpreted, considerations arising from the no-successor problem present these accounts with significant challenges—challenges that are as yet not fully resolved.

I conclude that the no-successor problem poses a challenge for powers that it is important to address in order to avoid the risk that powers be viewed as enigmatic. The challenge differs across differing types of powers, but in each case a starting point for addressing the challenge is a careful explication of the nature and timing of the manifesting or manifestation of the power—a greater focus on these issues is warranted.

1. State-State Powers

Suppose that a state-state power is in an activation state at time T. When does the manifestation state occur?

1.1 Manifestation State Occurs Just after the Activation State

It would seem that one possible answer to this question—and perhaps the answer it is most natural to suggest—is that the manifestation state occurs just after the activation state. Suppose that the manifestation state commences at T′ where T′ > T.

Could it be that there is a gap between the end of the activation state and the start of the manifestation state, that is, between T and T′? This would seem to suppose that the activation state's having ended and some period of time having elapsed, the manifestation state suddenly comes to obtain. This seems strange. Regarding the similar case of cause and effect, Russell argues that one specific reason that such a time gap is implausible is that something might occur in this gap that prevents the effect from occurring (Russell 1913: 197). If something occurred between the activation state and the impending manifestation state that prevented the manifestation state from obtaining, then this might seem to contradict the account of the state-state power: in such a case, the activation state obtains seemingly giving rise to a manifestation, but the manifestation does not occur.[6] Moreover, if there is a time gap between activation and manifestation states, then it would seem that the power, or perhaps some other feature of the activation state, has the additional task of determining when the manifestation state should start to obtain. This further task would seem to be worthy of careful consideration—but no such consideration would seem to appear within the literature on such powers.

Although perhaps we should not rule out accounts that posit such a time gap, I am not aware of any that have been explicitly advanced—and this might seem an unattractive direction to pursue.

It seems, then, that a more plausible account of state-state powers should posit a manifestation state that is contiguous with the activation state. Unfortunately, though, if time is continuous (that is, isomorphic with the set of Real numbers), then there is no successor to T within the available set of times, that is, the set of Real numbers. A fortiori T′ cannot be a successor to T, so that there must be a time gap between T and T′. If T′ is after T, then the activation and manifestation states cannot be contiguous and there is indeed a time gap between them.

If time is continuous, then (unless we do accept a gap between activation and manifestation states) the no-successor problem would seem to rule out the 'just after' answer to the time when the manifestation state occurs.

1.1.1 Discrete Time. One possible way to rescue the 'just after' answer for state-state powers from the no-successors problem is to suppose that time is, after all, not continuous but discrete (that is, the set of times is not isomorphic with the set of Real numbers, but is smaller—perhaps finite or countable). If time is discrete, then

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[6] I take it that typically, on state-state accounts, the power being in circumstances sufficient for its manifestation will bring about the manifestation of necessity. On the 'dispositional modality' account of Mumford and Anjum (2011), the manifestation is brought about with some modality weaker than necessity. But still, I take it that if these are state-state powers (see discussion in section 3 below), then nothing that happens after the activation state (but before the manifestation) could influence whether the manifestation occurs.

there may be a successor to each point in time. If T′ is the successor of T (in such discrete time) and the activation state occurs at T, then the manifestation state may obtain (or start to obtain) at T′—and in this case it would seem that there is not a successor problem.

Discrete time may, then, offer a route to supposing that the manifestation state occurs just after the activation state. To go this route, an explicit and careful account of the nature of discrete time is surely required. If macroscopic powers (powers above the quantum level) are posited, then it may be that the account will need to appeal to some notion of macroscopic (perhaps global) time that is discrete. In any case, following this route clearly comes with a price: the need to commit to some nonstandard theory of time.

1.1.2 Infinitesimal Time Steps. Perhaps it might be allowed that time is continuous, but supposed that the manifestation occurs only an infinitesimal period of time after the activation state, so that $T′ = T + d_o$, for some infinitesimal d_o. This might be taken to fit with the suggestion of Paul Horwich that where time is continuous, 'the state at a given time determines the state at an infinitesimally different time' (Horwich 1987: 134–35).

