Acting-arrangement Ontology Introduced

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For Jen

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Contents

1 Introduction

In this thesis I begin the task of setting out and arguing for an account of the ontology of the world. The account of ontology I propose, *acting-arrangement ontology* (AAO)*,* is radically new - it follows from a recognition that two seemingly prosaic and previously underappreciated features of our world are, I shall argue, the twin keystones of its ontology: *acting* and arrangement. My aim in this preliminary work is to develop and set out the main pieces of this ontology, showing how they fit together to form a compelling whole, so as to make a case that this account of ontology warrants further investigation.

This thesis comprises a multi-stage and multi-layered argument that leads to its overall conclusion by developing, clarifying and defending the ideas and claims advanced at each stage. As the ideas required interlink and build upon each other as the argument develops, attempting to convey to the reader the substance of these arguments in advance in this introduction is scarcely possible – and would certainly engender excessive repetition with the main text. I shall therefore keep my initial remarks here brief, simply outlining some of the most exciting innovations of AAO and the reasons for them, in order to give a flavour of what is to come, before embarking on the narrative journey.

Acting (as I use the term) is the bringing about of changing, e.g. attracting, repelling, pushing, cutting, heating, dissolving, building. Acting occurs through time, never at just a single point in time, and is the only type of principle of change, and indeed the only type of modal principle, within the base ontology of the world. Acting solves the problem of the bringing about of change by overcoming the challenge of no successors – a challenge which is devastating to other accounts of change. Acting is the principle of composition of physical beings (things and processes). I shall make these claims precise and argue for them in what follows.

As acting is bringing about of changing, an ontology that features acting must also feature changing (a paradigm example of changing is instantaneous velocity, changing of position). Both acting and changing require that *actors*, the entities that act, exist through time as ontologically prior to their temporal parts – they are *lasting* I shall say. These claims concerning lasting and changing must also be made precise and argued for carefully – this is my first task which I tackle in section I.

I shall explain how lasting ontology contrasts with mosaic ontology, the popular contemporary view that the world comprises a vast mosaic of point in time states championed by Bertrand Russell, David Lewis and many other neo-Humeans. Mosaic ontology, I argue carefully, precludes changing and acting. I recover lasting from Aristotle's ontology, where I find it has been hiding in plain sight, so that my adoption of lasting is not a move to a new position, but rather a reversion to an earlier orthodoxy.

AAO is a physical ontology, in a sense I shall make precise. The elementary physical beings, *elementary-actors*, are lasting, able to act, and have no parts. They are characterised exhaustively by their acting and their positions through time – their *trajectories*. On this account, then, at the base of ontology we find acting and trajectories – we do not find properties. I shall argue that this acting-trajectory basis accords closely with contemporary accounts of the physical world and is more parsimonious than the received property-position basis (of, for example, mosaicist accounts).

Composite-actors are (roughly) surviving acting-togethers of parts (other actors). For example, a hydrogen atom is a surviving acting together of a proton and an electron. I shall show how the entities generally taken to be things and processes are *actors* (elementary or composite). Composite-actors have a subtle existence which licenses their avoidance of problems associated with causal exclusion, I shall show. And I shall explain how this *subtle-existence* helps to underwrite *resultant novelty* – the obtaining of properties and/or powers of a composite that are not held by the parts of that composite – hence obviating the need to posit emergence.[1]

Given a plurality of concrete things that are spatially located (at some time), we have a spatial arrangement that is determined by those things. This arrangement may be abstracted from this plurality of things by paying selective attention to their spatial locations[2], I suppose. Whilst these things all exist, their (typically changing) arrangement exists. Such arrangements are, I claim, central to the nature of the ontology of the world and how it changes over time. I therefore pay careful attention to the nature of the existence of such arrangements, an existence I take to be sui generis. I focus in particular on the arrangement of the parts of composite-actors – labelling the nature of the existence of such arrangements *super-subtle-existence.* Super-subtle-existence plays a central role in what composite-actors can do (how they can act), and in how they may be characterised – e.g. their shape, size, structure, etc. I follow orthodoxy in labelling such abilities and characteristics of actors 'properties' – but AAO does not reify such properties. Hence, I explicate how AAO licenses properties whilst eschewing properties within its (acting-trajectory) base.

I thus set out an account of the nature of existence according to AAO by reference to a *base ontology* (the obtaining of all actors in time and space) and a *super-ontology* – the obtaining of features that obtain on account of the base ontology. The features of the super-ontology on which I focus are properties (including powers), knowledge, language, truth, natural kinds, causal relations, regularities, laws, possibilities and probabilities. I borrow from the playbook of (inter alia) David Lewis in accounting for such features in terms of a base ontology – but, so I claim, I go further than Lewis in providing an account of all of these features and why they may be expected – I do not simply treat them as brute. Arrangements will play a leading role in this story.

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[1] Resultant is to be understood as contrasting with 'emergent' as in the work of the British emergentists, e.g. McLaughlin 2008.

[2] Locations may be inter alia points in space, density functions over regions of space, and unions of locations of parts.

In assessing this preliminary account of AAO, I summarise arguments in its favour amassed through the text, and make the case for its fit with the empirical world, coherence (its avoidance of many aporia) and parsimony. I conclude that AAO is a plausible account of ontology with great strengths and exciting potential, a serious candidate to be an account of the ontology of our world, that does indeed warrant further investigation.

Without further ado, let’s turn to the narrative argument.

Section I: Lasting and changing

2 The Aristotelian roots of lasting

An entity that is lasting is roughly one that is obtaining through time as ontologically prior to it temporal parts. The first thing to note is that there seems to be no previous name for this form of existence, at least not one that is widely available in the literature, nor one known to the wide swathe of contemporary philosophers with whom I have spoken. And this is despite the fact that lasting is hiding in plain sight, seemingly unremarked, as the form of existence of Aristotle's substances, concrete things and processes (kineses)

Might lasting be just enduring, as understood in the contemporary debate in which enduring is the alternative to perduring? After all, Aristotle is widely taken to be an endurantist. The answer is no, at least not as enduring is commonly understood. Enduring is generally taken to entail persisting through time but not by having temporal parts. Lasting entities, on the other hand, do have temporal parts – these parts are 'potential', in Aristotle's sense, rather than 'actual', that is to say they may be abstracted from the lasting entity but do not compose that entity, as I shall explain. I address the question of enduring vs lasting carefully in a recent paper[3] – I will not rehearse that discussion further here as it is largely tangential to this investigation.

Given the importance of lasting to our story, and its previous lack of remark, I start by arguing carefully that Aristotle is indeed committed to the lasting of things and processes. Why bother bringing Aristotle into this? Why not simply start with a contemporary definition of lasting and proceed? Although it is true that recovering lasting from Aristotle is not strictly necessary for our journey, I take it as a great advantage to show that Aristotle does subscribe to lasting, adopting it at the heart of his ontology. He is, after all, one of the weightiest (perhaps the weightiest) authority in ontology. And adopting his views represents a reversion to the orthodoxy that obtained from antiquity to the mid-seventeenth century - not a new departure.

I shall first show that lasting fits with Aristotle's general mereology – so that it is not surprising for Aristotle to hold this position (section 2.1). I then explain how Aristotle makes explicit that motions (kineses) are lasting (section 2.2), before proceeding to some direct arguments that Aristotle's concrete things are lasting (sections 2.3). Finally I shall show how lasting is assumed by Aristotle in some of his key arguments – arguments that relate to change (section 2.4).

2.1 Lasting fits with Aristotle's more general mereology

Aristotle supposes that a whole is metaphysically different from a mereological sum (e.g. a heap or a bundle), contrary to what is widely supposed in contemporary philosophy. The difference for Aristotle lies in the fact that a whole is more strongly

[3] Pemberton 2022a.

unified than a sum.[4] In Aristotle's ontology, what explains the higher level of unification of a whole over a sum is that a whole is ontologically prior to its (potential) parts. The parts, on my reading, derive their identity from the identity of the whole.[5] A hand, for example, a part of a body, must be defined by reference to the body as a whole, and hence derives its identity from the whole.[6]

We may note that according to Aristotle's mereology (which differs markedly from orthodox contemporary mereology), wholes do have parts - they are not simples – but these parts cannot be separated from the whole, except by abstraction.[7] Aristotle takes such parts to be *potential* not *actual.* Wholes then have potential but not actual parts – they are not composed of parts, perhaps with inter-relations between them. Mereological sums, on the other hand, are composed of actual parts – these actual parts are ontologically prior to the composite, the sum.

Aristotle's holism with regard to spatial parts[8] is widely discussed and commonly recognised amongst Aristotelians.[9] In considering lasting, I am focusing on temporal, rather than spatial, parts. In arguing that Aristotle adopts lasting, I am arguing that Aristotle's holism extends to temporal as well as spatial parts. Lasting is, then, compatible with Aristotle's holism of substances with respect to their spatial parts, and might thus be considered unsurprising – a position that we might expect Aristotle to hold.

2.2 Aristotle is explicit that motions are lasting

Before presenting direct arguments that concrete things are lasting, I shall argue that Aristotle is explicit that motions (kineses) are lasting. This, on my reading, is Aristotle's only explicit commitment to the lasting of any entities. (For entities other than motions, notably concrete things, we may infer Aristotle's support for lasting, as I argue below.) The presence of some (explicitly) lasting entities within the ontology (i.e. motions) makes more plausible the claim that other (albeit very different) entities (such as concrete things) are also lasting – or so I suggest.

What is the relationship between motions (e.g. the flight of an arrow) and concrete things (e.g. an arrow) in Aristotle's ontology? This is a complex matter subject to exegetic debate which I shall not seek to address here. Rather, it will suffice for our

[4] Aristotle, Metaphysics, V.26. I need not digress into the details of the current debates concerning the unity of substances, and most notably the hylomorphic unity of matter and form, as this is tangential to my arguments here – but for discussion see e.g., Koons 2014, Peterson 2018, Marmodoro 2020, Simpson 2023.
[5] Aristotle, Metaphysics, VII, 10.
[6] Aristotle, Metaphysics, VII, 1035b10.
[7] In the case of functional parts (e.g. the hand as a part of the body) separation would result in loss of function of the part and hence its identity – a severed hand would be a hand in name only (Metaphysics, VII, 1035b23-25). Motions, too, are unities on Aristotle's account - see Section 2.2 below - so that the stages are ontologically dependent on the whole motion (they do not compose the motion).
[8] Including, notably, functional parts.
[9] See for example Pfeiffer 2018.

purposes to establish separately Aristotle's commitment to the lasting of motions and concrete things.

Consider motions (kineses), then – entities which are central to Aristotle's account of change and to his ontology. Change occurs, on Aristotle's account[10], when an agent is in suitable contact with a correlate patient, so that their correlate agent-patient powers are activated[11] – the salient changing is in the patient.

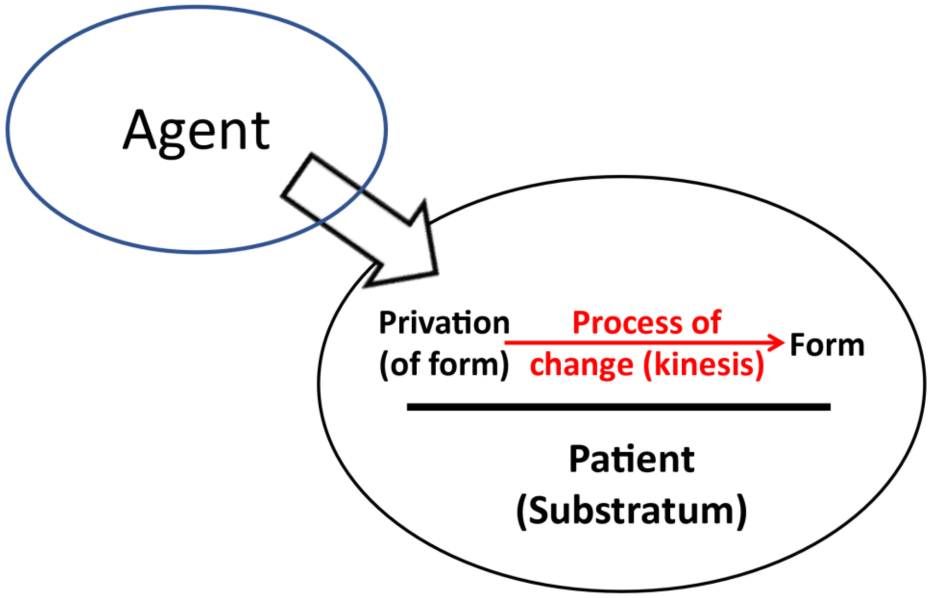

Figure 2.1: Agent, patient and process of change (kinesis, i.e. motion)

The correlate powers are in suitable contact and manifesting through time, so that the patient is changing through time. Aristotle uses the term *kinesis* to refer to the process of change, or motion, which is this changing over time. This process results in the change over time of the patient from being without (i.e. in privation of) a form to having a form (i.e. being enformed). The process may be understood as the transmission of a form to the patient (substratum) by the agent.

For example, when a builder (agent) and building materials (patient) are in suitable contact, building occurs, i.e. the becoming built of the building materials. This changing of the building materials over time is a process of changing (a motion) which results in e.g. a house – at the end of the process the patient substratum (building materials), which initially lack (are in privation of) the form of the house, has taken on the form of the house; the builder has transmitted the form of the house which was in her mind, to the building materials.

[10] Aristotle, Physics I.7-8; Physics, III.1; Physics 202a5-11; Physics 202a13-15. For discussion see Waterlow 1982, Sections III and IV; Marmodoro 2007, Sentesy 2020.
[11] I.e., they are in a state of activation – they are manifesting.

As the motion may be understood as the teleological[12] transmission of a single form, we might perhaps infer that it must be a unity. However, we need not rely on such inference as the unity of a motion (and hence its lasting) is a point on which Aristotle is explicit: he characterises motions as (temporally) continuous[13], whilst defining 'continuous' (in his refined, second, definition) as follows:

'*The continuous is that which is next to something, but I call them continuous only when the limits at which they are touching are one. …. And it is clear from this definition that the continuous is among those things out of which some one thing naturally comes into being as a result of their uniting*.'[14]

This definition is concerned with the unity of (potential) parts of a continuous thing – a unity that yields a whole. Aristotle's continuous things can be continuous either spatially, i.e. with respect to their (potential) spatial parts (as in the case of a body and its parts such as hand and heart), or temporally, i.e. with respect to their (potential) temporal parts (as in the case of the flight of an arrow and the stages of that flight). In the case of a motion, we are concerned with temporal parts of an entity that is temporally continuous. Aristotle, in advancing his second definition of continuity whilst ascribing motions as continuous, makes explicit that motions are unities: the conceptual temporal stages of the motion are in fact not many but rather one as the end of each (conceptual) stage just is the beginning of the next ('the limits at which they are touching are one'). In being such unities, the motions are ontologically prior to their temporal parts – they are lasting.

As confirmation that Aristotle takes motions to be lasting, Aristotle uses the lasting of motions to solve Zeno's arrow paradox, a central task of the Physics. Aristotle may be understood as formulating the paradox by way of the following syllogism[15]:

A1: The flying arrow does not move in any instant.
A2 (The *composition assumption*): The flight of the arrow is composed of instants[16].

C: The flying arrow does not move.

As an instant is the shortest duration of time, an arrow could not be in more than one place within an instant, for then the instant could be split into more than one part. So, the arrow cannot, and does not, move in any instant (A1).

Aristotle resolves the paradox by rejecting assumption (A2), that the flight of the arrow is composed of instants:

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[12] I.e. on consideration of the directedness of the motion towards some telos or end. For discussion of Aristotle's teleology see Johnson 2005.
[13] Aristotle, Physics, V.4, 228a20
[14] Aristotle, Physics, V.3, 227a10-14. Translation Sachs 2011, p140.
[15] Zeno's original texts setting out the paradox are lost. This is the formulation implied by Aristotle, who is widely taken to be our best available source – see Physics VI.9.
[16] An instant is a shortest duration of time. Both Aristotle and orthodox contemporary thinkers take time to be continuous – I follow that orthodoxy here taking time to be isomorphic to the set of Real numbers. We may then take an instant to be a single point in time.

'Zeno's reasoning, then is wrong: for he says that if everything is always at rest when it is in a given place, while what is changing place is always doing so in the now, then the flying arrow is motionless. But this is false, for time is not composed of indivisible nows, just as no other magnitude is.'[17]

For Aristotle time is the 'number of change' in respect of the before and after: numbers may be ascribed to the stages of the flight of the arrow, and this numbering is, in a sense that Aristotle explains, time.[18] In saying that time is not composed of indivisible nows, we may understand Aristotle as saying, on my reading, that the flight of the arrow is not composed of instantaneous temporal parts (or more simply 'instants').

On what basis does Aristotle reject the claim that the flight is composed of instants, i.e. the composition assumption (A2)?

The flight of the arrow is a motion (kinesis) on Aristotle's account[19]. As we have seen above, Aristotle supposes that motions are lasting – and a lasting entity is ontologically prior to its temporal parts (and a fortiori to its instantaneous parts) so that it is not composed of them. The lasting of motions thus provides grounds for Aristotle's rejection of the composition assumption, and hence his solution to the arrow paradox.[20]

2.3 Aristotle's concrete things are lasting – direct argument

A leading rival view to lasting is that concrete things are built from ontologically prior instantaneous parts – a view I dub mosaicism. Consider first substances, Aristotle's paradigm examples of concrete things. Here are five arguments that on Aristotle's account substances are not composed of instantaneous temporal parts:

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[17] Aristotle, Physics VI.9 239b 5-9.

[18] Aristotle, Physics IV.10-14, Coope 2005.

[19] In the case of the flight of the arrow, we may suppose that the archer with his bow (the agent) transfers the form of the flight (perhaps a trajectory towards some target) that is in the mind of the archer, to the arrow (the patient). On Aristotle's account of motion through the air, the air takes over as agent from the archer / bow to push the arrow forward during its flight – see Hanson 1965.

[20] Aristotle's first definition of the continuous (that which is infinitely divisible) renders the limit of infinite division as potential rather than actual, where the potentiality in play is that associated with the infinite (the limit of infinite division is never actually achieved, it is merely potential). This definition thus rules out points as actual parts of time thus providing a further ground for Aristotle to reject the composition assumption. See Pemberton 2022a section 6. On my reading Aristotle takes points (nows) to be potential parts of time – the limit of infinite division would be a single point in time– and hence he supposes substances have potential instantaneous temporal parts. Aristotle does, after all, suppose that there is a way that the world is in a now. I set out a fuller discussion of Aristotle's solution to Zeno's arrow paradox in Pemberton 2022.

1. Substances, on Aristotle's account, have *natures*, i.e. internal principles of change and rest.[21] A principle of change and rest would seem to have no useful meaning in relation to an entity that exists for a single instant. (An entity that exists at a single instant cannot change.) It seems implausible that substances (which are natured) could be built from ontologically prior instantaneous parts (which cannot, it seems, have natures).

2. Substances qua agents and patients are teleological beings, according to Aristotle: they act / are acted upon over time, where this acting over time of the agent is towards some telos (the transmission of a form from the agent to the patient). This too seems inconsistent with agent / patients existing at a single instant, or with their being built from entities which exist at a single instant (supposing that teleological beings cannot be built from non-teleological beings).

3. Substances within the superlunary sphere, such as stars, are explicitly eternal, on Aristotle's account. Such eternality is a source of perfection. It seems inconsistent with Aristotle's account to suppose that, rather than being ontological unities, such entities achieve the perfection of eternality on account of being built from a dense infinity of ontologically prior instantaneous entities (that stretches out throughout all time).

4. Sublunary substances, strive for the perfection of the unmoved mover both in respect of its eternality and its eternal motion.[22] (The unmoved mover is a supra-physical entity.) Substances in the sublunary sphere, such as animals, cannot attain eternality by themselves – but by reproducing they can, on Aristotle's account, ensure the eternality of their species. The degree of perfection achieved in respect of eternality by species on account of reproduction is of a lesser degree than that attained by eternal superlunary substances reflecting the fact that this is only a kind of approximation to eternality.[23] Individual substances obtain over some period of time so as to collectively achieve eternality. If reproductive substances were themselves composed of temporal parts, it seems the degree of approximation to eternality of the species would be lower still. It would seem highly doubtful as to whether substances built from instantaneous entities would underwrite the achievement of any degree of perfection at all – and implausible that Aristotle supposed that such substances are indeed built from instantaneous temporal parts.

5. Aristotle is explicit that '*nothing moves in the now*'[24]. An instantaneous entity could not, then, imitate the motion of the unmoved mover. Again, it seems implausible that substances (which do seek to imitate the motion of the

[21] See e.g., Waterlow 1982.
[22] Aristotle, On generation and corruption, II.10, 336b, 25-36; Dudley 2012, especially 116-117.
[23] Aristotle, On the soul, II.4, 415b2-8.
[24] Aristotle, PhysicsVI.3 234a24.

unmoved mover) could be built from instantaneous entities (which could not).

On each of these arguments, Aristotle's account is not compatible with substances being composed of instantaneous temporal parts.

How about concrete things that are not substances. Many hold that for Aristotle all concrete things, even rocks for example, are substances, albeit not paradigm examples of substances. If there are concrete things that are not substances, then I take it that these would be heaps or bundles of elemental matter (earth, air, fire, water). On Aristotle's account elemental matter is characterised by its moving towards its proper place (e.g. earth moves downwards, fire upwards). If such elemental matter obtained for a single instant, it could not exhibit such characteristic moving – and this would contradict Aristotle's suppositions concerning such matter. It seems that concrete things that are not substances – as well as substances - could not be instantaneous, nor be composed of instantaneous temporal parts.

Might concrete things nevertheless be composed of non-instantaneous temporal parts? This raises the question as to how such non-instantaneous temporal parts might be determined in a principled way: how might we choose to divide the underlying time period into halves, quarters, or some other of the infinitely many possible partitions in order to specify non-instantaneous temporal parts? Even if such a principled basis for partitioning the time period were forthcoming, non-instantaneous actual temporal parts would conflict (at least to some extent) with the unified nature of substances (as in (1)), unified teleological action (at least where the temporal parts divide the period of action), as in (2), the perfection of eternal substances (as in (3)), and the partial perfection of sublunary substances (as in (4)). (1)-(5) above, together with difficulties associated with a principled partition of non-instantaneous parts, thus represent a series of overlapping arguments against concrete things having either instantaneous or non-instantaneous actual temporal parts.[25] I am unaware of any explicit arguments that, on Aristotle's account, concrete things do have actual temporal parts.

One might wonder: If Aristotle's concrete things do not have actual temporal parts, might they be temporal simples, i.e. have no temporal parts of any kind (not even potential temporal parts)? Substances may change, on Aristotle's account. On Aristotle's account, time is the number of change in respect of the before and after[26]: we can ascribe (temporal) numbers to things corresponding to the stages of their change, and it would seem that this provides a basis for paying selective

[25] As explained in section 2.1, on Aristotle's account entities have actual parts just in case they are composed of those parts – these parts are then ontologically prior to what they compose.
[26] Physics IV.10-14, Coope 2005.

attention to the stages of their change[27] – and hence to abstracting temporal parts[28]. At least in this sense of licensing the abstraction of temporal parts, it would seem that Aristotle's things do have (potential) temporal parts.[29].

These overlapping arguments offer firm grounds for supposing that Aristotle's things have potential (but not actual) temporal parts, and hence are lasting.

2.4 Aristotle's solutions to certain key problems of change are predicated upon the lasting of concrete things

Aristotle's key aims within the Physics include showing how P can come from ¬P and that change is real. [30] I shall describe here how Aristotle's solution to both of these key problems is predicated upon the lasting of concrete things. The predication of key arguments upon the lasting of concrete things further supports the case that Aristotle does suppose concrete things are lasting.

2.4.1 How P can come from ¬P – the case of accidental change

Aristotle renders an aporia handed down from Parmenides and the Eleatics thus: '*nothing comes to be or passes away, because whatever comes to be must do so either out of something which is, or out of something which is not, and neither is possible*'[31]. If P comes from P, then we do not have change - to have change, P must come from ¬P. A widespread concern amongst the ancients was that change (the becoming of P from ¬P) must then imply the becoming of being from not-being. It was generally agreed, including by Aristotle, that coming from not-being would be problematic.

Aristotle solves the problem of P coming from ¬P by positing an underlying substratum of change that exists throughout the process of change from P to ¬P. In the case of accidental change, which I focus on here, change occurs within a concrete thing, perhaps a substance. On Aristotle's account PA, say, comes to be from ¬PA - for example a musical person comes to be from an unmusical person.[32]

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[27] What about a substance or other concrete thing that happens not to be undergoing change during some period? Here we may suppose that it is contemporaneous with other substances that are undergoing change – and that we may then use the temporal numbers of these other substances as a basis for the abstracting the unchanging substance's temporal parts.