Unfortunately, as Huemer and Kovitz note concerning infinitesimals, 'standard modern analysis does not incorporate any such quantities. This is the reason for the "delta and epsilon" proofs developed by Augustin-Louis Cauchy, Karl Weierstrass and others, and found in standard calculus texts today' (Huemer and Kovitz 2003: 561). Anyone wishing to use infinitesimal time steps to address the no-successor problem must first commit to nonstandard mathematical theories.

1.1.3 Open/Closed Set Solutions to the No-Successor Problem. Recently, attempts have been made to overcome the threat posed to causal relations by Russell's no-successor argument by appeal to open and closed sets (see, for example, Clay 2018). As these arguments have achieved some measure of popularity, they deserve careful consideration. A typical argument of this sort supposes that certain events (and, in particular, the types of events that may generally be causes and effects) may be understood as obtaining on semi-open intervals of time, that is, intervals such as [T-δ, T), where the first boundary point of time at T-δ is included in the interval, but the second boundary point at T is excluded. If causes and effects are such events, then it may seem that the cause and effect may be contiguous whilst the effect occurs after the cause—for example, if the cause obtains during [T-δ, T) and the effect obtain during [T, T+δ′), say. If such an approach can plausibly rescue causal relations, then it would seem that it might rescue state-state powers, too: we might, along similar lines, suppose that activation and manifestation states obtain during semi-open intervals of time.

One concern with such a solution is that it seems rather ad hoc. Why should we think that events (of suitable type) generally obtain over semi-open intervals? Another concern might be whether set theoretic solutions may provide plausible answers to ontological questions.

Consider more carefully the possible duration of the activation state. Could it be that an activation state obtains at T, but that a manifestation is not triggered at T, but

perhaps shortly after at time T+δ, say? One possibility is that some further trigger is required to precipitate the manifestation once the activation state obtains. But this would not be consistent with the original account of the activation state as comprising circumstances sufficient for manifestation. Alternatively, perhaps no further trigger is required, but the activation state simply obtains unchanging (in salient respects) through a period of duration δ and then the manifestation occurs. As Russell notes in relation to causes, it 'seems strange—too strange to be accepted, in spite of the bare logical possibility—that the cause, after existing placidly for some time, should suddenly explode into the effect' (Russell 1913: 196). Such a circumstance would raise the additional question as to why the manifestation arises at time T+δ rather than a little earlier of later. Such concerns perhaps arise from intuitions associated with a principle of sufficient reason. These considerations suggest that if an activation state obtains at T, then a manifestation is triggered at T. This would seem to imply that the activation state can exist at only a single point in time—and hence not over an extended interval of time, open or not.

Consider another of Russell's arguments (Russell 1913: 195–96), a contiguity argument that may seem to present an even more compelling objection to such open/closed set arguments.

Suppose that the activation state obtains during [T-δ, T). Consider the first half of this period [T-δ, T-δ/2) say. As this period is not contiguous with the manifestation state, then it seems (on the assumption that the activation and manifestation states must be contiguous) that this period cannot give rise to the manifestation state—it must in fact be the activation state during the latter period [T-δ/2, T) that gives rise to the manifestation state. Repeating this argument, we may deduce that the salient activation state obtains during the interval:

$$\lim_{\delta \to 0} [T\text{-}\delta, \ T) = \varphi$$

But this mathematical limit is just the empty set, φ.[7] And this yields an absurdity: the activation state obtains on the empty set of times. Alternative open/closed set arguments yield similar mathematical absurdities.[8]

Perhaps, though, there are ways to counter these Russellian objections: for example, perhaps it is supposed that the activation state must have some minimum (non-zero) duration so that the assumption that it can be (indefinitely) divided may be rejected. Or perhaps the adoption of dialethism, along the lines proposed by Graham Priest (2006), provides the basis for a solution. Or perhaps

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[7]
$$[T\text{-}\delta, \ T) = [T\text{-}\delta, \ T]\text{-}[T]$$
$$\Rightarrow \lim_{\delta \to 0} [T\text{-}\delta, \ T) = \lim_{\delta \to 0} [T\text{-}\delta, \ T] - \lim_{\delta \to 0} [T]$$
$$= [T]\text{-}[T]$$
$$= \varphi$$

[8] For example, if we suppose that the sets of times on which causes and effects obtain are of the general form (T-δ, T], that is, closed at their end point but not at their start point, then we may use the above argument mutatis mutandis to show that the effect, or manifestation state, obtains on the empty set of times.

other open/closed set solutions may be advanced. In any case, I urge that any such proposed solution should be set out clearly, along with any associated ontological assumptions, so it may be fully understood and assessed.

1.2 Manifestation State Is Simultaneous with the Activation State

Another possible solution to the no-successors problem is to suppose that the manifestation state occurs at the same time as the activation state. If the manifestation state is simultaneous with the activation state, then the absence of successors is not a problem.

Still, the simultaneity of the activation and manifestation states seems rather strange and perhaps contradicts our intuitions, in the same sort of way that allowing the simultaneity of a cause event and an effect event may. Indeed, the simultaneity of activation and manifestation states may seem yet more problematic: it seems the salient power must be both in (1) its ready-to-manifest state and (2) whatever state the power is in (if any) following manifestation—at the same time.

In at least very many examples considered as featuring the manifestation of powers (such as dissolving sugar cubes, heating rooms, colliding billiard balls[9]), the powers are invoked to account for change over time (or at least the obtaining of differing states at differing times). If manifestation states are simultaneous with activation states, how does this underwrite such change over time? (I explore some examples of such accounts of powers below in section 4).

2. State-Process Powers

State-process accounts of powers suppose that a power in an activation state gives rise to a manifestation that is a process. Clearly, to be well defined, any such account of powers must be predicated upon an adequate account of what such a process is.

Many contemporary accounts of processes (such as those of Salmon 1984; Ellis 2001; and Dowe 2000) derive, directly or indirectly, from the account set out by Russell. Russell offers a Humean account of processes, or *causal lines*, according to which (in accordance with Hume's proscription of necessary connections between existences at differing times) a process is just the obtaining of a dense infinity of similar (quasi-permanent) events, or states, at neighboring places.

But how could a power in some activation state give rise to a process that is merely the obtaining of a series of similar states, where there can be no suggestion that each state in any way brings about or influences later states? Perhaps we should think of the manifestation not as a single state, but as multiple states (a dense infinity of states perhaps). If so, this account of powers would seem to face with full force the problems of state-state powers, but to a greater degree: the later points in such a

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[9] As John Heil (2012: 120) makes clear, one billiard ball striking another is not a point in time event, rather it involves a period of contact of the balls and their compression and pushing against each other.

process are not contiguous with the activation state, so that contiguity problems would look particularly challenging.

It would work better, perhaps, if we could think of the process as a series of states in which each state does give rise to the next state—but this, of course, is exactly what is proscribed by the no-successor problem.

Perhaps processes that have a unity through time could license a plausible state-process account of powers. If a power manifests in a process that has suitable unity—for example, it has sufficient degree of ontological priority over any putative composing states—then it seems it may avoid the no-successor concerns about Russell-type processes (which are series of states) noted above. The processes envisaged by philosophers such as Henri Bergson (2004), Florian Fischer (2018), Johanna Seibt (2004), or van Miltenburg (2015), for example, may have such suitable unity. Van Miltenburg suggests that a manifestation process has an identity that derives from the associated power (Van Miltenburg 2015: 238–39), which seems promising. Nevertheless, such views are challenged by Williams, who thinks that the possibility of processes being interrupted causes problems as '[m]anifestations as processes is an all-or-nothing affair: the processes either come about or they do not' (2019: 132). Williams advocates the view that manifestations have shorter timescales, which may perhaps lead to cascades of (short duration) manifestations that may appear as processes. The debate over these points identifies important ontological issues that are worthy of careful consideration. In any case, to meet the challenge of the no-successor problem, any such accounts of powers should make sufficiently clear the ontology of manifestation processes that is proposed, and how this succeeds in avoiding the no-successor problem.

Another alternative is that processes arise from the manifesting of powers with Aristotelian-timing (this thought may underlie some accounts of manifestations as unified processes noted above). (I consider this possibility at the end of the next section.)

3. Powers with Aristotelian-Timing

A power with Aristotelian-timing obtains through the period of its manifesting—such a period of manifesting has non-zero duration (it is not merely a point in time) and typically involves changing through this period. Such a power does not feature an activation state[10] that yields a manifestation. How then is it supposed to work? In particular, how can it underwrite change through time—or at least the obtaining of temporally later states that differ from states in which the power obtains earlier?