[28] Abstraction may be understood as involving the paying of selective attention to certain aspects – see e.g. Bäck 2014, Cleary 1985. Abstracted parts, as in the case of a hand, may often exist in time and space and hence be physical – this is the case for both spatial and temporal parts.

[29] Jonathan Lowe makes a similar argument that things must have temporal parts at least in this limited sense of abstraction – see Lowe 2006, page 724.

[30] ¬P should be read not-P.

[31] Aristotle, Physics, I.8, 191a25-28.

[32] Aristotle, Physics I.7-8. For a history of the problem of being coming from not being in Ancient Greek thought see Sattler 2020 – especially pages 280-282 for Aristotle's solution.

This solution supposes that the substance obtains through the period of change: it remains numerically the same whilst changing from one state to another. How is this possible? If the substance were a composite of temporal parts, it would lack the required unity with respect to these parts to underwrite the required numerical sameness.[33] If it were temporally simple, i.e. totally lacking in temporal parts, then the achievement of a change of state would be problematic. For Aristotle, on my reading, it is the lasting of the substance (or other class of concrete thing) which licenses this change of state whilst staying numerically the same: the potential temporal parts of the substance may have different accidents at different times, but they all derive their identity from the substance as a whole.

2.4.2 The reality of change

Leading Eleatics, most notably Parmenides, cast doubt upon the reality of change. Zeno suggested that change may be paradoxical. These views challenged the possibility of the rational study of natural science. [34] It was thus essential for Aristotle's overall project that these views be rebutted and the reality of change be established – a task which he undertook within the Physics.

In order to establish the reality of change, Aristotle appeals to the actuality of the potentiality for change whilst that potentiality remains in being: '*Change is the actuality of what is potentially, when that which is potential is actually active not as itself but as something which is capable of change.*'[35] In the paradigm case of change brought about in a patient by an agent – pictured in Figure 2.1 - '*Change is the actuality of the changeable, qua changeable, and this happens as a result of contact with the agent of change.*'[36] Change arises just when the agent and patient are in suitable contact over some period of time (see section 2.2) - their correlate powers are activated (i.e. actualised) over this period of time.[37] And in order to undertake their teleological roles[38] within the process of change over this period, the agent and patient must exist through this period – they must be lasting.[39]

In the case of natural change[40], the natural being must be lasting in order to underwrite the change (e.g. developing) through time of the natural being.

Lasting of concrete things (e.g. agents, patients, natural beings), then, is required and presupposed in Aristotle's demonstration of the reality of change.

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[33] See Scaltsas 1994 for a discussion of the unity of substances with regard to their parts.
[34] See Sattler 2020, chapters 2 and 3.
[35] Aristotle, Physics, III.1, 201a27-29.
[36] Aristotle, Physics, III.3, 202a7-8.
[37] Aristotle, Physics, III.1-3; see Marmodoro 2007.
[38] Within Aristotle's ontology, powers and power-bearers are telic entities, i.e. entities that are oriented towards some goal.
[39] See Pemberton 2021 for discussion of the timing of the manifestations of powers, especially that of Aristotle's agent/patient powers which I dub as having *Aristotelian-timing.*
[40] See Aristotle, Physics, 192b8-23 and Waterlow 1982.

2.5 Conclusion

Lasting – holism with respect to temporal parts - is consistent with, and might be expected in light of, Aristotle's more general commitment to the priority of wholes over their parts. Aristotle is explicit that motions are lasting. I have set out direct arguments that Aristotle's concrete things are lasting (section 2.3) and made the case that Aristotle supposes the lasting of concrete things in key arguments concerning change (section 2.4). I suggest that together these overlapping arguments provide a strong case that Aristotle subscribes to the lasting of things (including substances) and processes.

3 Lasting

So, we have found lasting hiding in plain sight within Aristotle's ontology. Now I adopt lasting as the first feature of our new account of ontology. In order to do so it will be helpful and appropriate to characterise lasting somewhat more generally and precisely than I have so far – I shall do so in section 3.1 below.

Why, though, should I adopt lasting?

The justification for adopting lasting must ultimately appeal to the success of AAO – and that is the argument of this thesis as a whole. No more immediate justification is required. However, I shall identify some early reasons for favouring lasting as we go, starting in the next chapters by showing that lasting licenses changing and hence overcomes problems of change that remain unsolved within mosaic ontologies (chapters 4-5).

Mosaicists might object that lasting conflicts with mosaicism, and mosaicism is so successful that it should be accepted as the default ontology[41], no longer requiring justification. I shall address such objections in section 3.2.

3.1 Lasting characterised

I shall take a *lasting* entity to be one which:

1. *Is physical (so that it exists in space[42] and time[43]);*
2. *Exists for some period of time[44];*
3. *Is ontologically prior to its temporal parts.*

In Aristotle's case the ontological priority of a lasting whole over its temporal parts, i.e. characteristic 3, is achieved via the identity dependence of the parts upon the whole (on my reading)[45]. In the more general characterisation of lasting given, the nature of the ontological priority of the lasting entity over its temporal parts is left open, and it may be supposed that contemporary philosophers may propose accounts of this priority which are consistent with their respective broader

[41] See for example the discussion of Humeanism by John Heil (Heil 2021 page 13 and page 187).
[42] I suppose here the existence of a classical domain and focus on this domain, remaining agnostic here as to how this domain may be related to any quantum domain. I discuss this point further in section 20.1.1.
[43] See section 20.1.6.
[44] That is to say, if lasting entity L exists at time t, then it exists for some period that contains t, i.e. L exists at $t \Rightarrow \exists\ T_0, T_1$ such that $T_0 \leq t$, $T_1 \geq t$, $T_0 < T_1$ and L exists $\forall t \in [T_0, T_1]$.
[45] I take my identity-dependence reading to be consistent with Scaltsas' view of the unity of substances (Scaltsas 1994), for example – but the form of ontological priority supposed by Aristotle is tangential to my argument here, so I shall not argue for it further.

ontologies (which may likely differ from Aristotle's account of priority). This characterisation of lasting is not then tied to Aristotle's ontology.[46]

Aside from Aristotle's identity-dependence account of the ontological priority of a lasting whole over its temporal parts, what other accounts of such ontological priority might there be? This is, on my reading, a largely unexplored question and one with a wide range of possible answers. The following are some options which may seem attractive and warrant exploration.

- Identity-dependence unity. Perhaps there are variations of Aristotle's account wherein the unity of a lasting whole is achieved by the identity-dependence of the temporal parts upon that whole, but where the identity-dependence posited is sufficiently different from that of Aristotle (in some way) for the account proposed to be distinguished from that of Aristotle.

- Brute unity. Perhaps the temporal unity of lasting entities is brute: certain physical entities we find in the world are lasting, they exist through time and are ontologically prior to their temporal parts, and this is simply a brute fact about the nature of the world. One refinement of this possibility is that there are certain building blocks of the world's physical ontology which are brute lasting, and that these lasting building blocks compose to form higher level entities which inherit their lasting from the building blocks.

- Teleological unity.[47] Perhaps the grounds of the temporal unity of some or all lasting entities may be associated with the teleological character of these entities in some way. As we have noted in discussion of Aristotle position, for an entity to act teleologically (e.g. to act to bring about some end (telos)), it would seem necessary for that entity to obtain over some period during which it undertakes a series of suitable actings. As well as human intentionality as a model for such teleology, the functional roles of entities taken to be mechanical (perhaps ones of the sort posited by the new mechanists[48]) might provide a basis for lasting.

- Causal unity. Perhaps lasting entities might be underwritten by some form of causal influence between stages: e.g. later stages of a lasting entity are caused in some suitable way by earlier stages, where what it is to be 'suitably caused' is defined by the putative account of causal unity. (Note the resonance with mosaicist accounts of persisting (common-sense) things such as that of Lewis and Russell for example, which both, in their differing ways, suppose that causal connections play a role in the unity of persisting things, alongside juxtaposition and similarity relations).[49] Any such causal account would need to ensure that such causal unity underwrites the ontological priority of the persisting whole over its temporal parts.

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[46] For background discussion see Pemberton 2023.
[47] I.e. unity achieved by reference to some telos (i.e. some end or purpose). For discussion of Aristotle's teleology see Johnson 2005.
[48] Bechtel & Abrahamsen 2005; Craver 2013.
[49] See Russell 1948, part VI; Lewis, 1986, xiii.

- Continuity-based unity. Perhaps lasting entities might be underwritten by some form of continuity across stages where the continuity posited is such as to ensure the ontological priority of the persisting whole over its temporal parts. (Such a continuity account of unity might resonate with 'genidentity' accounts of unity[50], perhaps appealing to causal influence as well continuity. Note, though, that existing genidentity accounts, on my reading, generally make no commitment to the ontological priority of either temporal wholes or their parts.)

- Sui generis unity. Perhaps the temporal unity of entities that we find in the world is not brute, but rather is explicable according to some sui generis account - presumably an account which is yet to be discovered or, at least, widely disseminated.

In making these suggestions, I do not, of course, mean to limit any exploration of other possible grounds of temporal unity – many areas of investigation might prove fruitful. Any specific account of temporal unity, at least any that is plausible, fills in one assumption in the set of assumptions which determine our account of ontology – it helps to give rise to a family of possible lasting ontologies, we may suppose.

3.2 Lasting is an alternative to mosaicism

I first clarify how I understand mosaicism (section 3.2.1), and contrast lasting and mosaicism (section 3.2.2), before arguing that mosaicism, no less than lasting, requires justification. Lasting is an alternative to mosaicism – in the chapters that follow in this thesis, I shall argue it is a superior alternative.

3.2.1 Mosaicism

A popular view within contemporary philosophy holds that the world comprises a mosaic of instantaneous[51] spatio-temporal tiles. A leading example of such a view is

[50] Guay and Pradeu 2016.

[51] An instant is the shortest duration in time, so that on the orthodox view that time is continuous, instantaneous entities exist for just a single point-in-time. Might it be suggested that tiles may obtain over some period within continuous time. The tiles are the fundamental basis of ontology. A tile cannot differ between one part and another, for otherwise proper parts of the tile would be needed in order to underwrite the complete ontology of the world – and this would contradict the supposition that the tiles form a basis for ontology. Hence, to have a tile that exists for some period, is to have a tile that is unchanging over some period of time. But this seems incompatible with contemporary physics – we do not find such periods of stasis (presumably with jumps in between, at least where we are concerned with continuous change). Nor do infinitesimals offer a plausible route to tiles that exist over some period. Whilst it is true that contemporary mathematics has developed certain structures which posit entities that may be labelled 'infinitesimals', these structures are non-standard and incompatible with supposing that time can be represented by the Real numbers in the way generally assumed in contemporary physics. I shall not explore the possibility of such temporally-extended tiles further.

the subscription of neo-Humeans to a Humean Mosaic. David Lewis expresses it thus:

> '*All there is to the world is a vast mosaic of local matters of fact, just one little thing and then another … We have a geometry: a system of external relations of spatiotemporal distances between points … And at those points we have local qualities: perfectly natural intrinsic properties which need nothing bigger than a point at which to be instantiated. For short: we have an arrangement of qualities. And that is all*.'[52]

Amongst the neo-Humeans there are differing flavours of mosaicism.[53] For example, we find different accounts of properties (e.g. instantiated universals, tropes) and how these properties get together (e.g. simple co-location, bundling); different terminology for the tiles – e.g. as 'states' or 'events'[54].

Mosaicists do not, to be clear, deny the existence of concrete things which persist through time within their ontologies – rather, concrete things on the mosaicist accounts are pluralities of adjacent and perhaps similar tiles. Bertrand Russell, for example, takes a 'common-sense' thing to be a dense infinity of adjacent events which exhibit '*quasi permanence*', i.e. suitable similarity relations.[55]

3.2.2 Lasting vs mosaicism

Mosaicist ontologies suppose that instantaneous tiles are the fundamental building blocks of ontology, so that persisting concrete things are derivative entities built from such fundamental tiles. Lasting ontologies, by contrast, suppose that concrete things are ontologically prior to their temporal parts, not built from them; instantaneous tiles are not posited within lasting ontologies. Lasting thus offers a distinct alternative to mosaicism.

We have identified Aristotle's ontology as lasting and we may suppose that many neo-Aristotelian ontologies inherit this feature of being lasting. We may suppose, too, that we may develop new accounts of ontologies that are lasting – indeed I shall develop such an account in this thesis as a whole. There are, then, accounts of lasting ontologies available.

Ex ante, it would seem an open question as to whether we should opt for a lasting ontology or for a mosaicist one. As we have noted, contemporary philosophers mostly opt for mosaicism - what is their case for doing so?

[52] Lewis, 1986, ix.
[53] Central aspects of mosaicism can arguably be traced to Plato's account of the Receptacle within the Timaeus (especially on spatial, as opposed to material, accounts of the Receptacle – see e.g. Zeyl and Sattler 2022, section 6).
[54] '*An "event" may be defined as a complete bundle of compresent qualities'* (Russell, 1948, 78).
[55] Russell 1948, 429-30.

The lasting of Aristotelian ontologies has (as I note above) not been widely articulated. And other lasting ontologies, according to my investigations, have not, been widely developed.[56] If this is so, then one reason that mosaicism is preferred would seem to be that the lasting alternative has not been sufficiently considered.

3.3 Mosaicism requires justification no less than lasting

Are there grounds upon which mosaicist could resist the pressure for justification of their position, claiming instead perhaps that it should be accepted as the correct default ontology whose credentials have already been established – so that it requires no further justification.

Perhaps they might seek to argue that lasting is not, contrary to my protestations, a possible ontological position, neither in Aristotelian nor non-Aristotelian versions. I do not know how any such argument might go – but if there is such an argument, then it would likely be a valuable addition to the literature.

Or perhaps they might argue that the popularity of mosaicism amongst leading philosophers, its success in advancing metaphysics and providing a foundation for the advancement of science, and its historic defeat of Aristotelian dominance, render it the rightful default ontology. Relative popularity, even if accepted, is surely not a conclusive argument. Whether contemporary philosophy has succeeded in much advance is a topic of debate[57], as is its efficacy as a foundation for science. [58] Moreover, the current resurgence of Aristotelian thinking gainsays any claims of its defeat.[59] The case that mosaicism is the rightful default ontology that no longer requires justification should not, I suggest, be accepted.

Or perhaps they might identify some knock-out metaphysical arguments in favour of mosaicism in preference to lasting which preclude further debate. Let's briefly consider some possibilities for such metaphysical arguments.

1. It might be argued that point-in-time entities (in some sense) fit with (and are perhaps required as the truth-makers of) sentences in the present tense – so that common language usage implies there must be point in time entities along the lines proposed by mosaicism. Supporters of lasting might reply that how a lasting thing is at some point in time (which may be abstracted from that lasting entity) is also a suitable truth-maker for such sentences. Moreover, lasting entities might claim a fit with tenses such as the continuous present, which might be a

[56] Jeremy Skrzypek (Skrzypek 2022) and Valerio Buonomo (Buonomo, 2018, chapter 2, especially section 2.2) also discuss the possibility of persisting wholes which have ontological priority over their temporal parts, and thus consider ontologies which are, on my reading, at least closely related to (but different from) lasting ontologies as described here. Skrzypek advocates a neo-Aristotelian ontology (see e.g. Skrzypek 2021).
[57] See, for example, Dietrich 2011, Chalmers 2015.
[58] See for example the work of Nancy Cartwright (e.g. Cartwright 1999, 2007, Pemberton & Cartwright 2014).
[59] See for example Simpson et al 2018, Koons 2020, Austin 2021.

reason for preferring them. In any case, inferences from common language usage to ontology are far from secure.

2. Another possible argument is that popular contemporary accounts of time, such as eternalism, presentism, growing-block, suppose that points in time (*e.g.,* the present point in time) exist, and that this underwrites an argument for the existence of point-in-time building blocks of ontology. If such an argument could be articulated and be found to have merit, it would likely establish a connection between the assumed account of time and mosaicism. These accounts of time (e.g. eternalism) and mosaicism might then be found to stand or fall together. Still, this would not yet be an argument for mosaicism. Lasting ontologists will likely wish to reject eternalism, etc., seeing these as mosaicist accounts of time. Like Aristotle, they will likely wish to adopt accounts of time which fit with lasting ontologies.[60]

3. Could it be argued that mosaicism fits with contemporary science and must therefore be preferred? For this to be an argument for mosaicism in preference to lasting, the claim must be that mosaicism fits better with science than lasting. Whether this is so may only be judged once contemporary lasting ontologies are articulated and assessed. In chapter 19 I advance some arguments that the reverse is the case (lasting is a better fit with the empirical world than mosaicism), at least for the lasting ontology I shall develop (AAO).

Perhaps others can find ways to improve arguments along these lines, or perhaps advance other stronger arguments for mosaicism in preference to lasting. If there are such arguments then, again, they would surely be a valuable addition to the philosophical literature. But this is, as I understand, work yet to be done – and whether it can be done remains to be seen.

In my own previous work, I have argued that lasting ontologies have certain attractions as compared to mosaicist ontologies - for example, in underwriting attractive accounts of change and the bringing about of change[61]. I shall further develop these arguments below. Insofar as these, or other arguments for the relative attractiveness of lasting over mosaicism are successful, the challenge to mosaicism is increased.

3.4 Conclusion

In this chapter I have adopted lasting as the first characteristic of AAO, have set out a more precise characterisation of lasting, and have made the case that it offers an alternative basis for an account of ontology to the mosaic assumption – indeed, ex ante, the assumption seems to be on a par with the mosaic assumption. I have

[60] For Aristotle's account of time as the number of change in respect of the before and after, see Physics, IV.10-14 and Coope 2005. See also section 20.1.6.
[61] See Pemberton 2021, 2022, 2022a.

argued against the view that mosaicism is a rightful default ontology that does not require justification.

I shall now proceed to add further characteristics of AAO, starting in the next chapters with changing and then acting.

In light of the contemporary popularity of the mosaicist view and its clear contrast with lasting, I shall use it as the main comparator in unfolding my case for lasting within this thesis.

4 Lasting licenses changing (mosaicism does not)

In this chapter I shall adopt changing as the second characteristic, alongside lasting, of AAO. In order to do so, I need to show that changing is compatible with lasting: I shall show (in this chapter) that lasting licenses changing.

4.1 The mosaicist rejection of changing

Before showing how lasting licenses changing, it will be helpful to make clear the sense in which mosaicism rejects changing. I shall focus primarily on changing of position, i.e. instantaneous velocity - this is not only Aristotle's paradigm example of changing[62] and central to contemporary science (especially physics), but is also the subject of the most precise analyses of any form of changing. We may use Zeno's arrow paradox as our focus for analysing changing of position as the paradox continues to be widely used as a framework for analysis of moving objects today.

We saw in section 2.2 how Aristotle solves the arrow paradox by appeal to lasting (the lasting of the flight).[63] The orthodox contemporary solution to the paradox, the at-at solution[64], promoted perhaps most notably by Bertrand Russell, differs markedly from that of Aristotle. Russell sets out this account most fully in his Principles of Mathematics, most notably in Section VII on matter and motion.[65] Let's first consider this account.

4.1.1 The at-at account of motion

Russell is admirably clear that the at-at solution rejects changing of position, i.e. instantaneous velocity:

> '*[W]e must entirely reject the notion of a* state *of motion. Motion consists* merely *in the occupation of different places at different times, subject to continuity as explained in Part V. There is no transition from place to place, no consecutive moment or consecutive position, no such thing as velocity except in the sense of a real number which is the limit of a certain set of quotients.'* [66]

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[62] For a thorough discussion of the priority of changing of position, i.e. locomotion, in Aristotle's physics see Odzuck 2014.
[63] I set out a fuller account of Aristotle's solution to the arrow paradox in Pemberton 2022.
[64] For background to, and discussion of, the at-at solution, see, for example, Dowden 2009, Huggett 2019, Salmon 1970.
[65] Russell 2010.
[66] Russell 2010, 480.

Russell makes explicit that this account requires *'[…] the rejection of velocity and acceleration as physical facts (i.e. as properties belonging at each instant to a moving point, and not merely real numbers expressing limits of certain ratios)'.* [67]

Recall the arrow paradox may be formulated by way of the following syllogism:

> A1: The flying arrow does not move in any instant.
> A2 (The *composition assumption*): The flight of the arrow is composed of instants.
>
> ---
>
> C: The flying arrow does not move.

Russell accepts the first assumption of the syllogism (A1) that there can be no motion in any instant: an instant is a shortest duration of time so that the arrow cannot be in two or more place in a single instant. He contends that all there is to motion is the arrow (in this example) being at one point at one time, and at another point at another time, and at appropriate points between those two points for intervening times. He therefore accepts the second assumption too – and simply rejects the conclusion.

Despite rejecting velocity as a physical fact, a number that we call 'velocity' may be associated with a persisting object such as the arrow, a common-sense thing on Russell's account. This number is calculated from consideration of the positions of this object at differing times. Let the position of the persisting object be described by a function of time, X(t) say[68], then Russell takes the velocity of the object at T to be:

$$\lim [\delta \rightarrow 0] \left((X(T) - X(T-\delta)) / \delta \right) \qquad \text{(AA)}$$

Here we see the velocity expressed as '*the limit of a certain set of quotients'* to which Russell refers in the quote above. This limit – the instantaneous velocity at T - is '*merely a real number*' it is not a part of the instantaneous state of that object at T, it is not for example an intrinsic property of the object at T. Velocity, on this account, is eliminated from the ontology – it remains as merely a numeric adornment to the ontology, a real number expressing a limit of certain ratios. The elimination of velocity, according to supporters of this approach, is an appropriate application of Ockham's razor, providing an elegantly parsimonious solution to the paradox. [69]

Although I cite Russell as the modern champion of the at-at account, the approach was also endorsed by earlier thinkers. It is perhaps no surprise that it was supported by William of Ockham, the champion of parsimony.[70] In contemporary philosophy

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[67] Russell 2010, 480.
[68] We may suppose position is either absolute or relative to some suitable frame of reference - relativistic considerations are not salient to the discussion here.
[69] For further discussion of the elimination of velocity on the at-at account (which we may also call the Ockhamist account) see, for example, Tooley 1998, 225-227, Arntzenius 2000, 189-90, Bigelow and Pargetter 1989, 289-295, Carroll 2002, 49-51, Lange 2005, 436-442.
[70] Ockham, 1944, page 46; Shapiro 1956.

the view point has become orthodoxy. This popularity stems in no small part from the fit between the at-at solution and mosaicism.

4.1.2 Mosaicism's fit with the at-at account of motion

Mosaicist accounts of ontology fit well with the at-at solution. Consider Bertrand Russell's ontology, for example. As we have noted[71], for Russell a (common-sense) thing is the obtaining of a dense infinity of neighbouring fundamental tiles – these tiles comply with the Humean proscription against necessary connections between them.[72] On this account, to consider the arrow at time T, is to consider the fundamental tile (i.e. the 'event') which exists at T, which is a component of the (common-sense) arrow. The quotient in limit equation (AA) references the position of the component of the arrow at T (i.e. X(T)), and the position of a nearby component, that at T-δ (i.e. X(T-δ)). These are distinct fundamental entities. At the fundamental level, nothing moves from X(T-δ) to X(T) – these are simply the positions of neighbouring events. The limit of quotients is derived from the pattern of positions of other instantaneous events (i.e. other components of the arrow, a common-sense thing) around T.

The adoption of a mosaic ontology would seem to preclude changing from the very base of ontology. As we have noted, instantaneous entities obtain for only the shortest duration of time so that they cannot exhibit change – the term 'changing' would seem to have no useful meaning in relation to such entities. As Russell notes, a surrogate for changing, e.g. changing of position (instantaneous velocity), may be fabricated at the derivative level of what Russell calls *common-sense things.* But this does not succeed in establishing any 'physical fact' – it is simply the calculation of what is '*merely a real number*'.

4.1.3 Conclusion: mosaicists reject changing

Contemporary philosophers widely adopt the at-at account of motion and hence reject changing. Contemporary philosophers also commonly adopt a mosaicist account of ontology. It seems that the mosaicist has no alternative but to eliminate changing from their fundamental ontology, i.e. to reject changing at the fundamental level.

4.2 Lasting licenses changing

In adopting changing as a characteristic of AAO, I again follow a different path from the mosaicist and the at-at position of Russell et al. As opposed to Russell's elimination from ontology of velocity, I shall argue that physical objects have

[71] Section 3.2.1.
[72] Russell 1948, VI.5.

velocities that are genuine features of the ontology of the world. We have seen in his solution to Zeno's arrow paradox how Aristotle secured changing based on lasting. Might we replicate this achievement within contemporary ontology? I will argue in section 4.3 that indeed we can.

I shall continue here to focus primarily on changing of position, i.e. instantaneous velocity, and hence on Zeno's arrow paradox. I make remarks on changing more generally in section 4.3.

I shall construct a contemporary solution to Zeno's arrow paradox which parallels (but does not replicate) Aristotle's solution. The solution parallels Aristotle's in that it solves the paradox by showing that changing of position is licensed by lasting (so that given a lasting ontology we may take the arrow to be (really) moving-through-time).

The solution is contemporary in that it is based on some simple ontological assumptions drawn from contemporary mathematics and physics that have very wide contemporary support. In physics I suppose that persisting objects, such as the arrow, have a determinate position at each time.[73] I also suppose a consensus contemporary account of time and space – in particular I suppose that both time and space can be represented by the Real numbers.[74] Complementing this assumption, in mathematics I embrace actual infinities[75] and the orthodox treatment of the Real numbers[76]. I use, too, the orthodox contemporary approach to continuity, and hence

[73] As I have noted, I focus in this thesis upon the classical (as opposed to a quantum) domain.
[74] As Barbara Sattler (Sattler 2020) makes clear, this contemporary approach to representing space and time is very far from a given. For a discussion of many issues involved see Koons and Pickavance 2017, chapter 18. Although I shall use substantivalist terminology and imagery in discussing spatial locations, I suppose that a relationalist could render my account in relationalist terms.
[75] In contemporary analysis, the rejection of actual infinities (and hence actual points, the result of infinite division) is sometimes framed as the adoption of a point-free geometry – the approach may be traced to Whitehead (see Whitehead 1919, Simons 1987, pages 81-86). As Lowe rightly argues (Lowe 2006a, page 725), the choice of standard vs. point-free geometries concerns mathematical construction – it does not change the nature of the continuum (and hence the nature of space and time) that is posited: points are still posited in point-free geometries as limits of nested intervals. See also Barrett and Halvorson 2017.
[76] I take this to include the use of Lebesgue measures - these play a key role in practical application of the integral calculus. Importantly for our purposes, they underwrite robust methods for ascribing future positions to objects based on their initial velocity and their accelerations (as a function of time). These methods are robust in the face of a discrete set of points at which velocity differs from that expected (given the initial velocity and acceleration) – we suppose such sets have zero measure. (Allowance for such aberrant points is not an issue for standard classical physics, but may be an issue within metaphysical consideration of other (putatively) possible systems.) The robustness of these methods, and hence the adequacy of appealing to the standard use of Real numbers, has arguably been challenged by those who claim that certain sets are not Lebesgue measurable – most notably by Vitali (1905). Vitali's argument rests on a construction which requires the use of the choice operator on an uncountably infinite set. Given that adoption of Lebesgue measurability rests on the rejection of the application of an addition operator to uncountable sets, the case for accepting Vitali's construction is not clear, at least for any metaphysical purposes. In brief, adoption of orthodox treatments of the Real numbers remains, I argue, adequate for our purposes.

to the differential calculus, that makes use of developments over the past two centuries by, inter alia, Cauchy and Weierstrass.[77]

These ontological assumptions differ from those of Aristotle, so that the solution I set out (being based on these assumptions) does not replicate exactly that of Aristotle.[78] For one thing, from our post-Newtonian perspective we must draw a more precise distinction than does Aristotle on this point: The changing which arises from the acting together of agent and patient (e.g. the archer, with his bow, and the arrow[79]) is the accelerating, not the moving (i.e. velocity), of the arrow. (The arrow, as other masses, continues to move at constant velocity in the absence of net forces under Newton's laws). Our solution must have regard to this difference.

Alongside these basic ontological assumptions, I also (like Aristotle) suppose that concrete things are lasting.

4.3 Proposed solution

This solution makes use of contemporary mathematical methods and notations (including ones related to open / closed sets, functions, and limits).

Let's suppose, without loss of generality[80] , that the arrow exists for some period of time $[T_0, T_1]$. Let's choose some point on the arrow, perhaps its tip or its centre of gravity. Given our ontological assumptions (as above), this point on the arrow has a well-defined position at each time, X(t) say. Let's suppose that:

1. X(t) is continuous and differentiable over $[T_0, T_1]$, that is to say that both left-hand and right-hand limits:

   $$\lim [\delta \rightarrow 0] ((X(t) - X(t-\delta)) / \delta) \qquad \text{(AA)}$$

   exist and are the same at each $t \in (T_0, T_1)$.[81]

2. X'(t), i.e. the function from time to these limits, is continuous.

I take the senses in which these limits exist and that the function is continuous to be those established in orthodox contemporary mathematics. The differentiability of X(t) may be ensured by (inter alia) orthodox assumptions for an object in classical

[77] See for example *The calculus according to Cauchy, Riemann, and Weierstrass* in Edwards 1979, 301-334.

[78] For a careful consideration of Aristotle's assumptions concerning the continuum and in relation to velocity, see Sattler 2020, especially chapters 7 and 8.

[79] As noted above, on Aristotle's account, once the arrow has left the bow the air takes over pushing the arrow forward.

[80] The existence of the arrow over some such period is guaranteed by its being lasting.

[81] Where the right-hand [left-hand] limit exists at T_0 [T_1] and is continuous with X'(t) in the interval, we may take this limit to be the velocity at this point, so that velocities are taken to exist in $[T_0, T_1]$.

mechanics (e.g. that the arrow has non-zero mass and that any relevant forces upon the arrow are finite).[82]

Consider the arrow at some time $T \in (T_0, T_1)$[83]. We may choose an ε such that $(T-\varepsilon, T+\varepsilon) \subset (T_0, T_1)$.

Now, in taking our limit to derive the instantaneous velocity, as in (AA), we may without loss of generality choose $\delta < \varepsilon$. This ensures that the position $X(t-\delta)$ is the position of the (lasting) arrow at that time – i.e. that all the positions referenced in taking the limit are positions of the (lasting) arrow. The average velocity calculated in each step of our limit calculation (viz. $(X(t) - X(t-\delta))/ \delta$) may (perhaps must) then be interpreted realistically as the average velocity of the arrow over that period. This realistic interpretation as an average velocity is appropriate because the (lasting) arrow moves through the calculated distance $(X(t) - X(t-\delta))$ over time δ. Hence, it is appropriate to interpret the limit (derived in (AA)) realistically as the instantaneous velocity of the arrow at T.

The account of the arrow afforded by our contemporary mathematical treatment accepts assumption A1 – the arrow does not move in any instant: it has a single position at any time t, viz. $X(t)$. We may, though, follow Aristotle in rejecting A2, and do so on similar grounds: the arrow is not composed of instantaneous parts as it is lasting, is it ontologically prior to any such parts.[84] This resolves the syllogistic expression of the paradox.

But intuitively why does this mathematical treatment represent a solution to the paradox? This treatment allows the conclusion (C) to be rejected. The arrow is moving at every instant (although it does not move in any instant).[85] We may take it to be moving as it has a derivative of position that we may interpret realistically. We thus have a precise moving-through-time account of the arrow: the arrow moves over any interval of time as it is moving at every instant of time. The movement of the arrow over some interval of time does not require that it moves in any instant. This is the solution to the paradox.

[82] How about cases in which the position function is not continuously differentiable? These may be entertained to allow for consideration of non-standard mechanics, or (perhaps more often) other possible worlds (see e.g. Tooley 1988, Carroll 2002, Meyer 2003). Here too we may show that where the derivative of the position function exists and is continuous it may be interpreted realistically. But now we may have jumps in velocity and/or jumps in position. In order to provide an analysis of motion in each case we require an account of what motion, including jumps, is allowed, and perhaps how it may come about – i.e. the salient local laws. The appropriate analysis will be specific to each case – I do not pursue such analyses here.

[83] Where the end points have suitable one-sided limits, we may apply this lasting solution analogously at these end-points too on a one-sided basis.

[84] Note though that Aristotle obtains his solution via consideration of the lasting of the motion, the flight of the arrow, not the arrow itself.

[85] It is moving as it has a velocity (the derivative of position which we may interpret realistically). It does not move in any instant as it does not have more than one position in any one instant.

4.3.1 This solution is predicated upon lasting

Note that where the arrow is not lasting, but is built from ontologically prior instantaneous states (as in Russell's ontology) the position X(t-δ) is the position of a neighbouring state (which is ontologically prior to the 'common-sense' arrow), so that the calculation at each stage in our limit derivation (AA) concerns a relation of the state at T to a neighbouring state at T- δ.[86] In such an ontology, the arrow posited at T- δ may typically be taken to have an identity that is independent of the arrow at T. Now the calculation, being based on a relation, does not correspond to any average velocity – and hence the limit (AA) does not correspond to an instantaneous velocity. This is consistent, of course, with the at-at solution's success in eliminating instantaneous velocity from the ontology (and relegating it to the status of a numeric adornment) in order to achieve parsimony in keeping with Ockham's Razor.

Note, too, that the approach adopted in the solution above cannot ascribe an instantaneous velocity to any putative entity that exists at just a single point in time. Rather, it only licenses the ascription of an instantaneous velocity to each point in time during a period of time in which the arrow exists. It is crucial to the derivation of the instantaneous velocity at each point in time, T, that $T \in (T_0, T_1)$ for some T_0, T_1, where the arrow exists over (T_0, T_1). The lasting of the arrow ensures that it does exist over some period of time (which I take to be (T_0, T_1) without loss of generality) and not just for a single point in time.

In order to be able to ascribe a velocity to an object at some time, and to treat this realistically as the moving of the given object at that time, the object must be lasting.

4.3.2 Proposed solution conclusion

The solution shows that the lasting of the arrow ensures that the derivative of the position function, where (as in standard cases in classical mechanics) it exists and is continuous, can (perhaps must) be interpreted realistically as the moving of the arrow at that time – so that we may take the arrow to be (really) moving over time, and hence move over any interval of time.

4.4 Possible objection: a free lunch?

In order to stress the parsimony of the at-at account we may render it thus: when one has given the position of an object at all times, one has said all there is to say. The contemporary solution to the paradox I have outlined above licenses agreement with this at-at claim – and in this sense matches the parsimony of the at-at solution.

[86] See discussion in chapter 3.

Nevertheless, as we have seen, whereas the at-at approach eliminates velocity from the ontology, in a lasting ontology the derivative of position may be interpreted realistically as the velocity of the given object.

This might seem to suggest that the lasting ontology solution offers a free lunch: we seem to get instantaneous velocities for free. How can this be?

From a lasting ontology perspective there is no unwarranted free lunch: velocities do come for free with the pattern of positions, but that is in the nature of a world of lasting objects. Instantaneous velocities become problematic when we suppose persisting entities are built from component entities which exist at a single point in time, as in mosaic ontologies. If a base ontology is taken to comprise a mosaic of instantaneous entities, then velocity is eliminated from the very base of ontology itself. Problems associated with the existence of instantaneous velocities are, I contend, an artefact of adopting such a mosaic account.

4.5 Lasting licenses changing more generally

We have focused so far on changing of position. How about changing of a concrete thing more generally, for example, in respects that may generally be called qualities?

Suppose that in the ontology in focus, a thing is taken to have a quality, Q say, that takes values within some continuous Real number interval. For example, Q might be temperature, concentration (of a solution, e.g. of salt in water), hardness, etc.[87] In such cases, we might employ the method of solution in section 4.3, mutatis mutandis, to show that lasting licenses changing in respect of Q, i.e. dQ/dt may be interpreted realistically as changing in respect of that quality.

How about cases where the change appears as discrete, e.g. from being not-pregnant to pregnant, or from not-being-a-house to being-a-house? To answer this question we must look separately at the lasting ontology in question, as the answers are different. I shall consider first Aristotle's ontology and then (in a provisional manner) AAO – these are the two specific lasting ontologies we shall identify in this thesis. Then I shall consider lasting ontologies yet to be specified.

4.5.1 Aristotle's ontology

Aristotle makes explicit that two determinate states cannot be adjacent – he says: '*Nows are not consecutive*'.[88] Change from one determinate state to another (e.g.

[87] Many contemporary philosophers might suppose that such a Q is, or is associated with, a 'determinable property' of the persisting thing – where the meaning of 'determinable property' is set out in their account of ontology.

[88] Aristotle, Physics, VI.6, 237a25. Note that this is Aristotle's explicit recognition of no successors within the continuum appropriate for time.

the change of a thing from being black to being white) must therefore take time – it cannot occur as a step change: '*Everything that has changed from a starting-point to an end-point has taken time to complete the change.'*[89] And this change through time is continuous: '*every change is continuous, since every change is divisible'*[90]. The continuity of this process of change over time means that, on my reading, we may understand this as being a process of changing-through-time. For example, in the case of the building of the house, there is first a pile of building materials and later a house – but there is not a step change from one to the other, rather there is in between a process (kinesis) of building. On Aristotle's account, the house is the terminus of this process of change – the house comes into being all-at-once at the end of the process of building (changing) by way of a transition (not a change) to this new status.

We have noted that the contemporary solution makes explicit that we may generally ascribe a velocity to a (lasting) object at each point in time during an interval in which that object exists – but not to a putative entity that exist for just a single point in time. On my reading, this is exactly Aristotle's view too – where Aristotle holds this view of changing (motion) more generally. Aristotle rejects the ascription of changing to instantaneous objects when he says, 't*here is no such thing as being in motion or at rest in the now*'[91] and '*for a thing to be at rest it has to be in the same state for a period of time.'*[92] Nevertheless, as Ben Morison notes, Aristotle does make extensive use of motion at an instant in his analysis of motions in Physics VI ([93]). Morison argues carefully that this is consistent - Aristotle's position is: '*Being in motion or at rest at an instant is derivative from being in motion or rest over a period which includes that instant*.'[94] Caleb Cohoe summarises Aristotle similarly: '*strictly speaking, the mobile neither moves nor rests over any instant, since motion or rest require an extended (hence divisible) time. However, the mobile will either be moving or resting over the temporal interval in which an instant is included. This allow for a derivative sense in which the mobile can be said to be in motion or at rest in the instant.'* [95]

In making these points concerning Aristotle's position, we must, of course, be careful not to ascribe to Aristotle a position which outreaches the limits of the account of motion that was available to him at the time – changing in regards to position, in particular, cannot be parsed more precisely using contemporary notions which distinguish velocity and acceleration.[96]

[89] Aristotle, Physics, VI.6, 237a19-2.
[90] Aristotle, Physics, V.4, 228a20-21.
[91] Physics, VI.8, a36.
[92] Physics, VI.8, a26-27.
[93] Morison 2013.
[94] Morison 2013, page 180.
[95] Cohoe 2018, pages 54-55.
[96] For an excellent discussion of these limits, see Sattler 2020, chapters 8 and 9.

4.5.2 AAO

As I stated in the introduction, AAO, the ontology I shall set out in this thesis, supposes that at the base of ontology we find acting and trajectories – we do not find properties. Trajectories are spatial locations over time, so that, I shall argue, all change bottoms out in change of location. Hence, we may infer that in AAO lasting licenses changing in general from its licensing of changing of positions in particular.

4.5.3 Lasting ontologies yet to be articulated

In the case of the lasting ontologies that we have to hand, then, lasting does license changing more generally. The question of whether and how qualitative changing is licensed by lasting within other lasting ontologies will need to involve careful case-by-case consideration of those lasting ontologies as and when they are articulated. Given the nature of lasting, intuition suggests (to me, at least) that lasting will underwrite changing generally in other lasting ontologies too. If we discover counterexamples, this would require careful consideration and perhaps differentiating more sharply between types of lasting ontology.

4.6 Conclusion

Entities that exist at a single point in time cannot feature change – they cannot be in more than one state – and for such entities changing has no apparent meaning. Hence mosaic ontology, as we saw in chapter 3, eliminates changing (instantaneous velocity in particular) at the fundamental level.

Lasting entities exist over some period of time. I have shown how lasting licenses instantaneous velocity, and indeed changing more generally.

5 Arguments in favour of lasting / changing

5.1 Plan of campaign in this thesis

It will be helpful at this point to sketch out the overall plan of campaign in this thesis. In setting out my argument in favour of AAO, I shall not seek to establish a logical proof that AAO is correct, nor a proof that competitor ontologies (such as mosaicism) are wrong.[97] Rather I shall seek to show that AAO is superior to mosaicism (our chosen comparator in this thesis) on many specific points that I shall identify. These points concern areas such as goodness of fit with the empirical world, coherence (I take ontologies that are challenged by unresolved aporia to have lower coherence) and parsimony – as well as many others. I shall then present a summary of these amassed points of superiority in the assessment at the end of the thesis, seeking to show that AAO is a plausible ontology that is stronger on many salient points than mosaicism. I shall settle in this work for the claim that this thesis secures the case for further investigation of AAO. I shall make the stronger claim that AAO is the ontology of the world (on a balance of points in favour basis) in future work, after undertaking some of the tasks identified in the concluding chapter. Nevertheless, in my own opinion, the assessment here is sufficient to secure the superiority of AAO over mosaicism – and I hope at least some readers will agree.

I shall present arguments in favour of AAO as they become available on the basis of the characteristics of the ontology adopted at each stage. I have adopted lasting and changing as characteristics of my preferred ontology, so I shall present here some arguments in favour of an ontology which appeal to only these characteristics.

5.2 Lasting solves the problem of temporary intrinsics

Sally Haslanger states it thus: '*The problem of temporary intrinsics is this: ordinary objects persist through changes in their intrinsic properties, i.e. those properties which an object has in virtue of the way it is, independently of anything else. To use Lewis's example, "when I sit I'm bent, when I stand, I'm straight". But an object cannot have incompatible properties. So how is intrinsic change possible?*'[98]

Although many philosophers advance their own preferred solution, none is generally accepted[99] – that is why this is labelled as a problem. Here I note the simple solution to the problem that is afforded by lasting.

[97] In this, as on many other points, I follow David Lewis: '*Nowhere in this book will you find an argument that you must accept the position I favour because there is no alternative.*' (Lewis, 1986a, viii).
[98] Haslanger 1989, 119.
[99] See, for example, Gallois 2016, Wasserman 2003.

Aristotle's formulation of the problem, which of course predates the temporary intrinsics formulation, is just the problem of how P can come from ¬P that I discussed in section 2.4.1. I showed how Aristotle solves the problem by his assumption of lasting.

A similar result holds more generally for lasting ontologies. However the problem of temporary intrinsics is expressed or understood[100], the underlying problem is of a concrete thing, such as a substance, changing and remaining numerically the same. Lasting solves this problem, regardless of the details of the specific lasting ontology in play. As for Aristotle, the (potential) temporal parts of a lasting concrete thing are each a part of the same thing, whilst each such part may have differing properties (this is no threat to its being a potential part of the lasting whole) – so that the lasting whole may change over time.

5.3 Changing is supported by folk intuitions

Folk intuition, I suggest, strongly supports the view that when you are cycling along on your bicycle you are moving forward. An ontology which licenses changing, e.g. moving, is then in accord with folk intuition, whereas one which rejects moving is not.

Whether, and to what extent, being in accord with folk intuitions counts as support for a metaphysical view is, of course, a matter of considerable debate.[101] If you think folk intuitions do count as support, then this is a mark in favour of an ontology which underwrites changing (as compared to mosaicism which does not).

5.4 Lasting / changing solves the problem for those who believe physics requires instantaneous velocity to underwrite causal roles

Many philosophers hold that science, notably physics, requires instantaneous velocity to be a part of the state of an object at each instant in order for objects to fulfil their causal roles. This view was widely held in the Middle Ages, where it was dubbed 'impetus' theory, as it sought to provide an account of why projectiles continued on their trajectories rather than falling straight down.[102] Newton's adoption of the view brought it in to more recent developments of mechanics. More recently, a significant body of philosophers have argued that contemporary physics requires instantaneous velocity within the ontology to fulfil causal roles which include underwriting instantaneous momentum and licensing the possibility of determinism[103].

[100] See, for example, Lewis 1986, 203-205.
[101] For a defense of intuitions see Chalmers 2014.
[102] See e.g. Dijksterhuis 1986, especially 179-185.
[103] See *e.g.* Arntzenius 2000, Bigelow and Pargetter 1989, Carroll 2002, Lange 2005, Meyer 2003, Tooley 1988.

However, introducing instantaneous velocity as a part of the ontology (e.g. an intrinsic property) of an object threatens to give rise to a difficulty: we now have two 'velocities' – that which is derived from the pattern of positions via the standard limit, and that which is a part of the ontology. There is no immediate justification for assuming that these two 'velocities' are the same. Perhaps the most popular solution proposed for this difficulty is to suppose that, '*it is a law of nature that "intrinsic velocities" always equal the temporal derivative of position developments'*[104]*,* i.e. that the two 'velocities' are constrained to be the same by some law. But this raises further concerns: compared to the at-at account, '*one has additional ontology (one has a larger-state space) and one needs an additional law to forbid developments in this state-space in which position developments of objects in a neighbourhood of time t do not correspond to their "intrinsic velocities at t."'* [105] Some find the obtaining of such a law ad hoc and implausible, whilst generally such additional ontology is deemed unattractive on parsimony grounds.

As we have seen, followers of Russell insist that the temporal derivative of position developments is not a part of the ontology. Hence it is not available to perform causal roles. However, I have argued in the last chapter that in a lasting ontology this derivative can be interpreted realistically as the velocity of the object – this velocity is then real within lasting ontologies and hence available to fulfil causal roles. This interpretation of the derivative as a real velocity does not entail the introduction of any additional entities into the ontology so that, on this argument, lasting, in underwriting changing of position, provides an elegant and parsimonious solution to this problem.

5.5 Lasting / changing provides solution to the homogeneous rotating disc challenge

According to the Humean Supervenience thesis, all there is to the world is a mosaic of local matters of particular fact. On this view, if one world differs from another, then there must be some difference in this underlying mosaic. Kripke, amongst others, has suggested that a homogeneous rotating disc provides a counter-example to the HS thesis. [106] Consider two worlds that are identical save that in one a totally homogeneous disc is rotating within some stationary location, but in the other the disc is not rotating. As the disc is homogeneous, it seems that the HS basis for both worlds is identical – but that common opinion would hold that these worlds do differ. The various arguments by supporters of the HS thesis that this is not a refutation of their position remain controversial.[107]

In a lasting/changing ontology the velocity of each portion of the homogeneous disc is ontological, so the challenge is met in a straightforward and principled way.

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[104] Arntzenius 2000, page 196.
[105] Arntzenius 2000, page 196.
[106] For references to unpublished discussions by Kripke and others see Robinson 1989, 394, footnote 3.
[107] See e.g. Robinson 1989.

5.6 Conclusion

I have set out some preliminary reasons for favouring lasting and changing within our ontology. I now turn to the main reason for including these features (i.e. lasting and changing): they are required to license acting – and acting is a keystone of the ontology of the world on the account I offer.

Section II: Acting

6 Acting

I now add acting to lasting and changing as a characteristic feature I adopt for AAO.

6.1 Acting introduced in brief

First let me outline *acting* briefly and roughly, before setting out a more precise account within this and subsequent chapters.

Acting (as I use the term) is the bringing about of changing, e.g. attracting, repelling, pushing, cutting, heating, dissolving, building (and the correlates being-attracted, being-pushed, etc.). Acting occurs through time, never at just a single point in time. Acting is the only type of principle of change, and indeed the only type of modal principle, within the base ontology of the world.

Acting is one of the twin keystones (along with arrangement) of the ontology of the world:

1. Acting is the principle of composition of physical beings (the beings widely taken to be common-sense things and processes) - and hence the principle of all composite existence. It is the glue of the world.

2. Acting is the ontological principle that underlies all other modal principles and features, including possibility, necessity, powers, causation, laws and natural kinds. By showing how these modal principles and features derive from acting, I shall make sense of them and their roles in the world as we find it.

Acting brings about changing – and therefore only fits with a world in which there is changing. Moreover, acting must occur over a period of time, it cannot occur at just a single point in time, so that it fits with the lasting of that which is acting (e.g. a mass, charge, heater, knife, builder, teacher). Acting therefore fits with changing / lasting ontologies.

Acting, note, is not consistent with mosaic ontologies in which there is neither changing nor lasting. Mosaic ontologies are, then, incompatible with acting, and hence are unable to capture this basis of either modality or composition.

Acting is not, of course, a new idea - it is central to Aristotle's account of change. As we have seen (section 2.2), on Aristotle's account, when correlate agent / patient powers are in suitable contact and nothing prevents it, then they must act. Acting we may understand, then (in Aristotle's account), as the manifesting of these agent and patient powers (e.g. the power to heat or to build, or to be heated or be built). The outcome of this acting is changing – where the salient changing is in the patient. (The agent generally suffers reciprocal changing in acting on the patient).

However, I do not wish to rely on Aristotle's account, which may be unfamiliar to many contemporary philosophers and subject to exegetic complexity. I therefore explicate an account of acting directly as follows.

6.2 Acting – an ontological principle

6.2.1 Preamble

It will be helpful to say a few words about what I am about to do.

Acting and *actors*, the lasting entities that act, are intimately interrelated. (Actors are entities generally taken to be concrete things or processes, in a sense I shall make clear.) I have a chicken and egg problem about which to introduce first - I have chosen to go with acting. It will be helpful, though, to make some preliminary comments here about actors to help the reader through. This will be said much more carefully and precisely in section III.