A putative answer to this question goes as follows: A power with Aristotelian-timing is manifesting when the bearer of that power is in suitable contact with the bearers of other correlate powers (that have Aristotelian-timing).[11] The

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[10] An *activation state* (like other states: see above, note 4) does not involve change and may typically obtain at just a single point in time.

[11] That is, given a period in which the bearer of the power is in suitable contact with the bearers of correlate powers, the power is manifesting throughout this period.

manifesting of these powers together through time is the changing, through time, of some or perhaps all (depending on the account) of the bearers of these powers.

On Aristotle's account, for example, suitable power-bearers are an agent and a correlate patient, and the manifesting of the agent and patient powers together (through time) is changing (through time) of the patient. Aristotle carefully sets out the details of this account in the *Physics*, especially books 3 to 6 (see Sachs [2011] for a good commentary and Marmodoro [2007] for helpful discussion). He illustrates his account by reference to human powers, such as building, teaching, curing. When a builder and building materials are in suitable contact, building occurs, that is, the becoming built (such as the being moved in to suitable locations and perhaps becoming suitably attached together) of the building materials. This changing of the building materials (that is, the patient) over time may result in a heap of unassembled bricks and timbers at an early stage giving way to a house at a later stage. The changing through time is itself a continuous thing, a process (kinesis), on Aristotle's account, which may generally be understood as the transfer of a form from the agent to the substrate (patient)—this process has a unity that may, in cases such as human powers, be associated with the telos of the agent (Aristotle *Physics* 3.3; Marmodoro 2007).

This account of how a power with Aristotelian-timing works rests on a notion of changing through time. Changing, though, has long been a problematic and controversial notion. Zeno famously argued that motion (changing of position) is not possible. Consider a smallest unit of time, an instant: an arrow does not change its position at an instant, as there are no smaller units of time that might afford such change, so that it is not moving at any instant, and hence not moving at all. Contemporary analysis of the paradox focuses on instantaneous velocity, and in particular the tension between a notion of instantaneous velocity that is (1) drawn from the pattern of positions of an object over time (such as the limit as $\delta \to 0$ of $((X(T) - X(T-\delta))/\delta)$, where $X(t)$ is the position of the object) or (2) a property of the state of the object at each point in time. Despite extensive and careful analysis, the solution to the paradox remains a matter of lively contemporary debate. (See, for example, Arntzenius 2000; Bigelow and Pargetter 1989; Carroll 2002; Lange 2005; Meyer 2003; Pemberton forthcoming; Tooley 1988.)

Another formulation of concerns about changing raises the seemingly paradoxical issue of the moment of change. For example, when we look carefully at the point of transition of an object from rest to motion, is the object at rest or in motion (or perhaps both or neither)? Again, despite an extensive and lively debate, which continues in contemporary literature, the issue remains highly controversial. (For a thorough history of the debate, see Strobach [1998]; for a good exposition of central issues see Sorabji [1976].)

If an account of powers with Aristotelian-timing does suppose that such powers give rise to changing, then a prerequisite for such an account is surely an adequate account of changing, one that addresses these apparent paradoxes. Moreover, the account should apply to changing generally, not just changing of position.

One possible starting point for such an account of changing is that of Aristotle himself. Aristotle explicitly recognizes the no-successor problem (see, for example,

Physics 6.6, 237a24–25), noting that change from one determinate state to another (such as from being at A to being at B) cannot occur as adjacent instants, but rather must occur over time: 'everything that has changed from a starting-point to an end-point has taken time to complete the change' (*Physics* 6.6, 237a18–19). For Aristotle, such change over time is a process of change (kinesis) that has a unity and is continuous, and hence is not composed of point-in-time entities: 'it is impossible for anything continuous to be made of indivisible things; for example, a line cannot be made of points' (*Physics* 6.1, 231a23–25, in Sachs 2011). Rather, continuous things, such as processes of change, are ontologically unities: any putative point in time states associated with the process are abstractions from the process that are only potential within the process. Aristotle is thus explicit that a thing cannot move or be at rest at a single instant: 'Neither moving or resting is in the now' (*Physics* 6.8,239b2–3, in Sachs 2011; see also 6.3, 234a24–b9). Rather, motion (velocity) is to be associated with the process of change (such as the moving arrow) and only derivatively with the point-in-time states abstracted (perhaps as limits) from that process. Based on this analysis, Aristotle sets out an explicit solution to Zeno's arrow paradox (*Physics* 6.9). In the modern formulation of the paradox, Aristotle's embrace of an ontological priority of the process over the putative point-in-time states that are potential within that process, resolves the tension between the differing notions of velocity (noted in (1) and (2) above): The tension arises from supposing that there are independent point-in-time states that compose the process of the moving arrow. Aristotle rejects this supposition.