Actors are lasting and can act. I am effectively going to assume that actors (at least sometimes) act consistently – they do the same things in the same types of situations – at least in respect of some of their acting. I suppose such characteristic acting of actors may sometimes be identified – and the actor then characterised as acting in this characteristic way in such situations. For example, mass characterises an actor as one that attracts other actors with mass with strength GMm/r^2 (usual notation) when in the vicinity of other masses. Hence, we may characterise actors as acting in characteristic ways in certain types of situations. It is such consistent acting by actors that renders acting a plausible and useful ontological principle.

In order to establish acting as a principle, I shall explicitly ascribe responsibility for changing to the ontology (the salient configuration of actors), as described below.

6.2.2 The world features stable correlations between certain types of configurations and the changing which occurs in those configurations

Physicists and metaphysicians of physics are often explicit in positing stable synchronic correlations between (1) the configuration of features which obtain within the local ontology and (2) the changing which occurs amongst those features. Bertrand Russell, for example, supposes that basic ontological laws can be expressed by way of differential equations where the independent variable is time.[108] Tim Maudlin posits, and stresses the central role of, laws of temporal evolution which give rise to just such stable correlations (i.e. between (1) and (2)).[109] And Michael

[108] So that for some feature (e.g. quality or position) Q, say, dQ/dt is functionally related to some aspects of the local configuration. See for example Russell 2009, pp287-9; Russell 1913 (especially p208).
[109] Maudlin 2007, especially 12-14.

Esfeld and Dirk-André Deckert are explicit in supposing just such stable correlations when they derive mass and charge, for example, associated with *permanent matter points*.[110]

It is widely agreed amongst metaphysicians that the world features regularities – where many such regularities may be understood as associated with regular change. If change comes about via changing-through-time, as I have suggested, then just such stable associations between (1) configurations and (2) changing might be expected. Such stabilities might reasonably account for regular change– and it is not clear how we would account for regular change otherwise.

I shall therefore follow this lead of physicists and metaphysicians in supposing that the world does feature some stable correlations between configurations and changing. (I present various examples of such stable correlations in what follows.)

6.2.3 Supposition: the configuration *brings about* its own changing

I suppose that the ontology of the configuration *brings about* the changing which occurs.[111] This is a major move which serves to establish acting as an ontological principle. I do not suppose that such *'bringing about'* may be analysed in terms of any other (perhaps putatively more simple or basic) principles or features of the ontology - rather I take such 'bringing about' to be basic. This supposition that the ontology brings about changing is central to the account of acting proposed here – it renders acting an ontological principle of changing. The justification for this supposition (that acting brings about changing) is the attractiveness (perhaps superiority) of AAO, which is the argument of this thesis as a whole.

Metaphysicians often eschew ascribing responsibility to the ontology for changing (or change), often preferring instead to posit laws. This preference for laws over ontological responsibility may often be motivated, in part at least, by a desire for parsimony. Whilst it may perhaps be the case that positing 'bringing about' (and hence acting) entails an additional ontological commitment to law-based ontologies (although no additional entities), this additional commitment (if such it be) avoids the need for other modally-related commitments, as I argue, and thus underwrites great parsimony.[112] I return to this point in chapter 19.

[110] Esfeld & Deckert 2018, especially 41-43.

[111] Where the change in focus is change of position, the changing that is brought about by acting is acceleration, not velocity. As I have argued, in adopting lasting we underwrite velocity as a real feature of the world – it needs no contemporaneous bringing about (as Newton teaches in his first law of motion).

[112] Laws are then derivative: they describe regularities that arise from consistent acting (bringing about of changing) - see chapter 17 on regularities and laws.

6.2.4 Acting - described

The *acting* of a part within a configuration is the bringing about of changing[113] of the configuration by that part, where the acting of each of the parts of the configuration (which are acting) occurs together and through time within the configuration (and hence brings about changing through time of the configuration).

Acting may be associated with both micro configurations (including ones in which change is taken to arise from basic forces of physics) and macro configurations (e.g. configurations which involve a hot object heating, a knife cutting, or a heart pumping).

6.2.5 Identifying acting

The starting point for identifying how parts are acting in some configuration is an analysis of the stable correlation between the configuration and its changing. It may be possible to identify stable[114] correlations between (aspects of) each part of the configuration and the changing of the configuration. We may use these stable correlations to posit actings of the parts by supposing that the part brings about the changing to which it has a stable correlation. For such posited actings to be plausible:

- the posited actings of the parts within the configuration must be mutually cooperative in bringing about that changing of the configuration;
- the posited actings of each of the parts together in the configuration should account for the salient changing of the configuration as a whole.

6.2.6 Example – deriving mass from changing which occurs

Consider configurations in which the changing in focus is the accelerating of the parts of the configuration. This example is key, of course, as much physics is focused on just such cases. To fix ideas, let's focus first on a simple case: a configuration of free masses which is sufficiently isolated (such as a solar system) in which gravitational attraction dominates what happens. The positions of the masses over time (at least once we set aside interference) may be calculated as follows: For each mass, add together vectors in the direction towards each other mass with GMm/r^2 magnitudes, and use this vector sum to calculate the acceleration of that mass (by dividing by M) – and then trace forward the position and velocity of each mass through time allowing for its initial position and velocity, and this acceleration. This type of configuration (a sufficiently isolated configuration of free masses) therefore does exhibit a stable correlation between (1) the configuration that obtains and (2)

[113] On some occasions, the acting may result in null changing of the configuration in certain respects, i.e. stasis in those respects.

[114] I.e. relations which are stable across configurations of the type which is in focus.

the changing which occurs: each of the masses is accelerating according to the $\Sigma GMm/r^2$ vector at every time.

Analysing this stable correlation from the perspective of each of the parts, we may note that the stable correlation which obtains for the configuration as a whole is consistent with a stable correlation between each mass, μ say, and an incremental acceleration (using vector addition) of $G\mu m/r^2$ of each other mass. If mass μ is ascribed responsibility for this incremental acceleration (i.e. it is taken to bring about this incremental acceleration), then we may describe it as pulling or attracting the other masses (towards μ). We may then posit this attracting to be the acting of μ in this context. Such attracting might also be talked of as the exerting of a force, in line with common parlance, but it is important to be clear that talking of forces does not imply that they are reified entities: it is not supposed that an *acting* is an entity.[115]

In addition to the acting of each of the parts in attracting each of the other masses, each of the masses is also acting in another way: being attracted (by other masses). The attracting and being attracted are cooperative actings of the parts of the configuration. And the changing of the configuration as a whole, i.e. the accelerating of each of the masses, is accounted for by all of these actings together within the configuration: the magnitudes associated with the individual actings add vectorially to the overall accelerating of each mass (when divided by M).

The trajectories fix the values of mass with which we may characterise each part so as to yield the pattern of accelerating that we find in these trajectories.

This example illustrates the way in which we may provisionally identify actings of the parts which bring about the changing of the configuration as a whole. Such a provisional account of acting may be investigated in other related types of configurations to test and strengthen the empirical evidence in its favour.[116]

6.2.7 Example – a knife cutting

As another example, consider the changing that occurs in a configuration where the sharp edge of a knife is moving into some cut-able material, a lump of ham, say: the ham is becoming divided along a line roughly coincident with the leading sharp edge of the knife. We may posit the acting of the knife to be dividing the ham along this line, i.e. cutting the ham. The ham is also acting: the acting of the ham is becoming divided along the edge of the knife, i.e. being cut. The acting of the knife (i.e. cutting) and the acting of the ham (i.e. being cut) are co-operative. And, in a sense, these two actings are sufficient to account for the salient changing: the becoming divided of

[115] Note how this addresses the long-standing debate concerning whether we should take component or resultant forces to be real (see e.g. Oliver Massin 2017): forces are not reified and hence not candidates for being real (in the sense implied by this debate).

[116] For now I shall admit empirical methods without justification. In section 19.3 I show that empirical-bootstrapping is consistent with AAO – so that the empirical methods we have used in developing our account of ontology, AAO, are consistent with that ontology.

the ham along the sharp edge of the knife. In another sense, we may bring into focus a broader configuration of which the knife and ham are parts – perhaps this broader configuration may typically include another actor that is responsible for pushing the knife into the ham. As we shall see in the following chapters, configurations are typically interconnected.

The changing of many macroscopic configurations can be accounted for by reference to similar complementary actings (i.e. similar to cutting / being cut), e.g. pushing / being pushed, heating / being heated, dissolving / being dissolved, turning / being turned, pumping / being pumped.

Such acting (i.e. bringing about of changing) by a part accords with common intuitions: the idea that masses attract other masses, knives cut ham, pumps pump liquids, etc.

6.2.8 Acting-powers

Where a part consistently acts in some way in some type of configuration, this (acting in this way in this type of configuration) is characteristic of the part.[117] Such characteristics I call *acting-powers*. Powers (including acting-powers), like other properties, are not entities, but rather are characteristics of entities.[118] Acting (which may sometimes be described by acting-powers) is ontological. An account of an acting-power may typically reference the characteristics (properties) of the part which is acting, and the location of this part within the configuration. For example, the shape of the (leading edge of) the knife and its location, which fix the locus of cutting; or the magnitudes of the free masses and their locations within the configuration, which fixes their acceleration vectors.

In the examples above, we may suppose that the masses have the (acting-) power to attract, the knife to cut, the heater to heat, the solvent to dissolve, the turner to turn, and the pump to pump.

We may, in accord with common parlance, call the acting of a part, where it is accurately characterised by an acting-power, the 'manifesting' of that acting-power.

[117] I suppose there is at least some such consistent acting of some actors - this follows from the assumption of some stable relations between configuration types and the changing which then occurs (see section 6.2.1) and the assumption that the ontology is responsible for changing (see section 6.2.2). Following the views of Nancy Cartwright, I do not rule out the possibility that actors may sometimes act by hap (see e.g. Cartwright & Merlussi, 224), i.e. that some of the acting of actors may not be consistent with a regular pattern of acting by that actor.

[118] As I shall make clear in chapter 12 on properties and powers – powers are no addition to (what I call) the *base ontology*, rather they are features of the *super-ontology* which are derivative from the base ontology - see section IV.

6.2.9 Actings are tied to configurations

A posited acting of a part, i.e. the manifesting of an acting-power of that part, is tied to configurations of suitable type – so that such an acting always occurs in conjunction with other actings of other parts of the relevant configuration-type (e.g. the accelerating and being accelerated of other masses; the cutting of the knife and being cut of the ham). It is important to be clear that in talking of the acting of a part (i.e. the manifesting of an acting-power of a part) we are not supposing that there is something that the part does by itself in isolation. As Cartwright & Merlussi put it: '*We must not confuse the abstract description we give of the nature of a power, which allows us to figure out what will happen in various real situations, with a description of what it does in some strange situation-less Platonic heaven*.' [119] It is not just that an isolated acting of a part cannot be instantiated in practice, but rather that no meaning can usefully be ascribed to the notion of such an isolated acting, e.g. the cutting of an isolated knife.

The changing of a sufficiently isolated configuration of actors may often derive predominantly from the acting of that configuration as a whole – i.e. it may be the case that the acting of actors external to this configuration with this configuration can be set aside for practical purposes as being sufficiently insignificant. The acting of this isolated configuration as a whole then (roughly) gives rise to the changing of this configuration. The acting of each part of this configuration cannot be separated from the acting of the configuration as a whole, except by abstraction. (This resonates with Aristotle's account of a whole, wherein parts are potential rather than actual as they cannot be separated from the whole other than by abstraction.[120] This is not, though, to suggest that actings are reified entities.)[121]

6.3 Conclusion

Parts acting together through time within a configuration (that we may treat as sufficiently isolated) bring about changing through time of that configuration.

[119] Cartwright & Merlussi 2018, pages 240-241.
[120] As discussed in chapter 2 and Pemberton 2022.
[121] Nancy Cartwright developed an account of powers (capacities) according to which their manifesting was a *contribution* – the contributions of the powers manifesting in the arrangement together then yielded the (occurrent) changing. (See Cartwright 1983, essay 3, Cartwright 1989, chapter 4; Cartwright 1999, chapter 4, Cartwright & Merlussi 2018). Molnar (Molnar 2003, page 194-198) and Mumford (Mumford 2009, section 5), amongst others, also adopted accounts of manifestation as contributions. Working with Cartwright on powers (see e.g. Cartwright & Pemberton 2013), I too adopted this contribution view. But more recently Cartwright and I have recognised challenges to this view. What exactly is a contribution ontologically? (See e.g. McKitrick 2010.) How do manifestations combine? As a result, Cartwright and I have both dropped the contributions account – see *Cartwright and Pemberton on capacities and arrangements* (Cartwright & Merlussi, 2018, section 5). Actings, as set out above, may be understood as my replacement for contributions. Unlike contributions they cannot be separated in the ontology of the world from the manifesting of other powers (i.e. other actings) within the arrangement (the given actings must all occur together in the arrangement so that the individual actings can only be separated by abstraction), so that the question of how they combine does not arise. The question of the ontological status of actings is addressed by noting that they are not reified entities – rather they are ontological principles (of changing).

This account of acting fits with the widespread intuition that parts do act through time – e.g. attract, cut, heat, dissolve - to bring about changing through time. This widespread intuition provides some initial plausibility to this account of acting, and hence to the claim that the ontology of a configuration brings about the changing of that configuration: actings are ontological - and are provisionally a plausible alternative to laws of association.[122]

[122] Nancy Cartwright (recently with my support) makes a parallel claim: laws of association are not basic – rather, it takes nomological machines to account for the regularities that we find in the world (regularities that we may record as ceteris paribus laws). This is the central argument of Pemberton & Cartwright 2014. Nomological machines are configuration of features with powers, *acting-powers* we may suppose. I shall not rehearse, nor appeal to, these arguments in this thesis, but rather develop alternative complementary arguments. Nevertheless, those arguments complement the arguments advanced here.

7 Acting solves the problem of the bringing about of change

In this chapter I advance an important argument for acting: acting solves the difficult problem of providing a coherent account of the bringing about of change. (Change as distinct from changing.) I first set out briefly what I take change to be. I suggest that identifying change (and in particular, demarcating it from mere difference) is itself a challenging task – and that lasting and acting can help here. I then explain how acting solves the difficult problem of the bringing about of change.

7.1 Change

Change is a pre-philosophical notion familiar to both folk and science. A pot is first on the shelf and then on the stove – it has changed position. It is first cold and then hot – it has changed in respect of temperature.

Change, I take it, involves a difference between an earlier and later circumstance. To be change, rather than merely difference, some connection must be supposed between these two circumstances. For example, the circumstances may be how some persisting concrete thing is at an earlier and then a later stage. How change is demarcated from mere difference (e.g. coldness here, hotness there), and hence what is to count as change, is a complex and controversial matter.

In ontologies that do not embrace changing, such as mosaic ontologies, it is typically supposed that at the fundamental level we simply have just one little thing and then another[123]. Now we need some account of how we may pick out the mosaic tiles which are suitably connected so as to exhibit change, rather than simply difference. On Russell's account, for example, the tiles of a common-sense thing exhibit *quasi-permanence* – they are spatio-temporally juxtaposed and are suitably and sufficiently similar.[124] It seems, then, that here we are to pick out the tiles that we take to be the components of the common-sense thing in focus by reference to quasi-permanence, i.e. by reference to similarity and position relations. Once we have picked out these tiles, then we may suppose that one stage of the resulting common-sense thing may exhibit change with respect to another. The details of each such account of change depend on the details of the ontology that is in focus. And it might reasonably be suggested that these details are in many cases rather sketchy. As challenges such as the problem of temporary intrinsics[125] attest, ensuring that such an account is coherent is no easy matter, so that all such accounts are philosophically controversial.

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[123] As for example Lewis: '*[T]he world is a vast mosaic of local matters of particular fact, just one little thing and then another*.' Lewis 1986, volume II, ix.
[124] Russell 1948, VI.5.
[125] See discussion in section 5.2 and the references there to the relevant literature.

Embracing lasting and changing improves the position. A lasting object is ontologically prior to its temporal parts, so its temporal parts are ontologically connected (as potential parts of the same lasting object): differences between the temporal stages of a single lasting object are then one example of change – change in that lasting object. Furthermore, changing allows us to embrace a changing-through-time account of change – now we may pick out change (as opposed to simply difference) via the changing-through-time which goes on.

Still, the charge against mosaicists that their account suffers from a problem with providing an adequate account of change is disputed. I shall not pursue these unresolved debates here, but rather turn to yet more clearcut problems for mosaicism: problems associated with the bringing about of change.

7.2 Bringing about change – the problem

Like change, the bringing about of change is a pre-philosophical notion that is familiar to both folk and science. The cook might suppose, for example, that placing the pot on the stove brought about its change from being cold to being hot.

Such bringing about of change may often be expressed in terms of causation – most commonly in terms of a relation between a cause C and an effect E that occurs afterwards, typically shortly afterwards. C brings about E, or perhaps the change from C to E, we may say. Placing the pot on the stove (the cause) brought about the (change from cold to hot and hence) the hotness of the pot (the effect).

Despite Russell's famous attacks on causation[126], appeal to causation remains ubiquitous within both folk and scientific practice. Indeed, contemporary metaphysicians do not now typically seek to deny causation, but rather to render it in acceptable terms within their preferred ontology.[127]

7.2.1 Step-by-step change

Unfortunately as Russell notes[128], there is a serious problem with diachronic causal relations of the sort typically posited as underwriting the bringing about of change such as that from C to E[129]: If E occurs after C (which it must in cases of change), then

[126] See for example Russell 1913, especially his caustic, perhaps humorous, claim that '*The law of causality, I believe, like much that passes muster amongst philosophers, is a relic of a bygone age, surviving, like the monarchy, only because it is erroneously supposed to do no harm.'* (Page 1).
[127] Indeed Russell himself in his later work takes a more positive stance on causation, shifting from an attack on diachronic causal relations (1913) to an account of 'causal lines' (Russell 1948) – see below.
[128] Russell 1913.
[129] There are differing types of causal relation that are posited and these deserve careful analysis. Undertaking this task requires explicit consideration of the underlying ontology posited. I therefore defer this work until chapter 16 on causation. For now we may suppose (somewhat roughly) that we are dealing with diachronic relations of the sort that new mechanists may take to arise between (an aspect of) an earlier stage of a mechanism and (an aspect of) a later stage of that mechanism.

there must be a time gap between C and E[130]. This follows from the mathematical fact that there are no successors in the set of Real numbers, so that E cannot be next to C (i.e. E cannot in any sense occur at the next instant to C).

This time gap is problematic as it implies that the causal influence involved in the bringing about of E by C must jump forward through time over some intervening period (between C and E). It is generally agreed that such a jump of causal influence across time is implausible.

It is tempting to think that there must be a simple way around the no-successor problem. Perhaps, for example, we can simply introduce intermediate effects in between C and E, so that C brings about E_1, which in turn brings about E_2, which in turn brings about … which brings about E. But however many further steps we introduce, the causal influence at each step must still leap forward through time – leaping a shorter distance does not much alleviate the problem. A number of other possibilities for solving the no-successor problem have been advanced in recent years, such as time being discrete[131], infinitesimal time steps[132], and events that occur during open / closed sets of times[133]. Unfortunately, none of these provides a

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130 Provided that time is continuous – that is to say, I suppose, isomorphic to the set of Reals numbers – as is typically assumed (often without being explicitly stated) within orthodox accounts of contemporary physics.

131 If time is discrete, then there may be a successor to each point in time. If T' is the successor of T (in such discrete time) and C occurs at T, then E 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 solution to the no-successor problem. To adopt this solution, an explicit and careful account of the nature of discrete time is surely required. If macroscopic causal relations (i.e. causes / effects 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 which is discrete. In any case, following this route clearly comes with a price: the need to commit to some non-standard theory of time.

132 It might be allowed that time is continuous, but supposed that the effect occurs an infinitesimal period of time after the cause. 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, 134-135). 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 Cauchy, 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 adopt certain non-standard mathematical constructions and then commit to an ontology which accords with those constructions.

133 See e.g. Clay 2018. Such approaches suppose 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, i.e. 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 – e.g. if the cause obtains during [T-δ, T) and the effect obtain during [T, T+δ'), say. One concern advanced against 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 is whether set theoretic solutions may provide plausible answers to ontological questions. I argue that such an account fails: Suppose that C 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 E, then it seems (on the assumption that C and E must be contiguous) that this period cannot give rise to E – it must in fact be the latter period of C [T-δ/2, T) which gives rise to E. Repeating this argument, we may deduce that the salient part of C obtains during the interval: Lim(δ→0) [T-δ, T). But this mathematical limit is just the empty set, φ. ([T-δ, T) = [T-δ, T] – [T]. So Lim(δ→0) [T-δ, T) = Lim(δ→0) [T-δ, T] – Lim(δ→0) [T] = [T] – [T] = φ) And this yields an

solution which avoids the adoption of non-standard assumptions (e.g. the discreteness of time, the reification of infinitesimal times, the occurrence of events in semi-open sets of times) which most analysts find unattractive.[134]

7.2.2 Process change

Some philosophers, recognising the intractable problem of causal time steps, have sought to develop process accounts of causation. Russell himself proposed the notion of *causal lines*[135]. '*A "causal line" … is a temporal series of events so related that, given some of them, something can be inferred about the others whatever may be happening elsewhere. A causal line may always be regarded as a persistence of something - a person, a table, a photon, or what not. Throughout a given causal line, there may be constancy of quality, constancy of structure, or gradual changes in either, but not sudden changes of any considerable magnitude*.'[136] On Russell's account, an earlier event within a causal line may be said to cause a later event in the line. This process account of causation was later developed further by other philosophers, e.g. Wesley Salmon and Philip Dowe[137]. Such causal process views presuppose a distinction between causal lines / processes on the one hand (e.g., the flight of a ball) and *pseudo-processes* on the other (e.g., the moving shadow of a ball). (The former, but not the latter, are supposed to transmit (in some sense) causal influence.) Unfortunately, no proposed criteria for distinguishing causal processes from pseudo-processes (e.g., the transmission of a mark[138], conservation of some quantity[139]) have received wide acceptance[140] - these process accounts of causation remain very much a minority view.

Other philosophers have recently pursued powers-based accounts of processual change.[141] Here it may be supposed that the manifestation of a power, which occurs when it is in circumstances appropriate to its manifestation, is a process (not a new state). Clearly, to be well defined, any such account of powers must be predicated upon an adequate account of what such a process is. According to the popular Humean account, a process is just the obtaining of a dense infinity of similar states at neighbouring places (as we saw with Russell). But how could a power manifest a process which 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

absurdity: C obtains on the empty set of times. Alternative open / closed set arguments yield similar mathematical absurdities.

[134] I set out a fuller narrative account of the no-successor problem with a focus on the manifestation of powers in Pemberton 2021.

[135] Russell 1948, Part VI, chapter 5.

[136] Russell 1948, page 404.

[137] See for example Dowe 2010, Salmon 1984, Dowe 2000.

[138] Salmon 1984.

[139] Dowe 2000.

[140] See for example Kitcher 1989.

[141] See for example Brian Ellis (Ellis 2001 and discussion in Pemberton 2021, section 5.4), Florian Fischer (Fischer 2018, chapter 4) and Niels van Miltenburg (Van Miltenburg 2015).

to face with full force the problems of no-successors: the later points in such a process are not contiguous with the state giving rise to the manifestation, so that causal influence would seem to jump through time.

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.

Neil Williams notes another difficulty with process manifestations: '*Manifestations as processes is an all-or-nothing affair: the processes either come about or they do not*'[142]. If the process does not come about, then it would seem the manifestation has not occurred after all – and this seems problematic. But for the manifestation to occur it seems the whole manifestation process must occur – and to ensure this is so would seem to require that the process cannot be interrupted. Unfortunately, non-interruptible processes seem at best rare in the world as we find it. So even if a suitable account of processes that are unified through time were to be advanced, it is not clear that such a process manifestation account of powers would be plausible.

7.3 How acting solves the problem of bringing about change

On the one hand, it is widely accepted that there is a need to embrace bringing about of change in order to do justice to both folk and scientific practice (as reflected in popular appeal to the notion of causation, for example). But on the other hand, accounts of the bringing about of change step-by-step remain without an answer to the no-successor problem. And appeal to process accounts of the bringing about of change seem, as yet, beset by unresolved difficulties. So, the bringing about of change presents a serious problem.

Acting provides the solution. As we have noted[143], acting cannot occur at a single point in time, but rather must occur (whenever it occurs) over some period of time. Acting-through-time brings about changing-through-time, and hence a change (over time) from one state to another. A change from one state to another is then brought about by acting. But this bringing about of a change of state does not involve the direct bringing about of a diachronically later state by an earlier state at any stage – there is no jumping forward through time, and hence no problem associated with no-successors.

We may note, too, that bringing about changing does not involve a state (which might be labelled a cause) bringing about of a new synchronic state (which might be labelled an effect). I offer no account of any such synchronic bringing about of one state by another. Rather, acting through time brings about changing through time.

[142] Williams, 2019, 132.
[143] Chapter 6.

As noted in 6.2.8, we may generally understand acting as the manifesting of an acting-power (where such a power is a characteristic of that which is acting rather than a reified entity). The acting-power continues to exist (qua characteristic) through the period of its manifesting. This talk of manifesting may be contrasted with talk of the manifestation of a power, which is appropriate to accounts of powers where it is supposed that when the power is in its *activation state* – i.e. is in circumstances appropriate for its manifestation - the power gives rise to either a new state or a process. Such a manifestation of a power entails a termination of the activation state and its replacement with the manifestation state, or the unfolding stages of the manifestation process.

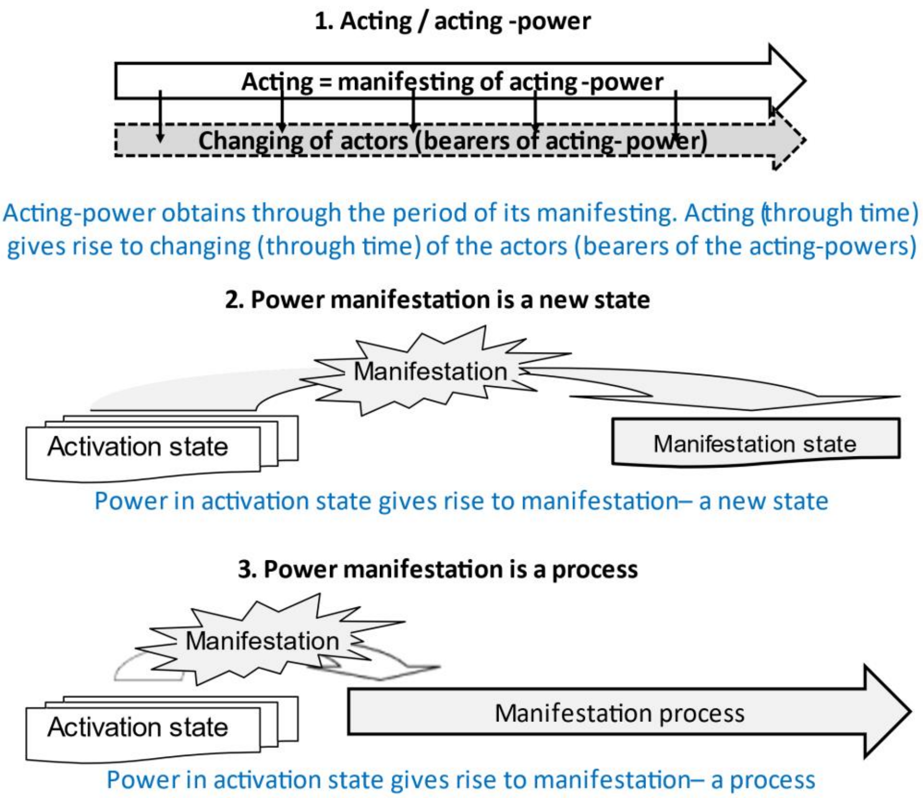

Figure 7.1: Acting (the manifesting of an acting-power) differs distinctly from the form of manifestation of powers commonly posited by contemporary philosophers

In coming to understand acting, it is helpful to mark this clear distinction between acting-powers and these other power types – I illustrate this in Figure 7.1.

7.4 Conclusion

Acting offers a solution to the difficult problem of providing a coherent account of the bringing about of change. Indeed, I argue, it offers the only solution to the problem of bringing about change which does not entail the adoption of non-standard – and to most minds unattractive - assumptions. Solving this difficult problem provides an important argument in favour of ontologies which embrace acting.

Lasting and acting also offer help with the problem of providing an adequate account of change itself. Although this benefit too is important, it is controversial and I do not press it here.

Adding acting to changing-lasting ontologies gives us, we may say, lasting-changing-acting (LCA) ontologies. We may add the arguments in this chapter in favour of acting, to the arguments in Section I in favour of changing-lasting ontologies, to provide a developing case for lasting-changing-acting ontologies.

We now turn to further arguments in favour of such ontologies – arguments that relate to composition.

Section III: Actors

8 Actors introduced

I turn now to *actors,* the entities which act, the physical beings of the world. I shall start with a rough sketch and expand more fully in chapters 9-11.

An *actor* is either an *elementary-actor* or a *composite-actor.* An elementary actor has no parts, is lasting and able to act. A composite-actor is an acting-together of parts (other actors) which is *surviving* through time within the prevailing context.

I have explicated acting in section II. Here we see that acting is the principle of composition – the glue of (composite) existence, we may say.

Surviving is the criterion of composite existence.[144] Surviving entails roughly what is suggested by the standard meaning of the word. The demarcation (of existence) achieved by this criterion is not bivalent - it is not the case that composite-actors either exist or do not exist tout court, rather composite-actors have (what I shall call) *subtle existence.* (What some other analysts might perhaps call 'vague' existence.[145]) In keeping with this subtlety of existence, the criterion of surviving cannot be rendered accurately through a definition using merely abstract or logical terms. Rather, the surviving criterion is a physical criterion – we must derive this criterion through a careful empirical investigation of the examples of composite-actors that we find in the world. I undertake such an empirical investigation in the next chapter, and say more about surviving in section 10.2.

Actors comprise entities that are generally taken, by folk and science, to be things or processes. There is typically wide agreement as to whether many of the things and processes that we commonly find in the world do exist, or not, at each stage (as illustrated in the next chapter). Nevertheless, there are cases where existence is less clearcut – for example, existence may be less clear:

- When a thing or process is coming into being;
- When a thing or process is ceasing to be;
- When there is ambiguity as to whether parts form a (unified) whole or an aggregate (e.g. whether some portion of leaf mould is one organism or many organisms).

I take this lack of clarity concerning existence to be ontological (rather than merely epistemological). The next chapter aims to sharpen intuitions here by reference to salient examples.

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[144] And perhaps, as I shall suggest in chapter 10, the criterion of existence of elementary actors too.

[145] I avoid using the term 'vague' as it suggests (to me at least) something that is not quite right – and, at the very least, that there are physical beings whose existence is not 'vague'. I do not posit any composite beings whose existence is not subtle.

Composite-actors are, then, surviving acting-togethers – this an account of restricted composition[146] which meshes empirically with the things and processes that we find in the world.

I shall discuss *elementary actors* in chapter 10. For now it will suffice to say that candidate elementary actors include particles of the Standard Model of particle physics.

Crucially, this acting-surviving composition of composite-actors yields *resultant novelty*: composite-actors may have genuinely novel properties, including novel powers, which their parts do not have. But we do not need to appeal to the opaque mysteries of emergentism. Rather, such novelty arises from the coming into being of the spatial arrangement of parts of a composite-actor just when that composite-actor comes into being[147] – novel properties flow from this existent spatial arrangement. The importance of resultant novelty cannot be overstated, as I shall explain. Of equal importance, I shall explain how novel powers of composite-actors arise from the powers of their parts without threatening anything akin to causal overdetermination – i.e. how causal exclusion concerns may be allayed.

[146] As opposed to an unrestricted account of composition, such as that of classical extensional mereology, wherein any combinations of parts compose some further whole.
[147] I shall call the nature of existence of this arrangement of parts which may be abstracted from a composite-actor (which has subtle-existence) by paying selective attention to the spatial locations of these parts *super-subtle-existence* – see section 11.2.

9 Empirical review of things and processes

This chapter[148] considers a wide range of entities within the world that are generally taken to be things (e.g. atoms, molecules, bundles, artefacts), or taken to be processes (e.g. the oscillating of a pendulum, the firing of a neuron), or perhaps to have characteristics of both things and processes (e.g. stars, organisms, parts of organisms, Rayleigh-Benard convection cells). I analyse and describe these entities in a way that that shows how they are the acting-together of parts that survive through time within their context – and hence that they are composite actors as posited in this thesis. In order to bring out the nature and diversity of acting-togethers[149], I shall articulate a range of characteristics which they may have – this list of characteristics will provide a starting point for considering properties of actors in chapter 12.

9.1 Things and processes

I consider a wide range of examples of (entities taken to be) things and processes from across the sciences, including physics, chemistry, biology, engineering and astronomy. In each case I describe the thing / process as an acting-together of parts. In the cases of these things, the acting-together underwrites the sufficiently stable juxtaposition of certain of the parts in such a way that the acting together survives through time. I find no examples of (non-elementary) physical things that cannot be described as an acting together of parts - and provisionally conclude that there are none. (This conclusion remains open to challenge by counter-example.)

How about processes? I start by considering common and familiar examples of processes which we find presented in text books, articles and research papers across science and commerce. A review of such literature reveals the widespread use of diagrams to represent processes, where the diagrams show the spatial layouts of parts of the process and often feature arrows indicating how the layout changes over time, or perhaps a sequence of diagrams which denote the stages of such change. Typically, accompanying text describes this changing of the arrangement and the properties of the parts through time, and how it is that the parts bring about this changing.

[148] This chapter develops *Individuating processes* (Pemberton 2018) – note the change here in terminology, especially use of the term ‘process’.
[149] I shall use the term ‘acting-together’ as a noun, an alternative and often more perspicuous term for a *composite-actor*. I often suppress the qualification that the acting-together is surviving through time within its context, leaving this as implicit.

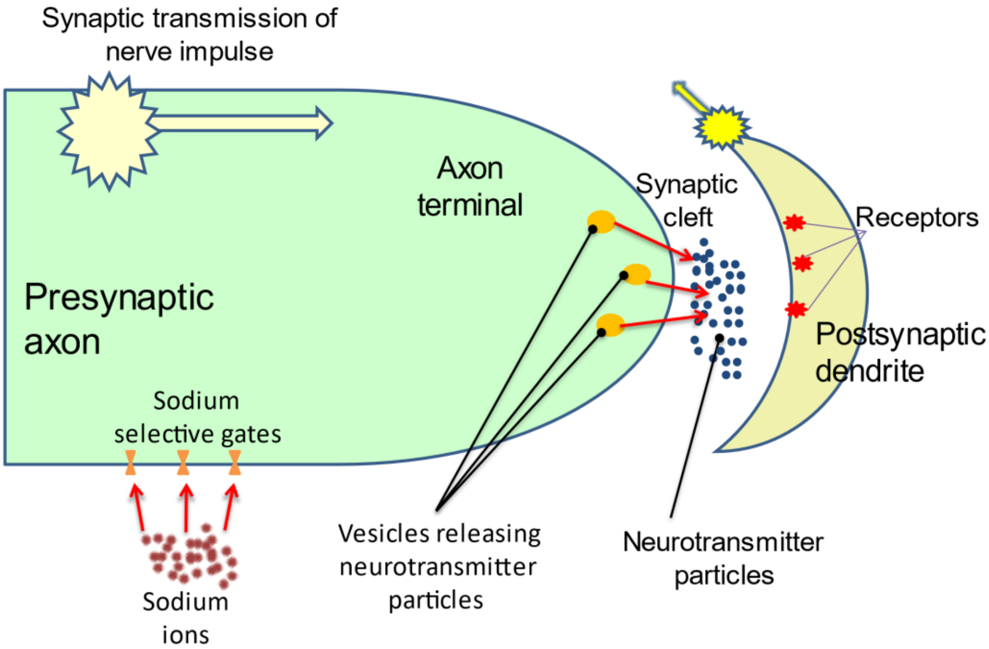

Figure 9.1: Diagram of synaptic transmission

As an example, Figure 9.1 shows the layout of some of the key parts involved in synaptic transmission which is similar to diagrams used in many biology text books, such as Bear et al 2007 (Figure 2.15), whose accompanying text explains:

> When a nerve impulse arrives in the presynaptic axon terminal, neurotransmitter molecules are released from synaptic vesicles into the synaptic cleft. Neurotransmitter then binds to specific receptor proteins causing the generation of electrical or chemical signals in the post-synaptic cell.[150]

Other works focus on certain of the parts shown in Figure 9.1, and depict diagrammatically the acting together of their more detailed parts – Südhof and Rizo[151], for example, use a series of spatial diagrams to explicate the vesicles and the processes in which they engage. Other texts focus on numerical measurements of aspects of such processes, for example Eijkelkamp et al present alongside a spatial diagram representing the operation of a sodium gate, a graph depicting the magnitude of the potential across the gate over time during the passage of a nerve impulse, i.e., action potential[152].

This example is representative of a vast number of other examples across the sciences. A common feature of the processes explicated in such diagram-based

[150] Bear et al 2007, p39.
[151] Südhof and Rizo 2011, Figures 1–5.
[152] Eijkelkamp et al 2010, Figure 1.

accounts is the acting together of parts within some arrangement at each stage, to bring about a next stage – these are acting-togethers which survive through time in the given context.

The view that much science is centrally concerned with such configurations of interacting parts is supported by many philosophers of science, perhaps most notably the *new mechanists*, who take *mechanisms* to be very widely occurring[153]. Such mechanisms are taken to involve parts that are spatially arranged acting together to exhibit processes of change (sometimes referred to as *activities* or *behaviours* of the mechanism)[154]. The views of such philosophers of science have particular salience as they are typically based on careful and extensive observation of examples from the practice of science.

Are there examples of processes that are not an acting together of parts? There may well be stages of some processes that we may treat as comprising the movement of a part relative to other parts without any significant interacting – but I suppose that other stages of such processes do generally involve acting together of parts.

9.2 Characteristics of things and processes

Let's turn, then, to characteristics of things and processes considered as acting-togethers of parts. I set out here a list of characteristics that may often be useful for classifying things and processes into salient types. Other (or further) such taxonomic criteria may often be preferred – the proximate purposes of the classification may often guide such preference.

The first three of the characteristics on my list are often to the fore in consideration of common processes, perhaps from a new-mechanist perspective.

a) <u>The nature of the parts at each stage</u>

The elements of the spatial diagrams used in science, noted above (e.g. in Figure 9.1), are typically shapes or pictures representing the parts engaged in the process – i.e. the spatially located entities which act together with the other parts at each stage to give rise to the process. The diagram typically represents some stage of the process (although arrows or other pictorial devices may be used to suggest the pattern of change over time) – and hence the parts which are present and perhaps acting at that stage. The nature of the parts varies from science to science: in biology perhaps neurons, vesicles, neurotransmitter particles, as in Figure 9.1. In astronomy familiar spatial diagrams include those with force arrows indicating the mutual gravitational attracting (acting together) of stars (planets) and their planets (moons)

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[153] Some new mechanists take mechanisms to be widely occurring throughout the sciences (e.g. Glennan 2017), others focus on narrower areas and take mechanisms to occur widely within their areas of focus (e.g. Darden 2006, Craver 2007).
[154] See e.g. Machamer, Darden & Craver 2000, Bechtel & Abrahamsen 2005, Glennan 2002, Illari & Williamson 2012

and the resultant elliptic orbits – here parts include stars, planets and moons. In chemistry parts may include electrons, protons, molecules; in engineering perhaps cogs, spark plugs, cylinders. In each case the parts are typically things which are familiar to the science concerned.

b) The spatial arrangement of the parts at each stage

By choosing the duration of a salient stage as sufficiently brief, we may typically be able to limit the change of the configuration during that stage so as to be able to characterise the arrangement of parts (i.e. their spatial locations and orientations) at that stage using a single snapshot spatial diagram. Sometimes a diagram may show schematically the spatial layout of differing parts at differing times, perhaps using arrows to indicate the time sequencing (as in Figure 9.1). In engineering, the spatial arrangement of parts may typically be specified by use of a blueprint (which may also generally specify the nature the parts), which may be used as the basis for constructing the configuration, and hence instantiating the relevant process. Similarly, for certain laboratory experiments, the initial spatial layout of pieces of laboratory equipment and entities under study may be represented in a diagram – when the layout is instantiated the aim may typically be to produce some repeatable process involving the entity under study, i.e. a run of the experiment. In other sciences (such as astronomy, biology, geology) the processes in focus are typically found in nature – the diagrams may show the spatial layout of typical processes of the relevant kind at salient stages.

c) The nature of the change an acting-together exhibits across certain stages

The swinging of a pendulum might be described as U-shaped or perhaps as exhibiting a stopped–slow–fast–slow–stopped pattern. Other processes may be smooth, intermittent, or explosive; or perhaps give rise to spherical, circular or linear spatial patterns of change. In Figure 9.1 the rough pattern of change over time is indicated by the arrows and explicated further by the text.

We may note that the temporally-extended nature of processes leads to two somewhat differing senses in which the term ‘process’ is often used. Sometimes the changing which occurs may be in focus – i.e. criteria (c), e.g. the swinging of a pendulum, the beating of a heart, a run of some experimental set-up in the laboratory. This changing occurs over time and this sense of the term ‘process’ might be thought of as somewhat abstract. Alternatively, we might have in focus the configuration of parts which are acting at each stage, e.g. the swinging pendulum, the beating heart, the acting parts of the experimental set-up[155]. I take a process, an acting-together of parts that transitions through stages, to embrace both these notions – this is reflected in the recognition of criteria (a), (b) and (c).

[155] In Carl Craver’s terms, ‘the ψ-ing S’ rather than ‘the ψ-ing of S’ (Craver, 2007, 7).

d) Classification of entity into: (1) Thing ((i) thing-with-homogeneous-stages, (ii) thing-supporting-a-process) / (2) process ((i) beginning-to-end, (ii) on-going, (iii) episodic) / (3) thing-process-hybrid

An acting-together may be characterised by classifying it into one of these classes of entities.

Although they do generally have a beginning and an end, things may generally be considered on-going. Many (but by no means all) things exhibit a high degree of homogeneity between stages, i.e. largely the same parts act together in largely the same ways at each stage – we may call this a *thing-with-homogeneous-stages*. As an example, consider a water molecule.

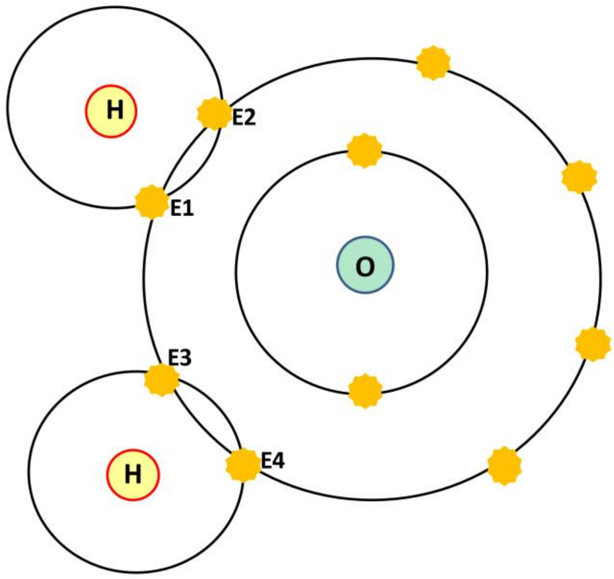

Figure 9.2: A water molecule - an example of a thing

On the standard scientific account, the parts of the water molecule are protons, oxygen nucleus and electrons arranged along the lines shown in Figure 9.2.[156] Within this configuration, the parts exert (and experience) basic forces of physics on (due to) other parts – perhaps most notably electrostatic forces associated with charge. This acting together of the parts[157] continues through time in a way which is self-sustaining - the water molecule survives within its context. The molecule exhibits a high degree of homogeneity through time: the same parts are acting at each stage and acting in the same sort of way (although perhaps the strength and direction of the basic forces may vary over time).

[156] See e.g. Keller 2013 – cover diagram.
[157] The exerting of a force and the experiencing of a force are how the actings of the parts (e.g. masses, charged bodies) may be understood in this context.

Bundles, as characterised by Aristotle for example[158], may also be taken to be examples of things-with-homogeneous-stages. Consider for example a bundle of sticks bound by some binding such as string. When roughly static, the binding gives rise to forces which hold the bundle together, whilst the sticks push against each other and the binding so as to form a stable physical unit: the same parts act giving rise to similar forces (i.e. roughly homogeneously) at each stage. When external entities act, e.g. when the bundle of sticks is kicked, the binding forces within the bundle may increase reactively so as to prevent the sticks flying apart, for example.[159] In this reactive way, bundles are effective at surviving – they are a common, if somewhat prosaic, form of thing. At the micro level bindings may be atomic or molecular bonds, so that the bundles may then be graphite rods, diamonds, lumps of copper, rocks, drops of water, etc. At the macro level forms of binding may include tying, gluing, nailing, bolting, interlocking of congruent shapes, containing by a wall, linking by tissue / fibre, etc. Examples of macro bundles may include bundles of sticks, packets of biscuits, broken (or perhaps non-functioning) mechanisms, and dead organisms.

By contrast with the homogeneity across the stages of such things, many processes typically run through from a certain type of starting configuration to a certain type of ending configuration via a series of well-defined stages over some rough given timescale – we may call these *beginning-to-end processes*. The firing of a neuron, for example, perhaps starts with neurotransmitter particles binding with ligand-gated neuroreceptors, hence opening certain ion channels. The movement of ions across the neuronal membrane which follows may result in an increased potential across the membrane, and hence the opening of nearby voltage-gated ion channels, which may in turn lead to a cascade of voltage-gated ion channels opening along the neuron, and then to the opening of vesicles which release neurotransmitter particles.

As another example, when a coin is inserted in a drink vending machine a process of well-defined stages may ensue which results in a drink in the output bin.

Beginning-to-end processes exhibit heterogeneity: perhaps differing parts act at differing stages, or perhaps parts act in differing ways at differing stages. The ligand-gated neuroreceptors feature at the start of the process of the neuron firing, whilst voltage-gated ion channels and vesicles feature later on. The coin inserted in the vending machine perhaps depresses a lever which turns various cogs leading on to the acting of different parts which release the cup and liquid.

In practice beginning-to-end processes are often supported by things (e.g. a neuron, a vending machine).[160] The thing may underwrite the parts which act in the process

[158] See e.g. Aristotle's *Metaphysics V.6* especially 1015b35- 1016a2.
[159] Of course, a sufficiently hard kick may cause the bindings to break or sticks to escape the bindings, so that the bundle ceases to be.
[160] Other types of beginning-to-end process (e.g. lightening, avalanche) may be supported by configurations of a type which recurs within nature (e.g. a storm, a body of unstable snow).

being in suitable locations at suitable stages. Such a thing might then be characterised as a *thing-supporting-a-process*, a subset of things.

Other processes may be on-going rather than beginning-to-end. Consider, as an example from engineering, the process of the running engine supported by a motorbike. This process transitions through differing stages involving the acting of differing parts at each stage: the sparking of the cylinder by the spark plug, the exploding of hydrocarbons, the driving down of the piston, the opening of the exhaust valve, the emitting of the exhaust gasses, the closing of the exhaust valve, the moving upwards of the piston, and the admission of new hydrocarbons. In this sense, the process exhibits a high degree of heterogeneity. By ensuring that the process arrives at (roughly) the same configuration as it started, the process is rendered cyclical, and hence on-going.

Here the motorbike is a thing-supporting-a-process, and the process it supports is on-going. Both the process and the motorbike are acting-togethers which survive through time in context – the process involves a subset of the parts of the motorbike at each stage, where this subset may differ from one stage to the next.

Organisms may involve a processual transition through developmental stages, e.g. seed, young and mature organism; where each stage exhibits multiple life processes (e.g. mitosis, respiration, digestion, photosynthesis, self-repair, etc.). The organism comprises an acting-together of parts which survives in the prevailing context. Organism processes exhibit heterogeneity, but in a vastly more complex way than those of machines. The differing parts of an organism may act in differing ways at differing stages to self-maintain the organism and perform desired functions. Many of the sub-processes of the organism (e.g. the firing of a neuron, the contraction of a muscle, the digestion of a meal) might be taken to have a beginning-to-end character. But the appropriate coordination of such sub-processes ensures that the organism as a whole is on-going. Organisms have generally been taken to be things (albeit with processual characteristics), but more recently arguments have been advanced that they are processes.[161] We might classify them as thing-process-hybrids.

Other processes may be understood as episodic, for example the heating of a house by a thermostat controlled central heating system. Many organic processes might be viewed as episodic, e.g. the cooling of a human body by vasodilation. Other examples of episodic processes are task-oriented human activities such as building a house or learning to play the piano. Typically, episodic processes are characterised by alternating periods of activity and pause, where each period (or episode) of activity may often (but not always) be characterised as a beginning-to-end process.