With the claim that a thing cannot move or be at rest at a single instant, Aristotle also offers a solution to the paradox associated with the moment of change: there is neither motion nor rest at this instant (see Strobach 1998: ch. 2; Sorabji 1976).

Aristotle designs his account of change from the outset to meet the no-successor problem,[12] as I have noted: Change from one state to another occurs via a process of changing through time, there is no change from one state to another at adjacent times, for example, from a heap of building materials to a house. And changing, on Aristotle's account, is typically associated with the manifesting of agent-patient powers through time—so that his account of changing fits nicely, of course, with powers with Aristotelian-timing.

Aristotle's account of change, and perhaps most notably his claim that there is neither motion nor rest at an instant, has come under attack from a number of authors, including Nico Strobach (1998) and Richard Sorabji (1976). As with any account of change, Aristotle's account is controversial. My intention here is not to argue in favor of Aristotle's account of change. Many philosophers involved in the debates concerning the instantaneous velocity and moment of change controversies, including Strobach and Sorabji, have advanced solutions to the various paradoxes that deserve serious and careful consideration.

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[12] I might, of course, have cited Aristotle rather than Russell in the introduction to the essay as the champion of the no-successor problem, but Russell's presentation of the problem is more succinct and accessible to those engaged in the relevant contemporary debates.

Rather, my aim here is to point out that if one wishes to posit an account of powers that have Aristotelian-timing, one first needs an account of how such powers work. If one wants to answer this question with the putative answer suggested above (that is, that the manifesting of such powers is the changing of certain of the bearers of these powers), which currently seems the only answer on offer, one first needs an account of changing and a base ontology that can underwrite such changing. These are points I bear in mind in my consideration of contemporary discussion of powers in the next section. Those who reject all currently available accounts of changing might perhaps suppose that there is no adequate account of changing to be had—and they might then take this as grounds for rejecting powers with Aristotelian-timing.

One reason for positing powers with Aristotelian-timing, then, is the possibility that they may not be compromised by the no-successor problem—although whether this is so will, of course, require careful analysis of the precise account of powers (and associated changing) proposed.

Another reason is that Aristotelian-timing seems consistent, not just with human powers of the sort that Aristotle focused on, but with many examples of powers salient in contemporary science: masses attracting other masses, charges attracting or repelling other charges, hot objects heating colder objects, billiard balls pushing billiard balls, cogs turning cogs, knives cutting butter. In each case such powers (such as powers to gravitationally attract or be attracted, heat or be heated, push or be pushed, cut or be cut) obtain through the period of their manifesting (attracting, heating, pushing, cutting) and seem to give rise to changing of certain of their bearers (such as accelerating, becoming hotter, becoming cut) through this period. The bob of a pendulum, for example, is being pulled downwards (due to the gravitational pull of the Earth) and being pulled toward the fixed pivot (due to the string)—and hence through time it accelerates and moves so as to swing from one side (an earlier stage) to the other (a later stage). Again, there is no direct move from one side to the other, but rather change from the earlier to later state is via a period of changing of (some of) the bearers (such as the bob) of the salient powers.

Nevertheless, even if we embrace powers with Aristotelian-timing, it seems that not all powers are like this. Many popularly cited powers, such as that of poison to kill or that of glass to break, do seem to feature a manifestation that occurs after their activation state, perhaps with a time gap between the two. Perhaps, too, a builder has the power to build a house (as well as the power to build); and a pendulum displaced to the left has the power to yield a later stage in which it is displaced to the right (or perhaps a process in which the bob travels along a U-shaped trajectory, of which displacement to the right is a later stage). These suggestions raise the possibility of connections between powers that give rise to future manifestations and powers with Aristotelian-timing that may seem to underwrite the change (over time) of the manifestations of such powers. These connections between powers raise important ontological questions worthy of careful consideration. Such considerations may likely be salient in addressing the no-successor problem as regards powers.