This classification of acting-togethers into things / processes / hybrids of differing types might be further refined or developed. Others may suggest classifications which are more salient to their subject matter, or perhaps which better reflect their

[161] See e.g. Dupré 2012, Bapteste & Dupré 2013, Nicholson and Dupré 2018.

account of the subject matter. The classification suggested here is one possible starting point.

e) <u>Originating things</u>

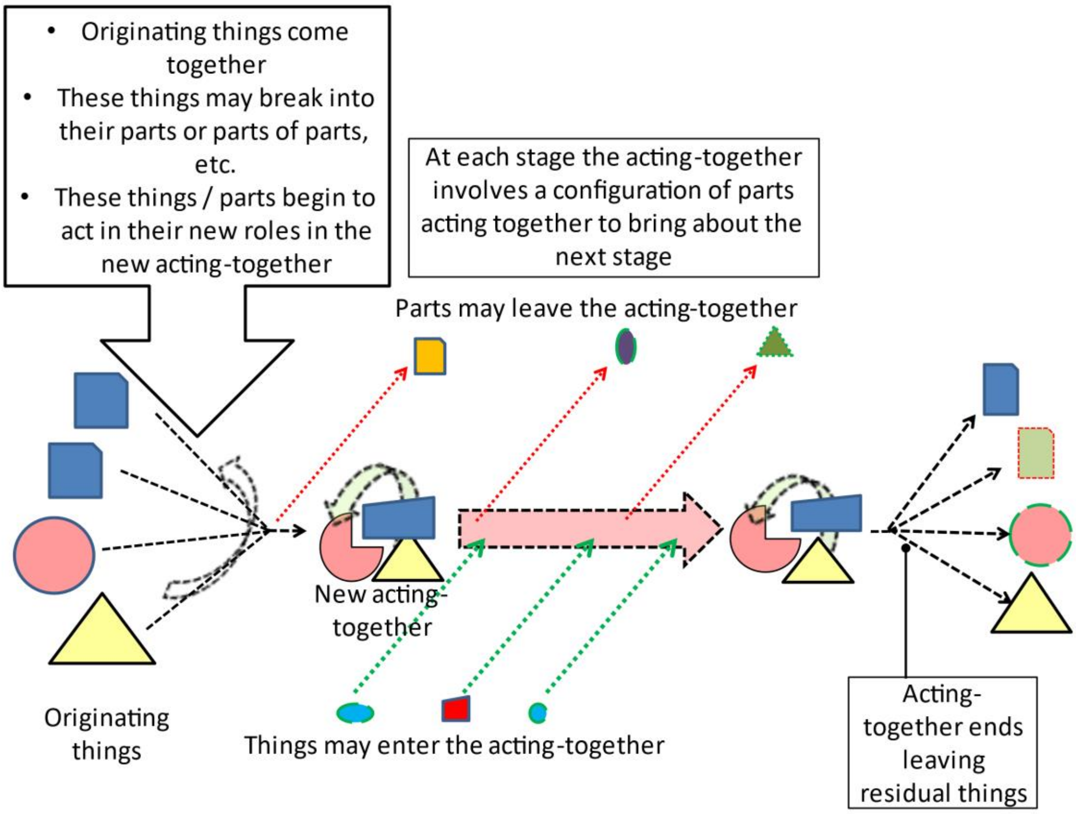

Figure 9.3: Originating things come together to form a new acting-together – things may join and leave the acting-together during its currency

Sometimes we may characterise an acting-together, a thing or a process, according to the things which came together to give rise to that acting-together. Originating things may or may not remain as identifiable unities within the new acting-together.

For example, we might take the cogs, cylinders and spark-plugs used to build a motor-bike as the originating-actors of that bike – these originating-actors do typically remain as identifiable parts of the motorbike. In biology we might take the originating-actors of a certain mule to be the gametes from the donkey and the horse which fused to form the zygote which was the earliest stage of this mule. The story of these gametes after their fusion is complex - it does not seem that these originating-actors remain as identifiable unities within the mule longer term. Certain eggs may be amongst the originating-actors of a cake – these originating-actors do not remain as unities within the cake.

f) The nature of the things / parts which join or leave the acting-together at each stage

Things may both enter and leave an acting-together at each stage (as illustrated in Figure 9.3). For example, hydrocarbon fuel (motorbike) or nutrients (organism) may enter a process, whilst exhaust gasses or urea may leave a process. Things / processes are often characterised by the nature of the things which join or leave, for example organisms may be characterised as herbivores or carnivores (according to the nature of food taken in by the organism); and similarly, engines as diesel or petrol – or perhaps according the rate of emission of certain polluting gasses.

g) Residual things

When an acting-together comes to an end there may typically be some things which are left, *residual things* say. Following the death of an organism, i.e. the ending of its life process, a corpse remains (initially at least). When an experimental set-up is run in the laboratory, perhaps a chemical experiment, the process which occurs may give rise to characteristic products and residues.

h) Context in which the acting-together obtains

Some acting-togethers, for example some things (e.g. a hydrogen atom, a stone), may obtain robustly across a wide range of contexts – they might be characterised as largely context independent. Other acting-togethers, many processes for example, can, by contrast, only obtain within specific contexts - they might be characterised as dependent on their context and characterised according to the type of context in which they can obtain.

One form of context dependency is that of the acting-together on aspects of the context which bring about salient changing of the acting-together. A pendulum, for example, acts with the Earth (which gravitationally attracts the bob downwards) within its characteristic changing - it might be characterised as obtaining within a region with suitable gravity.

In engineering, a machine process, such as that of a drink vending machine, typically involves only some of the parts of the machine at each stage. Such a process can, in practice, only occur within the context of a suitable machine – the other parts may, for example, locate the active parts in suitable positions at suitable times and shield them from interference (e.g. a protective casing). Such a machine process may be characterised according to the type of machine of which it is a process.

Biological processes and parts-of-organisms are typically dependent on their context.[162] Parts of organisms, for example, must typically obtain within the context of an organism which, inter alia, provides that part with oxygen and other inputs. Moreover, parts of organisms typically act with other specific parts of the organism

[162] See Dupré 2010 for a discussion of the importance of context for biological entities.

and hence must be suitable located with respect to those other parts to act in processes with these parts, e.g. a muscle may pull on a bone, a heart pumps blood through the bodies capillary system. As another example, many proteins are dependent on *chaperone* proteins to fold them in to their correct spatial configuration (they are not merely topological structures) – hence they are contextually dependent in this way. Parts of organisms may be characterised according to the type of organism of which they are parts (e.g. a heart as a horse heart or perhaps a mammalian heart), or perhaps of larger parts of an organism of which they are a part (e.g. a cell as a brain cell). Beginning-to-end biological processes are generally specific to certain types of parts of an organism and may then be characterised as occurring in these types of parts, e.g. an action potential transmission may be characterised as neuronal. Organisms are generally dependent on their ecological context – e.g. they live in jungles or on rocky cliff faces – and can be characterised accordingly. Many organisms also depend on a group of organisms of which they are a member, e.g. families or packs: parents may provide nutrition to their young; packs may herd for mutual protection or to hunt. An organism might be further characterised as a member of such a group.

In astronomy, *stellar nucleosynthesis* may be characterised as occurring within a star.

i) Function in a larger acting-together

An acting-together may often play a functional role within its context, especially in cases where it is dependent on that context.

A key (which might be viewed as a shaped-bundle type thing) can engage in a process of lock-opening when it is in a suitable configuration with a lock and a person, e.g. it is inserted in the lock and rotated by the person (a *person-turning-key-in-lock process,* say). We might ascribe to the key (a thing-with-homogeneous - stages) the function of opening the lock. We might also ascribe this function to the person-turning-key-in-lock process, but in a different sense: this process may end with the lock being open.

In the biological context, many biochemical structures, such as proteins, have key-like (or lock-like) characteristics.[163] A protein which is an enzyme, for example, may have a function as catalyst in some particular biochemical reaction – typically the reactants bind with the protein's active site whose spatial molecular structure and charge pattern lowers the energy requirement for the reaction.[164] Other possible functions for proteins include transporter, inhibitor, and binding agent, for specific molecules or reactions. The function of a protein has been embraced as a crucial taxonomic criterion within extensive recent work in this area.[165]

Many other parts of organisms (and the processes in which such parts engage) may also be characterised according to their function. For example, a heart pumps blood,

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[163] This is not to advocate simplistic key-in-lock theories of e.g. enzyme operation.
[164] See e.g. Copeland 2000, especially 1.4 and 1.5.
[165] See e.g. Wu et al 2004.

a kidney cleans blood. In engineering, a cog in the context of a bicycle might be classified as a *drive sprocket* – i.e. has the function of transmitting drive via a chain.

In some cases, the function performed by a part is central to the identification of that part and the salient process in which it engages. When a neuron is transmitting an action potential, certain configurations of polypeptide strings located in and around the walls of the neuron act together to open or close a pore in the lining of the neuron, hence allowing or inhibiting the passage of sodium ions across the neuron wall. It is this function within the higher-level process of neuron-firing that helps to license recognition of the unity of this process (i.e. the acting together of this configuration of polypeptide strings), which may be referred to as the opening / closing of a sodium selective gate, and hence the unity of the sodium selective gate itself.

j) <u>How a thing / process survives within its context at each stage</u>

The widespread supposition of science is not that the sequence of stage configurations of a process is inexplicable, but rather that the nature of the parts and their configuration at each stage (in the given context) brings about the next stage. Typically, an account of how the parts act together at each stage to bring about changing, and hence the next stage of the process, is available for each of the spatial diagrams of the parts illustrated and discussed above. For example, the approaching nerve impulse (action potential) of the neuron in Figure 9.1, opens sodium selective gates allowing movement of sodium ions and hence the local changing of potential difference across the wall of the neuron, which underwrites the movement of the action potential along this part of the neuron. At the axon terminal, the action potential opens the vesicles releasing neurotransmitter particles which cross the synaptic cleft and dock with receptors, etc. It is supposed that a detailed story is available (even if not yet discovered) about the acting of parts at each stage, and how these lead on to the next stage.

How an acting-together survives across each stage may often be a useful criterion for classification. Things-with-homogeneous-stages may survive in largely the same way at each stage – a hydrogen atom, for example, survives at each stage through the acting together of a proton and an electron, i.e. the mutual exertion of basic forces of physics. A bundle survives through binding forces which are similar at each stage (although these forces may increase reactively when the bundle is stressed).

For processes, the account may typically vary across stages. A fire survives at each stage by the oxidation of hydrocarbons releasing energy to maintain a high localised temperature and hence the release of more flammable gasses – but the parts (e.g. firelighter, kindling, logs, coal) acting at each stage may vary. For a process supported by an engineered machine which transitions through a dynamic locus of configurations before perhaps returning (more or less exactly) to some *starting*[166]

[166] As the locus of configurations exhibits a cycle, we might choose to ascribe any point in the cycle as the *starting* configuration, but where such mechanisms require a human action (e.g. pulling a chain,

configuration (such as motorbikes, cisterns, toasters, pendulums), an adequate account might reference how the process survives through each different stage of the locus of configurations.

k) <u>Team / constrained-crowd / complex acting-togethers</u>

Many acting-togethers may be characterised as *team acting-togethers*: they involve a limited number of parts (which we may think of as the team members) each of some specific (and often differing) type, in some distinctive spatial arrangement (or locus of arrangements). Examples of team processes include beginning-to-end processes such as machine processes (e.g. the vending of a drink on the insertion of a coin). Examples of team things include water molecules, pendulums and motorbikes.

Many other acting-togethers may be characterised as *constrained-crowd acting-togethers*: an acting-together of a large number of parts (which we may think of as the crowd members), which are often of the same type (or perhaps of a small number of types), and which are either self-constrained or constrained by another entity, a *constrainer,* say.

Although many of the examples of acting-togethers in focus in this thesis are of team type, the world also provides many diverse and interesting examples of the constrained-crowd type. Examples of crowd things which are self-constrained are bundles such as a steel bar (a crowd of mutually attracting / binding iron atoms)[167] or a drop of liquid (such as a rain drop), and stars. Examples which are constrained by a constrainer are a bundle of stick tied by a string, or water in a bucket – the sticks and water molecules are then the members of the crowd, and the string and bucket the constrainers.

Other examples of constrained-crowd acting-togethers come about when members of a crowd have a tendency to adopt a behaviour which then predominates amongst local crowd members, so that systematic variation of behaviour across differing regions of the crowd obtains. A nice example is that provided by Rayleigh-Benard convection, an effect which may occur when a liquid in a container is heated from below. The warmer liquid (at the bottom) becomes less dense and hence tends to rise, whilst the cooler liquid (near the top) tends to sink. Convection patterns may now form in the liquid which may be quite stable over time – a simple example is pictured in Figure 9.4.

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pushing a button, depressing a lever) to initiate a cycle, it is most natural to choose the rest configuration before this human action as the *starting* configuration.

[167] Such crowd composite-actors often exhibit complex and interesting characteristics - see, for example, Robert Batterman's discussion of the characteristics of steel bars at different length scales (Batterman 2013).

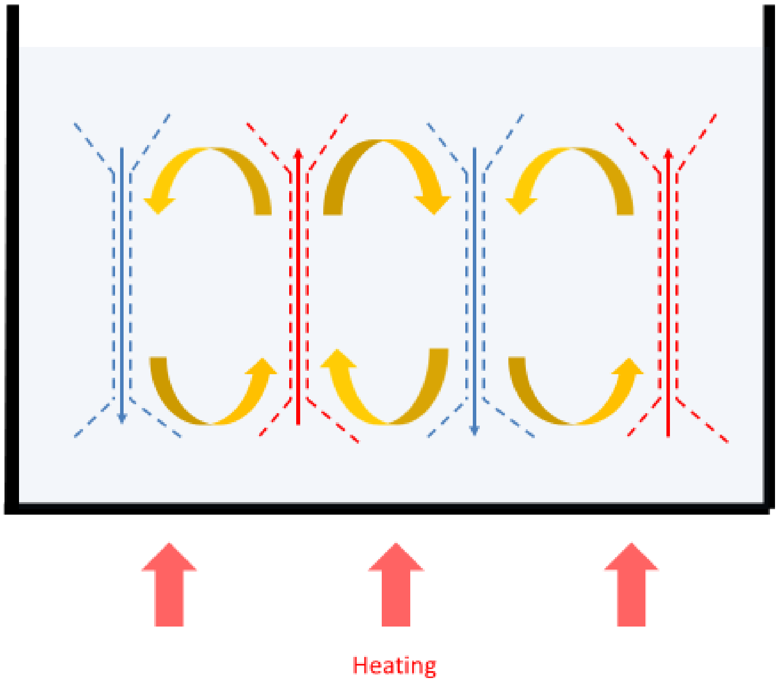

Figure 9.4: Rayleigh-Benard convection patterns

The stable features within these convection patterns, such as the rising and falling columns and the cells shown in the figure, involve members of the crowd (i.e. parts) acting together in the context of the larger crowd, and might themselves be regarded as things or processes. If so, these things / processes have distinctive qualities: they come into being and are sustained within the context of a constrained crowd.

Another interesting example of a constrained-crowd process is a river – here we might take the water basin of the river as the constrainer, and the water molecules falling in the water basin (e.g. as rain or snow) as the crowd members. Under the influence of gravity, the water molecules tend to be guided down towards streams and then into the river – we might call this a *constrained moving crowd process*. The river, and perhaps features of the river such as waterfalls[168], typically exhibits characteristics which are stable over periods of time.

Other examples of constrained crowd-processes include sound waves and clouds of chemicals, which might give rise to sensations of smell.

Organisms typically have many sub-processes which are team processes and many others which are crowd processes – organisms might be characterised as *complex processes*.

[168] Galton and Mizoguchi 2009.

Again, this classification of acting-togethers into team / constrained-crowd / complex might be further refined and developed – these classifications may admit borderline cases and perhaps overlaps.

l) <u>The *phase-stages* of an acting-together</u>

As noted in criterion (d), acting-togethers may vary considerably as to their degree of heterogeneity over time. Some may exhibit such a high degree of heterogeneity across sequential stages that it may be unclear whether they should be treated as one thing / process or a series of sequential things / processes. For example, an astronomic feature may have the stages diffuse nebula, main-sequence star, red giant, and white dwarf; an organism may have stages egg, caterpillar, chrysalis, and butterfly. I dub such radically differing stages *phase-stages*. Where an acting-together is taken to exhibit such phase-stages, the nature of these phase-stages, and how they lead on from each other, may provide a further useful classificatory criterion.

9.3 Things and processes as clusters of acting-togethers

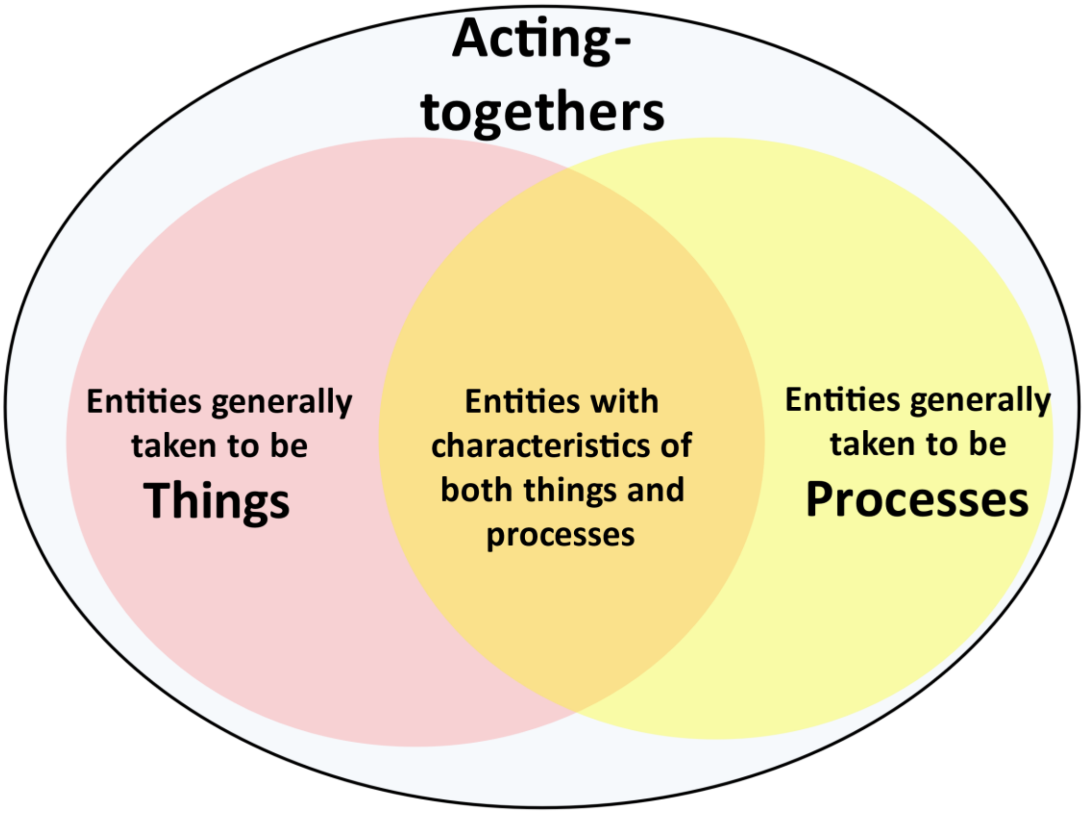

Figure 9.5: Two major clusters of acting-together: things and processes

Acting-togethers are typically demarcated by science or folk into two clusters: things and processes. Some acting-togethers may be widely deemed to be clearly within just one of these clusters, whilst others may have characteristics of both things and processes and hence fall into an overlap (e.g. stars, solar systems, organisms, convection currents in a Rayleigh-Benard set-up).

The key characteristics of things and processes differ – we might sketch these along the following lines.

Things typically have some of their parts bound to other of their parts, i.e. these parts act together (and perhaps with other parts which act in the binding) to maintain their spatial juxtaposition. Types of binding include chemical bond, bolting, nailing, tying, gluing. Additional parts which may act in the binding include bolts, nails, glue. The binding together of certain of their parts helps to ensure sufficient stability in the spatial arrangement of these parts over time, and hence helps to underwrite the surviving of the acting together of these parts through time.

Processes are the acting together of things. They typically involve transitions through stages, so that different parts may act at differing times and/or the same parts may act in differing ways at differing times. A process typically requires a context in which the parts which act in the process are suitably arranged. For example, a body of loose snow may facilitate an avalanche, or a storm may facilitate lightening. In many cases a complex thing, such as an organism or a machine, may be required for a process to obtain – the thing may then ensure that the right parts are available at the right times for the processes to obtain at each stage (e.g. a neuron in a suitable state is required in order for the firing of a neuron to occur), and perhaps that these parts are shielded from the acting of things which might otherwise enter the locality by chance.

9.4 Conclusion

Despite the division by folk and science of physical entities into two largely distinct (although perhaps overlapping) clusters (things and processes), this review supports the contention that we may take all things and processes to be acting-togethers of parts which survive through time within their prevailing context. These acting-togethers may exhibit widely differing characteristics one from another – we have identified a number of types of characteristics.

10 Actors

This chapter explicates the nature of *actors* making clear how they differ from the entities, notably continuants (e.g. substances), which have been more commonly posited by metaphysics.

An *actor* is either an *elementary-actor* or a *composite-actor.*

An *elementary-actor* is lasting, able to act[169], and has no parts[170].

A *composite-actor* is at each stage[171] a configuration[172] of parts (also *actors*), within some *context*, *acting* together (and perhaps with their context) bringing about changing (of that configuration of parts) and hence, over time, the next stages of that acting-together, so that that acting-together survives through time within the prevailing context.

As I explain in section 10.3.5 below, a *context* is a configuration of neighbouring actors with which the target composite-actor may act. Some composite-actors can only obtain within certain types of contexts. Others may obtain robustly across a wide range of contexts, the acting with these differing contexts being incidental to the existence of the composite-actor.

As we shall discuss below, composite-actors are lasting and able to act (at least at salient stages), so that all actors are lasting and able to act.

10.1 Elementary-actors

I remain agnostic here on the nature of the ontological priority of an elementary-actor with respect to its temporal parts (which renders it a lasting entity).[173]

[169] Elementary-actors are correctly characterised as being able to act, i.e. able to bring about certain changing in certain circumstances – but no entities are posited which carry this ability (e.g. power-entities). It seems that some actors in some types of circumstances always act – but I do not rule out the possibility that the acting of some actors in suitable circumstances is indeterministic: they may or may not act.
[170] Has no parts which are elementary-actors, or which are composed of elementary-actors.
[171] A stage obtains over some (perhaps brief) period of time, not at a single point in time.
[172] So a *configuration* (as I use the term) is some actors in some spatial arrangement – it is physical. An arrangement associated with a configuration may be derived by paying selective attention to the spatial location of the parts of the configuration – that is by abstraction. I shall pay careful attention to the nature of the existence of arrangements - see chapter 11.
[173] We set out possible accounts of this ontological priority (e.g. brute, sui generis) in section 3.1. Although I remain agnostic here, the nature of this ontological priority is important – we may understand different forms of priority as yielding different flavours of AAO. As I note in 20.1.2, this will be a topic of future work.

Possible candidates for *elementary-actors* are the particles of the Standard Model of particle physics[174] – adopting these as elementary-actors accords intuitively with the standard scientific view that the physical entities we find in the world are built progressively from the acting together of elementary particles, atoms, molecules, bundles of molecules, and e.g. proteins and higher structures.

10.2 Composite-actor surviving and existence

Figure 10.1 pictures a composite-actor (labelled 'target composite-actor'), an acting-together of actors which survives through time within its prevailing context.

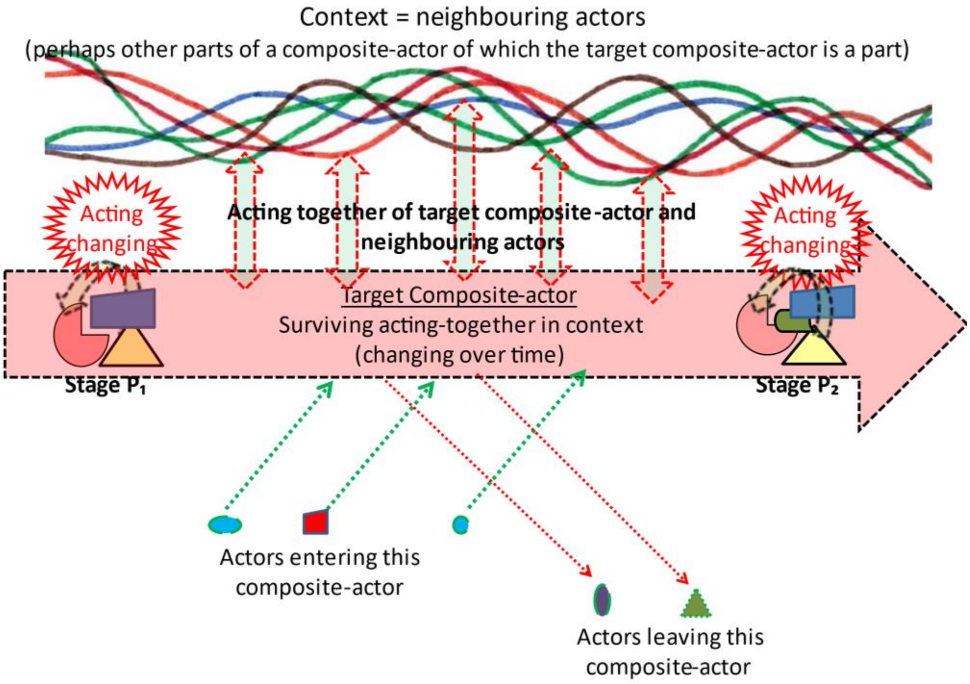

Figure 10.1: A composite-actor

When an acting-together of actors is bringing about changing over time so as to yield a further stage of this acting-together, then the acting-together is *surviving* through time. A composite-actor (an acting-together) exists just when that acting-together is surviving through time within the prevailing context.