4. Contemporary Accounts of Powers and the No-Successor Problem

There are now many contemporary accounts of powers. And many of these accounts have much to say concerning the manifestation of the powers they posit: the circumstances that must obtain for the power to manifest, the nature of the manifestation, and (sometimes) the timing of the manifestation. To this point, I have set out challenges presented by the no-successor problem to accounts of the manifestation of powers. It is appropriate to consider whether the contemporary accounts of powers on offer meet these challenges.

I offer for consideration in the following a variety of leading accounts of powers that seem to me to offer some of the clearest and most explicit accounts of the manifestation of their powers and that illustrate much of the range of differing accounts on offer.

4.1 Stephen Mumford and Rani Anjum

On this account, a compresence of mutual manifestation partner powers gives rise to a manifestation. 'The manifestation of a power will, for any pandispositionalist, be itself a further power or cluster of powers' (Mumford and Anjum 2011: 5), so it seems that the manifestation is some further state: the obtaining of that power or cluster of powers. According to their 'vector account', we may plot vectors on a one-dimensional quality space for each of the compresent powers that is operating, and add these vectors to derive the outcome property, that is, the cluster of powers that is the mutual manifestation. 'Each vector diagram represents the causal situation at one moment' (Mumford and Anjum 2011: 26). 'At the moment all the requisite powers are assembled they all make their contribution' (Mumford and Anjum 2011: 32). So it seems we may read the compresence of mutual manifestation partners as an activation state, and hence the powers as state-state powers. But if this is right, then there is a difficulty: nothing in this account, so far as I can discover, addresses the no-successors problem.

But perhaps there is another reading: concerning the moment at which the powers are compresent, 'a moment does not automatically mean an instant or an unextended temporal time slice . . . Some powers may involve such dynamism as cannot be captured at an instant' (Mumford and Anjum 2011: 26). So perhaps the powers obtain through a period of their manifesting, so that they are powers with Aristotelian-timing. And perhaps this seems consistent with the claim that causation should be seen as, 'a single unfolding process that occurs when a number of mutual manifestation partners meet.' 'Since such a process begins at exactly the time all such partners are together, and ends either when the process has run its course or been interrupted, then cause and effects are best understood as simultaneous' (Mumford and Anjum 2011: ix). And all of this seems nicely consistent with continuous change in the examples that Mumford and Anjum present, such as sugar cubes dissolving, rooms being heated.

Nevertheless, if we take Mumford and Anjum's powers to have Aristotelian-timing, how should we interpret the vector account? If all vectors could be

interpreted as forces, perhaps this might be made to work: we might posit resultant forces (presumably the vector sum of forces) acting through time—although the details here would require careful explication. But how about more typical cases where the powers give rise to qualitative change? Consider the lighting of a match: it seems we will need vectors for the successful manifestation of the lighting of the match, which include 'being struck', wind and damp, where these vectors determine whether there is a manifestation of the match's power to light—or not. How could we interpret these vectors as associated with powers obtaining through some period of manifesting and changing? A major part of the challenge would be to provide an account of how the underlying ontology can support the notion of qualitative changing at each given point in time.[13] Perhaps all powers must come in degrees, where the set of possible degrees is isomorphic to the set of real numbers R (or perhaps R^n, n $\in$ N), and such changing is the continuous changing of powers (which are numerically the same powers through the changing) in such degrees? Such a view seems highly controversial. How could such a schema accommodate a change from a quality ¬P (e.g. not alight) to P (e.g. alight) at some point in time (prima facie it seems that properties such as being alight or being pregnant do not come in degrees)? This would seem like step change rather than changing, hence raising the specter of the no-successor problem.