The term '*surviving*' here has, then, roughly its usual meaning. Surviving is a physical phenomenon closely associated with acting, the bringing about of changing. Surviving is a sui generis feature of the ontology of the world. I do not suppose that an account of surviving can be defined (in a non-circular way) using any other terms, such as terms for other physical phenomena or abstract or logical terms. Rather, 'surviving' is a term whose meaning must be derived from empirical consideration of features of the world. [175] Chapter 9 described examples of actors (e.g. things and

[174] See discussion in 20.1.1.

[175] Note that there may often be an ongoing acting together of two actors which does not comprise a surviving acting-together - perhaps because they are both parts of a larger surviving acting-together.

processes) which survive through time, hence providing an empirical basis for deriving the meaning of surviving. In practice, actings (such as attractings and pushings) which may maintain spatial juxtaposition of parts are central to physical existence: As we saw in chapter 9, such maintaining of juxtaposition may underwrite the continued acting together of parts and hence the surviving of an acting-together.

It would seem that the ontology of the world does feature some acting-togethers which survive robustly through time, and hence exist, as we saw in chapter 9, e.g. stars, organisms, motorbikes. But in other cases, such as local fluctuations which may be the latter stages of a dissipating wave, it may be ontologically indeterminate whether some feature of the ontology is a surviving acting-together, i.e. it is not an ontologically determinate matter whether that feature is a composite-actor.[176]

Given this indeterminacy concerning composite-actors, should we simply deny their existence? Might we rather suppose that the only physical entities are elementary-actors?

Perhaps. But to do so seems unattractive: it would deny existence to most of the interesting features of the world (e.g. non-elementary things and processes), including ourselves and the entities which provide evidence for the existence of candidate elementary-actors.

A more attractive idea may be that there is a difference in the nature of existence of elementary-actors on the one hand and composite-actors on the other. Perhaps it might be supposed that the nature of composite-actor existence is derivative from, or perhaps impoverished (in some sense) with respect to, the existence of elementary-actors.

I shall remain agnostic on such questions and simply suppose that elementary-actors exist as elementary-actors and composite-actors exist as composite-actors.

We should note explicitly that this account of the existence of actors remains agnostic as to the ascription of any ontological priority as between elementary-actors or composite-actors (or perhaps some higher-level such as the total ontology)[177] – rather this account allows that the ascription of any such priority may be determined on empirical grounds perhaps case-by-case.[178]

The acting together of these parts is not bring about the next stage of this acting together. For example, the moon and I gravitationally act-together throughout my life – but it would be a mistake to claim this acting-together is surviving through time. Rather, the Earth and the Moon is a surviving acting-together – where the Earth encompasses for this purpose all of its massive components (including myself).

[176] Existing and surviving are then differing ways of saying the same thing in respect of composite-actors. We derive the meaning of these terms empirically. As we shall make explicit in section 19.3, such empirical methods turn out to be consistent with the ontology which we will specify, viz AAO.

[177] See, for example Inman 2018 (substantial holism) and Schaffer 2010 and 2018 (priority monism).

[178] If electrons are taken to be elementary-actors, then contemporary physics typically takes the acting-together of a pair of an electrons in an entangled state to be ontologically prior to the composing electrons (which might now be viewed as potential rather than actual). So it seems this is a case where ontological priority will generally be ascribed to a level above that of the elementary-actors. (See section 20.1.1 for discussion of issues which are relevant here.)

10.3 Composite-actors: some key points

10.3.1 Composite-actors are lasting

A surviving acting-together must obtain over some period of time, not just at a single point in time. I do not posit any meaning for surviving in relation to a putative entity which exists at just a single point in time. We may abstract how a surviving acting-together is at a single point in time, and perhaps take this abstraction to be a point-in-time (potential) part of that surviving acting-together (i.e. composite-actor). But there is no sense in which a composite-actor is built from such point-in-time (potential) parts.

As a composite-actor is a surviving acting-together, each temporal stage (part) is brought about by the acting-together of parts at earlier stages. The temporal stages (parts) of a composite-actor cannot therefore be separated from that actor except by abstraction – they are stages of the continuous bringing about, the surviving of the acting-together. A composite-actor, a surviving through time, is ontologically prior to its temporal parts (each abstracted stage of the surviving acting-together).

A composite-actor is therefore lasting.

10.3.2 Composite-actors can act

A composite-actor is at each stage a configuration of actors, so that it too can act – its acting in some respect is the collective acting in that respect of the actors which are its parts.

10.3.3 Composite-actors are physical and generally, at least, spatially-extended[179] and heterogeneous

Each stage of a composite-actor comprises a configuration of parts acting together – as the parts are physical, so the configuration at each stage is physical – and hence the composite-actor is physical.

The parts are not, typically at least, spatially coincident, so that even if the parts are spatially located at a single point, the acting-together of these parts is typically spatially-extended.

[179] I use the term *spatially-extended* to describe an entity which is spatially located, but not just at a single point in space – e.g. it may have some density function over a region of space, or perhaps have parts (perhaps themselves spatially-extended) which are located at differing (perhaps non-contiguous) spatial locations.

A composite-actor which is spatially-extended features at each stage parts (typically of differing types) at differing locations typically acting and changing in differing ways – in this sense, such a composite-actor is heterogeneous.

10.3.4 Composite-actors are (generally at least) life-cycled

Composite-actors, generally at least, are *life-cycled*: that is to say they have a life-cycle which comprises (1) coming in to existence, (2) surviving through some period and (3) going out of existence. These three life-cycle periods are indicated in Figure 9.3.

The coming into existence of a composite-actor may itself be a process: the process of the parts of the composite-actor coming together, becoming suitably spatially organised, and starting to act together in their roles within the new composite-actor. This process of coming into existence may come about by the acting of one or more other actors. Alternatively, a composite-actor may come about by accident.

10.3.5 Composite-actors exist in some context

Figure 10.1 shows the situation of a typical composite-actor (labelled in the figure 'target composite-actor'). Composite-actors rarely, if ever, exist in complete isolation, but rather they exist in the context of other actors with which they may act, where this acting may bring about changing in the neighbouring actors and/or the target composite-actor.

Some composite-actors exist robustly across a wide range of differing contexts to which they may typically be exposed. Examples may be things such as atoms, molecules, bundles, artefacts, and organisms. In such cases, the actings of the parts of the composite-actor typically dominate (compared to the salient actings of the context) the changing of that configuration of parts to a large degree in a way that underwrites the composite-actor's surviving. For example, the acting together of the parts may yield mutual bindings that underwrite the on-going juxtaposition of these parts across many contexts, and hence their surviving. In such cases, neighbouring actors may be in the locality by accident – they might then often be regarded as interference with respect to the target composite-actor.

In other cases, a composite-actor is dependent for its surviving through time on aspects of the context in which it obtains – some examples are noted in the discussion of criteria (h) in Section 9.1. A swinging pendulum must act with a large local mass (such as the Earth) in order for the swinging to obtain. Sometimes the context must deliver things to the target composite-actor at suitable stages in order for it to survive, as when other parts of an organism ensure the delivery of oxygen and nutrients to an organ. Sometimes the context must transport certain parts that leave the composite-actor away from the vicinity. Sometimes a target composite-actor acts with actors in the environment in order to attain or maintain some spatial configuration of its parts, as when a protein acts with a chaperone in order to become suitably folded.

The dependency of a composite-actor on its context may be common when the relevant neighbouring actors are other parts of a larger composite-actor of which the target composite-actor is also a part, so that there may be a considerable degree of stability in these neighbouring composite-actors over time, i.e. stability in the relevant context. Here the dependent composite-actor may co-evolve with the larger composite-actor of which it is a part, e.g. a part of an organism with an organism, an organism with a group of organisms. Often a composite-actor (e.g. a river, an organism) may evolve in the context or some environmental context, e.g. climatic context, which then provides sufficiently stable conditions which license the surviving of that composite-actor.

Many composite-actors with process characteristics may typically only obtain within the context of suitable configurations of parts, where perhaps these configurations are brought about by a complex thing. A thing-supporting-a-process[180] may enhance the robustness of the process it supports by protecting it from interference. Examples of processes which may be fairly robust are a run of an experiment (which obtains within a carefully prepared experimental set-up), the production and delivery of a drink when a coin is inserted (which obtains within a vending machine), or the transmission of an action potential (which obtains within a neuron). In such cases, the actings of the parts of the composite-actor, perhaps together with stable features of the facilitating context, dominate the salient local changing, so as to underwrite the robust transition of the process across its various stages.

Other processes may occur within configurations of parts which are thrown up accidentally within a complex of actors, and which may be transitory. Some such processes (e.g. lightening, (snow) avalanche) may be robust. In other cases, the acting of the parts of the process may typically be less dominant with respect to the changing which happens to this configuration of parts, so that such processes may typically be less robust and less easy to type-classify – and may generally be of less interest. The examples of composite-actors set out in chapter 9 are of more robust composite-actors.

10.3.6 Composite-actors lack determinate boundaries

Composite-actors, typically at least, fail to have determinate boundaries. The following are respects in which the boundaries of a composite-actor may fail to be determinate:

- The spatial boundaries between the parts (which are themselves actors) of a composite-actor may not be determinate. For example, we might suppose that a horse is the acting together of (inter alia) a heart, blood, arteries, capillaries,

[180] See section 9.1, criterion (d).

lungs, and muscles. But these parts of the horse may not have exact boundaries one from another, e.g. there may not be an exact boundary between the heart and connected arteries or between lungs and capillaries.

- Some composite-actors involve things joining a target composite-actor and taking on roles as parts of this composite-actor during its currency, as in Figures 9.3 and 10.1. Similarly, some composite-actors involve parts leaving during the currency of that composite-actor. For example, water molecules may join or leave an organism. But there is in general no exact point in time at which such an actor begins to be a part of the target composite-actor, nor an exact point in time at which a part leaving a composite-actor ceases to be a part. For examples, a water molecule within the water of a watering-hole may be drawn into a horse's mouth, down its oesophagus and into its stomach, and thence perhaps take part in chemical combination resulting in the formation of working parts of the horse – but the exact point in time at which this water molecule became a part (or a part of a part, etc.) of the horse may not be determinate. The boundaries of a composite-actor may not be determinate with respect to the parts joining or leaving that composite-actor during the stage in which they are joining or leaving.
- The temporal boundaries of a composite-actor may be indeterminate, both at the start and end of that composite-actor. Typically, there is a period during which a composite-actor comes to be – for example, a period during which certain actors come together and take on their functions within the new composite-actor. Before this period during which the composite-actor comes to be, it is clear that the new composite-actor does not obtain whilst after this period it does obtain. But, in general, there is not a single determinate point in time at which the composite-actor begins. For example, neuro-transmitter particles may cross a synapse and dock with receptors in a target neuron hence leading to the firing of that neuron – but there does not seem to be a single point in time at which such firing starts. Similarly, the ending of a composite-actor may involve the parts of the composite-actor becoming separated, but no determinate point at which separation may be taken to occur.
- The boundaries of bundles (see Chapter 8 - e.g. a body of water, a mountain) may be subject to indeterminacy with respect to their exact limits, so that it may be indeterminate whether actors near the spatial limits of a bundle are, or are not, a part of that bundle, e.g. whether some specific expanse of rock is part of a mountain.

10.4 Continuants – a comparison with composite-actors

In order to bring out more clearly the distinctive characteristics of composite-actors and their existence, it may be helpful to contrast them with the more familiar metaphysical notion of continuants.

I do not posit the concept of *continuant* as having any application to the ontology of the world – and hence do not seek to offer any precise account of what a continuant is. Rather I use the term as capturing roughly the family of meanings ascribed by metaphysicians who do posit continuants[181], including, perhaps most notably, those who posit *substances*. The many accounts of substances on offer include those according to which the existence of a substance is underwritten by a spatio-temporal co-location of properties (perhaps instantiations of universals), bundling relations, bare particulars, haecceities, monads and forms (e.g. Aristotelian, Platonic).

I suppose that, at minimum, an entity being a continuant entails that that entity at any given time at which it exists is numerically identical to that entity at any other time at which it exists. The following diagram illustrates this point.

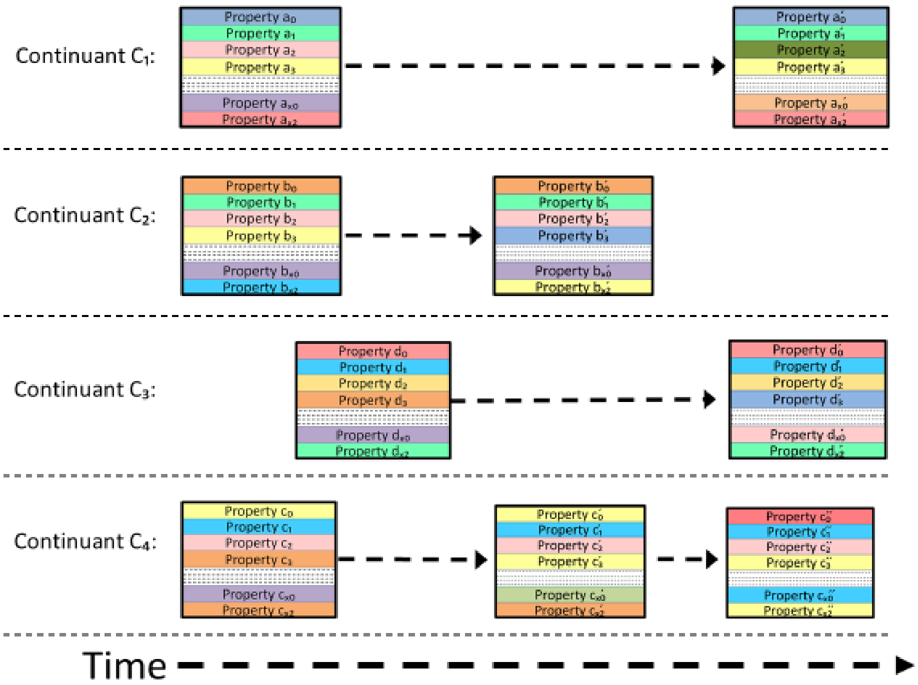

Figure 10.2: A representation of continuants

Each box represents a continuant at some time. The horizontal arrows represent the passage of each continuant through time. The first box on the continuant C_2 row, for example, represents the continuant C_2 at an earlier time, and the second box represents C_2 at a later time – it is supposed that the entity represented by the first box is numerically identical to the entity represented by the second box.

In order to aid familiarity, the figure reflects the popular view that a continuant may be wholly characterised by a list of properties at each time, where at least some of these properties may differ from one time to another - e.g. a dog may be dry at one time and wet at another.

[181] See Steward 2015 for a helpful recent discussion of the use of the term *continuant*.

10.4.1 Composite-actor vs continuant existence

Composite-actor existence is radically different from the existence of continuants, such as substances. Continuant existence is typically posited by metaphysics to be a determinate matter: a continuant either exists or not at any given time[182], as represented by the sharply-defined boxes in Figure 10.2. A composite-actor, by contrast, may be pictured as an intertwining of strands of spaghetti within a larger spaghetti of intertwining strands, as in Figure 10.3. (Where the strands are intertwining in the figure, it is supposed the actors they represent are acting together.)

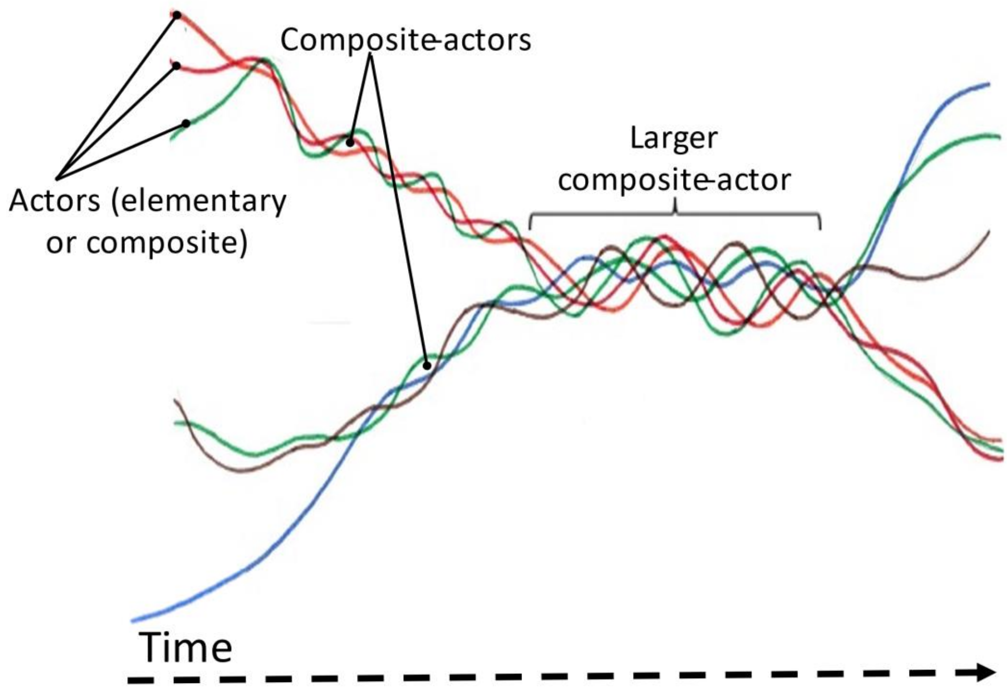

Figure 10.3: A representation of actors acting-together to form composite-actors

Where a complex intermingling of composite-actors (strands) obtains, it may be an ontologically indeterminate matter as to what composite-actors obtain. This may be especially the case during the period in which a composite-actor is coming to be or ceasing to be - as we have noted, the exact time at which a composite-actor comes into being may be indeterminate.

10.4.2 Identities are not posited in respect of composite-actors

To posit the existence of a composite-actor, such as the target composite-actor depicted in Figure 10.1, is to suppose that the acting-together of parts at stage P_1

[182] Where such existence is typically posited as requiring the satisfaction of certain identity or persistence conditions or relations.

survives through time (by the acting together of parts in the given context at each stage) to bring about stage P_2. Such surviving, and hence existence, is a phenomenon of the physical ontology – identities are not posited.[183]

In contrast, it is generally supposed that a continuant has some identity, and that the continuant at one time is numerically identical to that same continuant at another time (as in Figure 10.2), so that existence through time of the continuant is associated with transtemporal numerical identity.

This is an important respect in which composite-actors differ from continuants.

10.5 Conclusion

Actors comprise the entities in the world that are generally taken (by folk and science) to be things or processes.

Composite-actors are the acting-together of parts where this acting-together survives through time. Surviving is a physical criterion of existence – the nature of this criterion may be derived from empirical consideration of the examples of surviving acting-togethers that we find in the world (as in chapter 9).

Composite-actors are lasting, able to act, spatially-extended, heterogeneous, and life-cycled - they exist in some context and lack determinate boundaries.

Composite-actors are very different from continuants, the entities more typically posited by metaphysics. The contrast is reflected in the marked differences between Figures 10.3 (together with Figure 10.1) which indicates the spaghetti-like nature of a lasting ontology, and Figure 10.2 which illustrates the box view widely posited by contemporary metaphysics. The spaghetti diagram (Figure 10.3) points to the lack of clear boundaries of composite-actors: composite-actors have actors as parts and are themselves typically parts of larger composite-actors – composite-actors are intimately interconnected. It will be helpful for our future discussions to label the nature of the existence of composite-actors which we have identified: I shall call this *subtle-existence*.

[183] I set out an account of knowledge which is consistent with this absence of identities in chapter 13.

Section IV: Arrangement and super-ontology

11 Arrangement and super-ontology introduced

In section I and II I introduced, discussed and adopted lasting, changing and acting as features of AAO, noting their mutual interdependence and setting out some preliminary (and important) arguments for lasting-changing-acting ontologies. In section III I characterised the physical beings posited within AAO: actors. I characterised elementary-actors and introduced surviving as the criterion of existence of composite-actors.

It is now time to explicate the key role of arrangement within this ontology – and to set out an account of the nature of the existence of certain arrangements that obtain. Arrangement, as we have noted, is the second of the twin keystones of AAO alongside acting. Setting out this account of arrangements, and the nature of the existence of certain arrangements, will provide the basis for setting out an account of (what I call) the *super-ontology*, as I shall explain.

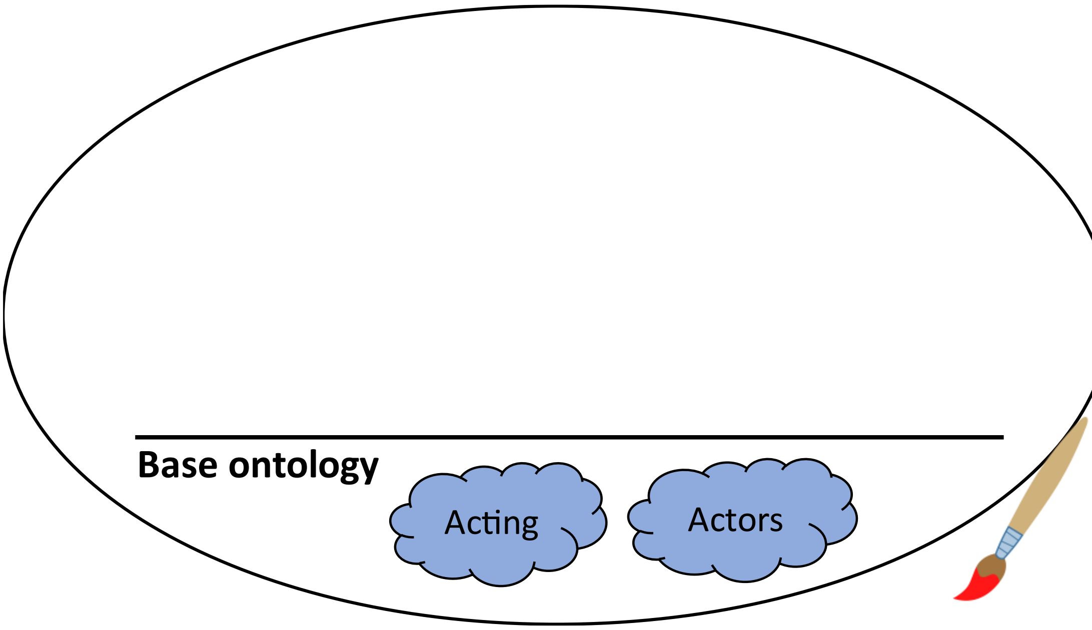

Figure 11.1: Sketch of the AAO base ontology

So far, I have set out an account of the *base ontology* – see Figure 11.1. I take the base ontology to comprise all of the actors obtaining in space and time. We have noted that acting is not an entity, but rather it is a principle of change – and we have recognised that this principle is ontological[184]. As we have located actors in the base ontology, and these are the entities that act, it is appropriate to include acting too within the base ontology.

In one sense all there is to the ontology of the world, according to AAO, is the obtaining of the base ontology.

[184] Chapter 6.

11.1 The acting-trajectory basis of ontology

We admitted composite actors into the ontology so as to include humans and our measurement devices: without these our consideration and claim to knowledge of the ontology seemed to threaten paradox.[185] However, as we have seen, composite-actors are built iteratively from the acting together of elementary-actors – so that, in this sense, we might take elementary-actors to form a narrower base ontology.

An elementary-actor may be fully characterised by its trajectory – its spatial locations over time[186] - and its acting. Hence, at the base of AAO we find just trajectories and acting.[187] We do not find entities that might be called properties – neither qualities nor powers (although, as we shall see in chapter 12, we may characterise actors and refer to these characteristics as properties if we wish).

This *acting-trajectory* basis of ontology is radically different from nearly all popular accounts of ontology – standardly accounts of ontology take properties as entities within their base ontology. I shall argue (in the assessment in chapter 19) that this acting-trajectory basis fits well, perhaps uniquely well, with contemporary physics – and that it supports great parsimony.

11.2 Arrangements and super-subtle-existence

The parsimony of the acting-trajectory base of AAO is promising – but for it to be of value, we need to show how this base supports the existence of the many features that we desire within our ontology, such as properties (including powers), natural kinds and laws. Like many philosophers (such as David Lewis), we must show how desired ontological features obtain on account of our chosen base ontology. On the AAO account, spatial arrangements play a central role in the obtaining of these desired derivative features. It is time, then, to look at *arrangement*, the second eponymous keystone of AAO alongside acting.