These considerations raise doubts as to whether we can really read Mumford and Anjum powers as having Aristotelian-timing. As discussed above, their account talks of the manifestation, rather than manifesting, of the power, and the manifestation of the power seems (at least in some of their writing) to be a new state. There is no discussion of the manifesting of numerically the same power over time (or perhaps of the power having a status of manifesting (or not manifesting) during some given period), or of how manifesting over time might be linked to changing over time. If Mumford and Anjum are in fact positing powers with Aristotelian-timing, it would be helpful to make this clear, and to make clear the associated account of changing and how this is licensed by their underlying ontology.

4.2 C. B. Martin

Martin's account of powers, too, supposes that it is when mutual manifestation partners are together that a manifestation occurs, that is, this is the activation state. But his account is quite distinctive: 'the reciprocal disposition partnering and their mutually manifesting are identical. No time gap or spatial gap is needed— not one happening before another. It is not a matter of two events, but one and the same event' (Martin 2008: 46). He writes, 'You should not think of disposition partners causing the manifestation. Instead, the coming together of the partners is the mutual manifestation; the partnering and the manifestation are identical. . . . You have 2 triangular-shaped slips of paper that, when placed together appropriately, form a square. It is not that the partnering of the triangles causes the manifestation of the square, but rather that the partnering is the square'

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[13] As Mumford and Anjum are pandispositionalists, I take it that substances may be taken to be compresences (or perhaps bundles) of powers at each point in time.
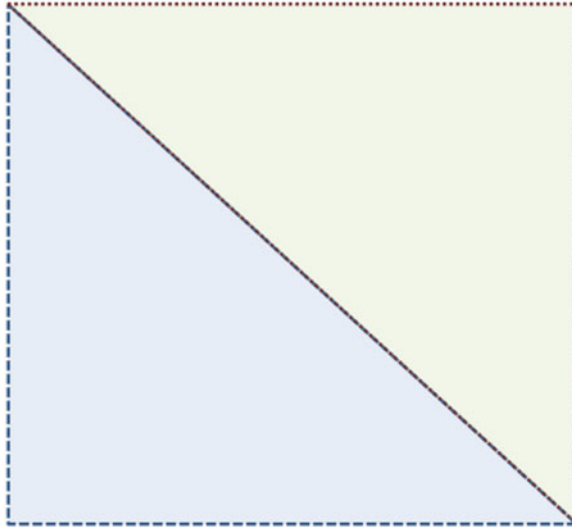
Figure 2. Martin's two triangles analogy for the manifestation of powers.

(Martin 2008: 51). In figure 2, I offer my visual representation of Martin's two triangles.

However exactly one interprets this, it seems that the partnering of the powers (that is, the activation state) and the manifestation occur at the same time—and this raises the sorts of concerns that I identified above in relation to state-state powers: How do such powers underwrite change through time?

Could we interpret Martin as proposing powers with Aristotelian-timing? Certainly, Martin's use of the progressives 'partnering' and 'manifesting' would seem to encourage us in this direction. Nevertheless, Martin's reference to manifestations as 'the intersection of readiness lines' or events (Martin 2008: 46), and his discussion of 'power nets' (for example, Martin 2008: 46), as well as his analogy of the two triangles, would seem to suggest he is proposing state-state powers. There would seem to be considerable work to do to argue that Martin's powers have Aristotelian-timing.

4.3 Alexander Bird

Bird distinguishes fundamental powers, *potencies*, from the ascription of higher-level dispositions that are not fundamental. In the case of potencies, he explicitly rejects the possibility of a time gap between stimulus and manifestation on similar grounds to Russell: this might admit the prevention of the manifestation, which he takes to be impossible. Therefore, he concludes, either the manifestation is simultaneous with the stimulus, or time is discrete and the manifestation occurs at the successor time (Bird 2007: 61–62).

Higher-level powers are also state-state powers it would seem: 'A dispositional ascription means that the object would give some characteristic manifestation in

response to a certain kind of stimulus' (Bird 2007: 3). 'A higher-level disposition manifests itself by relying on a mechanism that operates at a lower level' (Bird 2007: 63). So higher-level powers piggyback on potencies, it would seem, so that once we have sorted out the manifestations of potencies, the higher-level manifestations will follow—as a processes of potency manifestations, as I understand.

This is laudably clear and explicit—and fits nicely with my analysis in section 1 above. The problem remains: unless time is discrete, it seems that the manifestation of a potency is simultaneous with its stimulus. So how does such a power underwrite change through time? If potencies do not underwrite change through time at the fundamental level, how can higher-level powers (which piggyback on potencies) underwrite change through time at a higher level?

4.4 Brian Ellis

'If an event of a natural kind that would activate a given causal power occurs, an event of a natural kind which would then be an appropriate display of that power must occur' (Ellis 2001: 7). 'The causal powers of things are displayed in processes' (Ellis 2001: 5). So, it might seem that we can take Ellis to posit *state-process* powers.

But Ellis, following ideas of Wesley Salmon (1984), supposes that there are two essential kinds of 'processes': (1) events (like Salmon's 'interactions') that may occur at a single point in time; and (2) transmissions, which occur (like Salmon's) over time. 'Processes, I suppose, will consist of elementary events (for example, basic causal interactions between particles) and certain energy transmission processes' (Ellis 2001: 51).

If the process that is the manifestation of the power is a transmission, or perhaps some combination of an event and a transmission, then it seems we may well have a state-process power. Such transmission processes are acausal but 'not just sequences of instantaneous point events' (Ellis 2001: 52). So it seems Ellis rejects Russell's account of processes. This sounds hopeful. But what more precisely are such processes? Ellis largely follows Salmon's account of processes, so this seems the first place to look. But Salmon makes explicit: 'I shall not attempt any rigorous definition of processes; rather, I shall cite examples and make some very informal remarks' (1984: 139). Ellis supposes that such processes transmit energy locally, which is in the spirit of both the later Salmon and Philip Dowe (2000). But such conserved quantity approaches have not been widely embraced as providing an adequate metaphysical account of causation or processes.

Whatever the precise metaphysics of such transmissions, they surely cover only very limited cases. If the new mechanists are right, then much of the world comprises mechanisms (such as clocks, engines, hearts, neurons, planetary systems, and geological systems) where the parts obtain and typically interact over time—and here manifestations that are simple transmissions are surely not the norm. And even where we find transmission manifestations, where the transmission is of an entity that has either mass or charge, for example, the

entities will surely experience attracting or repelling by other entities during the putative transmission. So that this is not an acausal process.

It would seem on Ellis's account, that, very often at least, the powers that are present must manifest in 'events' (transitions to new states, it would seem) that are instantaneous, not in transmissions. If so, it would seem we are dealing largely with state-state powers—and the problem of no-successors looms large.

4.5 Summary

What may we reasonably conclude from these brief considerations of a handful of contemporary accounts of powers? Perhaps there are ways to interpret what is said in these accounts, or to clarify or add to them, so as to meet the challenge of no-successors. Or perhaps there are other accounts of powers that I have missed that are better for this purpose. But, I suggest, the consideration of no-successors in the earlier part of this essay points to puzzles for these accounts that are not, as yet, fully resolved.

5. Conclusion

The no-successor problem poses a challenge for powers.

If we posit state-state powers with the manifestation just after the activation state, then the no successors problem looms directly. The adoption of discrete time, infinitesimals, or innovative open/closed set approaches offer possible, but unorthodox, routes toward a solution to the challenge.

If we posit state-state powers where the manifestation obtains at the same time as the activation state, then the no successor problem is avoided, but puzzles arise: How can a power be in two states at the same time? How do the powers underwrite change through time?

If we posit state-process powers, what exactly is the nature of the process in play? If the process is the obtaining of (perhaps a dense infinity of) discrete states, then the no successor problem looms directly. If the process is more unified, then what precisely is the ontology of this process, how should we account (if at all) for the possibility of its interruption, and how does it avoid the no-successor problem?

If we posit powers that exist through the period of their manifesting (that is, have Aristotelian-timing), then quite how does this work? If the answer to this question posits changing through time, then what is the account of changing proposed, how does the base ontology adopted underwrite such changing, and how does this account of changing avoid the no successor problem? (See Pemberton [manuscript] for my proposed answers.)

If, after all, there is another account of how powers manifest that avoids the no-successor problem, then I urge that it should be made explicit.

The no-successor challenge to powers must be met if powers are to avoid seeming enigmatic. A starting point for addressing the challenge is a careful explication of the nature and timing of the manifesting or manifestation of the power—a greater focus on these issues is warranted.

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