As actors come with spatial locations, a plurality of actors comes with the spatial arrangement that is implied by those locations. When we put three objects on a table (not in an exact line) we have a triangle (formed by the points marking their centres of gravity say) – whilst the objects remain, the triangle remains. I shall say that the three objects give rise to the triangle, or that the triangle obtains on account of the three objects.

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[185] See section 10.2.

[186] I suppose that a trajectory entails some specification of space occupancy at each time, whilst maintaining a liberal position on how space occupancy may be characterised – e.g. as a density function, a bounded region (or set of bounded regions), or perhaps just a single point.

[187] See the characterisation of *elementary-actors* at the start of chapter 10 (which refers in turn to the characterization of lasting in chapter 3).

Where a plurality of actors comprises a surviving acting-together, i.e. a composite-actor, the (evolving) spatial arrangement of the actors (the parts of the composite-actor) exists as an on-going characteristic of that acting-together. I have termed the nature of existence of a composite-actor *subtle-existence.*[188] I shall term the nature of the existence of the arrangement of parts of a composite-actor *super-subtle-existence.* The 'super' prefix here is intended to reflect the fact that the arrangement exists (in its own sui generis sense) over and above the existence of the individual actors in that arrangement, or indeed the plurality of those actors (considered as a set say). In the case of actors generally taken to be things, this arrangement of parts may often exhibit a high degree of stability, whilst in the case of processes this arrangement may typically evolve over time.

I draw attention to arrangements, and in particular the arrangements of parts of composite-actors, and the nature of their existence, as they are key to the nature of ontology on the AAO account. Arrangements are a key determinate of how the entities in those arrangements may change. They are key to the existence of composite-actors and the change which those actors may bring about – their powers. Super-subtle-existencies may be understood as underwriting composite existence (subtle-existence).

I show in what follows, how arrangements, especially super-subtle-existencies, license resultant-novelty: the obtaining (inter alia) of properties (including powers) of a whole which are not properties of its parts but which result from those parts, in a sense that I shall make explicit. [189] I shall show, too, how super-subtle-existence disarms the problems associated with causal exclusion.[190] At their most general level, these problems suppose that no genuine causal efficacy can be ascribed to a higher-level entity, as all such efficacy must drain down to the lower-level entities which underwrite the higher level – the nature of such higher and lower levels following from the specific ontology that is in focus. [191]

11.3 Super-ontology

The main work of this section IV, which I shall undertake in chapters 12-18, is, then, to show how many features that we find in the ontology of the world obtain on account of (arise from)[192] the base ontology. I call the collective of these derivative features the *super-ontology* of AAO. As we see in Figure 11.2, the main features on which I shall focus are properties (including powers), knowledge, language, truth, natural kinds, causal relations, regularities, laws, possibilities and probabilities.

[188] At the end of chapter 10.
[189] Especially in section 12.4.
[190] Section 12.5.
[191] See, for example, Kim 2018.
[192] I use the terms '*obtains on account of'* and '*arises* from' as neutral placeholders for the ontological dependence of the feature of the super-ontology upon the base ontology. I set out an account of how the super-ontology feature obtains on account of the base ontology in each case.

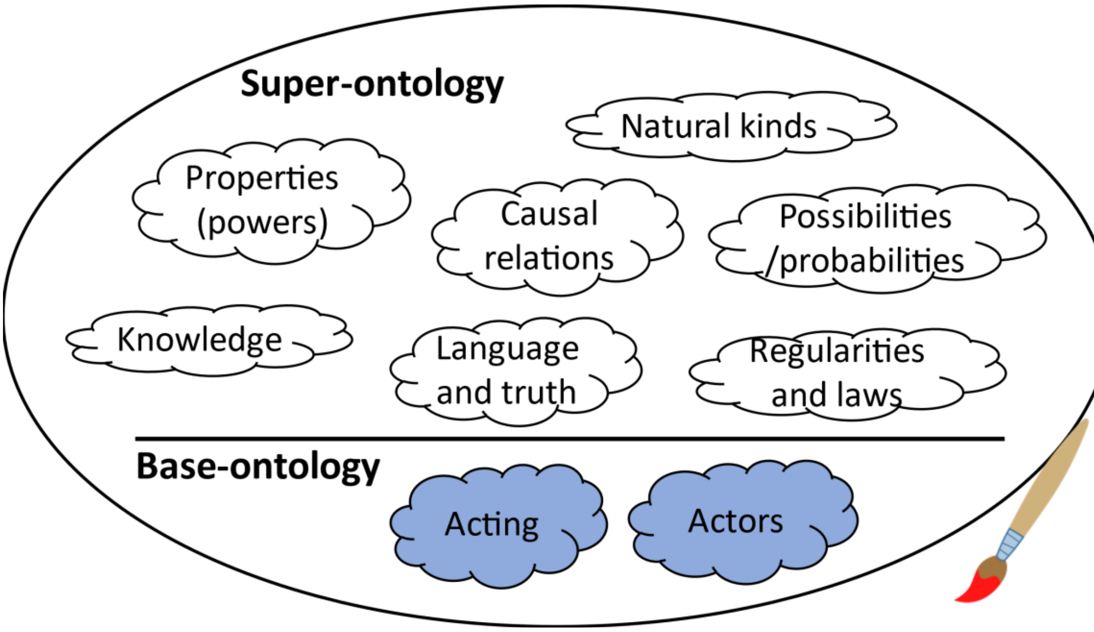

Figure 11.2: Plan for sketch of AAO super-ontology and base ontology

In each case, I shall explain how actors and their arrangements, in differing ways, underwrite the obtaining of the features of the super-ontology that is in focus. I thus set out a compelling explanatory treatment of these features: they are not simply brute additions to the ontology, or required background to the ontology with perhaps opaque ontological standing[193], but rather they may be expected and accounted for given the base ontology. The ability to provide this principled account of the features of the super-ontology is, I shall suggest (in the assessment in chapter 19), a source of parsimony and strength of AAO.

11.4 Summary and plan

The account of the features of the super-ontology set out in the following chapters (which form Section IV) complete the provisional account of AAO that I set out in this thesis. I shall set out an assessment of this ontology in Section V.

[193] I shall draw attention in chapter 19 to the opaque ontological status of features such as truth, logical principles, principles of best systems, metrics across possible worlds, etc. within mosaic ontologies.

12 Properties (including powers)

This chapter focuses on the first of our chosen features of the super-ontology: properties. I shall explain what properties are on the AAO account, and how they obtain on account of the base ontology of AAO, so that they are features of the super-ontology.

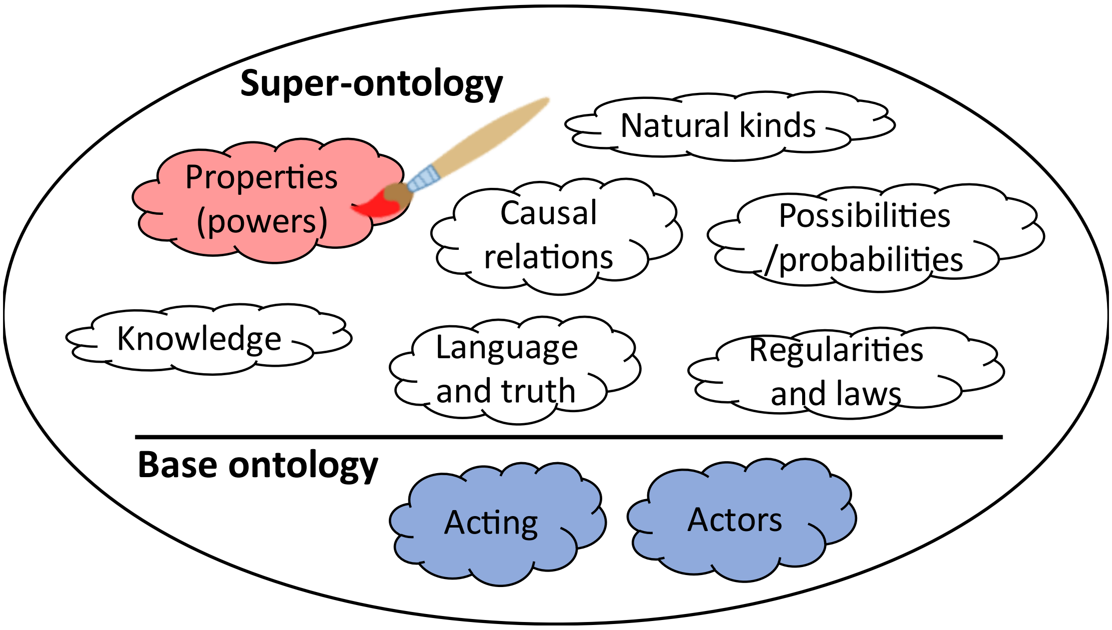

Figure 12.1: This chapter sketches properties as a feature of the super-ontology

We have recognised the acting-trajectory basis of AAO[194], noting that there are no entities that might be called properties at the base of AAO. Folk and science do, though, suppose that things and processes have properties (including powers), at least in a rough everyday sense, where these properties are how actors are (more specifically in the case of powers, what these actors can do). Consistently with folk and science, I shall call a way in which an actor is a '*property*' of that actor – but I shall not posit any entities associated with properties.[195] In chapter 9 we identified many of these ways that actors are in setting out criteria (a) – (j) for classifying actors[196] – we may call these ways that actors are characteristics or properties of an actor. Paying attention to how actors are in other specific respects (perhaps what they can do in specific types of circumstances) yields many further possible ways of characterising the ways an actor is, and hence properties in our terms.

Elementary-actors have the ability to act, so that we may characterise an elementary-actor as being able to act in certain ways in certain circumstances (typically positing a power when this acting is sufficiently consistent). But I do not

[194] Section 11.2.

[195] I classify a power as a type of property: how an actor is in the sense of its ability to bring about change under certain circumstances – but nothing hangs on whether we take powers to be properties or not.

[196] As noted in chapter 9, this list of criteria might be extended or refined.

suppose that this ability, this power, is some further entity.[197] There may also be other ways in which elementary-actors are – for example, they might perhaps be point-like or occupy space in some other characteristic manner. Again, we do not need to posit such ways of being as requiring further entities, property-entities say.

Properties (including powers), then, are the ways that actors are – they are characteristics of actors. For composite-actors, these characteristics are fixed by their parts and how the parts are arranged and act together (or, in the case of elementary-actors, by how that elementary-actor is). There is no need for any further entities, property-entities say, to fix the way that actors are – indeed it is not clear how any such entities could help to fix the way that actors are on this account. No such property-entities are posited within AAO.

According to many other available ontologies, a property is an entity which attaches to, or is a part of, (in some way) a continuant. The long history of discussion of properties thus conceived has posited many widely differing notions of what these are, developing technical terms associated with this variety of meanings, e.g. ideas, forms, accidents, instantiated (immanent) universals, tropes, modes.[198] These accounts of properties, at least typically, suppose that a property (in whichever way it is 'attached' to it) determines how the property-bearer is in the salient respect. For example, for Plato of the Timaeus objects participate in forms which determine how the object is; for Lewis (and many other contemporary philosophers) entities are compresences of properties at space-time points. On my account, by contrast, a property plays no role in informing how a property-bearer is, but rather characterises how it is – how it is is fixed by the base ontology.

To characterise an actor in some such way, i.e. to identify a characteristic or property of an actor, may be helpful for salient purposes. This use of the term 'property' as a way an actor is, accords broadly with common usage of the term amongst scientists and folk.[199]

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[197] How could God set up elementary-actors to act without needing power-entities? An occasionalist-inclined God (see Lee 2020) might bring about the acting of each elementary-actor directly by intervening during each period of time (doing so in a way that finesses the no-successor problem). Alternatively, a more efficiently-minded God might imbue each elementary-actor with an ability of acting in the right way in each circumstance, and mandate them to do so. In this latter case I suppose that God imbues this ability without creating any additional entity. This would be consistent with a parsimonious God: there are no other property entities in the ontology- it would seem curious to create this type of entity just for here. There are other ways God might set things up without power-entities. In any case, we may sometimes correctly characterise an elementary-actor as acting in the salient ways in the salient circumstances – and it is such a characteristic that I dub a power (an acting-power). But in AAO I suppose that such characteristics are not entities. Still, some might find it preferable to suppose that God does choose to make elementary-actor abilities entities: I leave it to others to explore such ontologies.

[198] For a discussion of properties see e.g. Orilia and Paoletti 2020. Perhaps the richest discussion of properties was that of the scholastic period – this topic alone occupies a considerable portion of Robert Pasnau's extensive discussion of metaphysical themes of this period (Pasnau 2011). Some accounts of properties, such as the class nominalist (see Quinton 1958) or ostrich nominalist (see van Cleve 1994) accounts, do not posit property-entities – but they differ from AAO in not positing a prior ontology which dictates how the entities described by properties are.

[199] Of course, as noted, metaphysicians may often adopt technical meanings for the term 'property'. Often, they may restrict the range of characteristics which are admissible as properties, e.g. perhaps

This account of properties requires to be supplemented by an account of how it is that people can successfully come to know such properties, and hence to agree (at least to a great extent) with other people as to what properties an actor has. I set out an account of knowledge, including that of actors and their properties, in chapter 13 to address this requirement.

Properties may be classified as either *powers* or *non-powers* – and there may be borderline cases (e.g. hot – see below) not readily classifiable into either grouping, or perhaps classifiable into both groupings (see Figure 12.2).

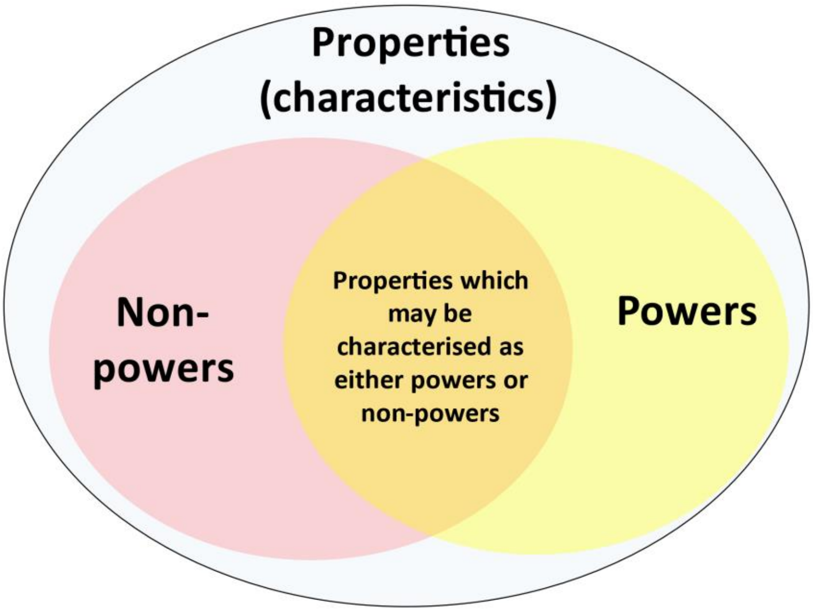

Figure 12.2: Properties (characteristics) of actors may characterised as powers, non-powers, or borderline

As properties are not entities, any such classification into powers / non-powers is not an ontological matter – rather it serves to connect the given description of properties with folk and scientific intuitions, and hence with standard usage of these terms. Generally speaking, properties that characterise an ability of an actor to bring about change are called powers, and other properties are called non-powers. Many properties, such as hot say, may be thought of in terms of how that object is (e.g. the average speed of its particles) and what it can do (e.g. its ability to heat other nearby objects) – so that the classification is not clearcut.

As acting is the only[200] type of modal[201] principle in the ontology, the consistent acting of actors is the source of all of the (non-accidental) regularities that we find in

disallowing some that fall under some of criteria (a) – (j). My use of the term 'property' does not, of course, accord with all the details of all such technical metaphysical usages.

[200] One might also, if one wished, take the existing through time of an elementary-actor to be another (i.e. other than acting) principle that may underwrite certain modal claims.

[201] I take the term 'modal' to have its standard contemporary philosophical meaning. The Stanford Encyclopedia of philosophy, for example, states, 'A modal is an expression (like 'necessarily' or 'possibly') that is used to qualify the truth of a judgement' (Garson 2023, 1).

the world. Such consistent acting may be characterised by acting-powers, i.e. powers that bring about synchronic changing. I began setting out an account of acting-powers in chapter 6 (as these brief comments were helpful in supporting an explication of *acting* itself). I develop this account more fully in section 12.1, showing how acting-powers arise from the base ontology, and are therefore features of the super-ontology.

I then set out, in section 12.2, an account of diachronic powers, showing how they too derive from acting and hence from the base ontology. Section 12.3 addresses non-powers, showing how they too arise within the base ontology.

In section 12.4 I explicate the idea of *resultant novelty*. I shall show how composite-actors may have genuinely novel powers which result from the spatial coordination of the powers of their parts. These powers, although novel, are 'resultant' (as opposed to 'emergent') in the sense of the terms used by, for example, the British Emergentists.[202] I show, too, how composite-actors may have novel (yet resultant) non-power properties.

In section 12.5 I shall explain why the powers of composites do not fall foul of causal exclusion issues – they do not conflict with the powers of their parts in a way which might threaten any form of causal over-determinism.

Section 12.6 concludes.

12.1 Acting-powers

We suppose that elementary-actors act. If they act consistently within configurations of some type, we may ascribe a power to the elementary-actor, an acting-power, which describes this consistent acting.

Composite-actors also act. Again, where a composite-actor acts consistently within configurations of some type, we may ascribe a power which describes this consistent acting. The acting of a composite-actor in some respect (i.e. in respect of some salient changing) is the joint acting of the parts of the composite-actor in that respect. We may suppose that the acting of a composite-actor is consistent when its parts and their arrangement is sufficiently stable, and the acting of the parts is consistent across the salient contexts. Such stability of parts and arrangements are typically associated with things rather than processes – so that acting powers are more typically associated with things rather than processes.[203]

[202] See for example McLaughlin 2008. I do not posit any 'emergence' within my own account, nor do ascribe any meaning of my own to the term 'emergent'.
[203] However, the final stages of a process may often be thing-like and hence have acting powers, e.g. the cup of tea in the vending machine output bin, the cloud of neurotransmitter particles in the far synapse.

For example, consider an iron knife, a blade-shaped bundle of a large number of iron atoms, which is cutting some ham. The parts of the knife (the iron atoms) are acting together maintaining the bonds of the iron atoms and hence (roughly) the shape of the knife. As the knife is pressed into the ham, it is acting – it is cutting the ham. The acting of the knife is the coordinated acting of the parts of the knife (the iron atoms), perhaps the coordinated pushing of these atoms, in respect of the ham (where these parts are acting together to retain their spatial configuration, i.e. the shape of the knife).

As another example, consider a thing which hosts a process: the running engine of the motorbike described in Section 9.1 (d). The engine acts to turn the rear wheel and hence accelerate the motorbike – this acting is the manifesting of an acting-power of the engine, the power of turning the rear wheel / accelerating the motorbike. Whilst the engine is acting in this way, the parts of the engine retain their appropriate bindings to each other, so that the internal changing of the engine (e.g. the moving up and down of the pistons) is constrained to an appropriate locus of change. The acting (i.e. turning the rear wheel) of the engine as a whole is the collective acting of the parts of the engine – this collective acting, inter alia, underwrites certain sufficiently stable juxtapositions (or perhaps constrained loci of movement) of the parts of the engine.

I wish to show that acting-powers are features of the super-ontology – that is to say that they arise from the base ontology: from the acting of actors in certain spatial arrangements we may suppose.

Acting-powers of elementary-actors are just the consistent acting of elementary-actors across types of spatial configurations – e.g. the consistent gravitational attracting of other actors by GMm/r^2. The base ontology does give rise to this stable pattern of acting, so that the acting-powers of elementary-actors are features of the super-ontology.

Similarly, the acting-powers of composite-actors are just the consistent acting of those actors across certain types of contexts - so these, too, arise from the base ontology. As we have noted, in the case of composite-actors we may account for such consistent acting by consideration of the parts of the composite-actor: the consistency of the parts, their arrangement and their acting. We may suppose that the spatial arrangement of the parts of the composite-actor – which has super-subtle-existence – coordinates the acting of the parts so as to license each power of the composite. Here we see more explicitly how arrangement plays a central role in underwriting a feature of the super-ontology: the acting-powers of composite-actors. (Note that the super-subtle-existences themselves are underwritten by the consistent acting of actors – i.e. by acting-powers.)

12.1.1 The diversity and nature of acting-powers

The acting-powers of a thing derive from the types of parts of that thing and how they are spatially arranged and act (e.g. bind) together. As we find widely differing actors in the world, so we find widely differing acting-powers.

In the case of elementary-actors, acting may be attracting or repelling in accordance with the fundamental forces posited by physics – such acting is homogeneous through time, we may suppose. In the case of composite-actors, the acting may be associated with changes at the level of the parts which are not entirely homogeneous through time. For example:

- Heating may involve the accelerating of individual molecules (or atoms, etc.), i.e. parts of the composite-actor (such as a hot iron bar or stone), through collision.
- Cutting involves, inter alia, the breaking of individual chemical bonds.
- Dissolving (typically) involves the breaking of individual chemical bonds and the formation of others.
- Pumping typically involves fluctuation in the level of pressure exerted by the pump (as it accepts in and then pushes out the liquid being pumped).
- Turning of the crankshaft (and hence accelerating of the motorbike) by the engine involves sequenced cylinder explosions, so that it is not entirely even through time.

The composite-actor (e.g. hot object / knife / solvent / pump / engine) is nevertheless acting through time as it is bringing about changing through time within the larger configuration of which it is a part (i.e. it is heating, cutting, dissolving, pumping, turning).

More complex things, such as organisms, may act in ways which are temporally less homogeneous still, perhaps in bringing about change via periods of episodic acting (e.g. building a nest out of sticks).

Acting-powers also vary considerably as to the types of configuration in which they manifest. It seems that the acting-powers of elementary actors, perhaps attracting and repelling in accordance with the fundamental forces of physics, may manifest in at least a very wide range of (perhaps all) configurations. Many acting-powers of more complex things, by contrast, may typically manifest in a narrower range of configuration types: a knife must have its sharp edge in contact with cut-able material; a pump must be located within a suitable configuration of liquids and tubes arranged in specific ways; electrical components (e.g. resistors, capacitors, transistors) must be suitable located within an electrical circuit in order to act in their characteristic ways.[204]

[204] In many cases, the manifesting of acting-powers within a configuration may yield stasis (or at least maintaining within certain ranges) of salient macro parameters. Such acting to yield parameter stasis may help to underwrite the survival of things - maintaining juxtapositions of parts is one key example, but maintaining sufficiently stable temperature, chemical concentrations may be others. As a process

Note that all such acting-powers are features of the super-ontology.

12.2 Diachronic powers

It seems that some actors, when they are in suitable configurations, may bring about certain future circumstances: e.g. an aspirin the end of a headache, neuro-transmitter particles the firing of a neuron, a coin (inserted in vending machine) a drink in the output bin. I explain here how bringing about future circumstances requires bringing about a process, where a later stage of this process features the given future circumstances (the future circumstance is not brought about by a jump across time). I describe how we may characterise an actor according to the types of processes which it can bring about in certain circumstances (its *process-powers* and *process-part-powers*), and how these powers (i.e. characteristics) piggyback upon the consistent acting of an actor, i.e. upon *acting-powers*.

12.2.1 Process-powers

A *configuration* (some actors in some spatial arrangement) in some *context* may give rise to changing which survives through time, i.e. a process (a composite-actor which transitions through differing stages).[205] Let's call the pattern of change that occurs over time, which may be abstracted from this process, the *process-of-change*.[206] Where a process-of-change of some type arises from an identified type of configuration (within a suitable context), we may ascribe a power to configurations of that type to give rise to the identified type of process-of-change (and hence perhaps some future stage of that process) – I dub this a '*process-power*' of that configuration.

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example consider an electrical circuit. When the power supply is initially connected, there is an increase in the current flowing, but after a brief period the circuit may exhibit stability in terms of the quantum of current flowing. Typically, it is this equilibrium state of the circuit which may be salient for practical purposes. We may suppose that the parts of the circuit, e.g. resistors, capacitors, etc., have acting-powers (e.g. resistance, capacitance) such that the acting of these parts in the circuit (i.e. the given configuration) maintain this equilibrium.

[205] For an account of my use of the terms 'configuration' and 'context' see the introductory remarks in chapter 10.

[206] As noted in section 9.2, a process may be characterised according to both how it is at each stage, e.g. the nature of the parts and their arrangement at that stage (i.e. criteria (a) and (b)), and how it changes across stages (i.e. criterion (c)). A *process-of-change* may be understood as a process characterised according to criterion (c). A *configuration* may be understood as the process characterised according to how it is at the salient stage, i.e. criteria (a) and (b).

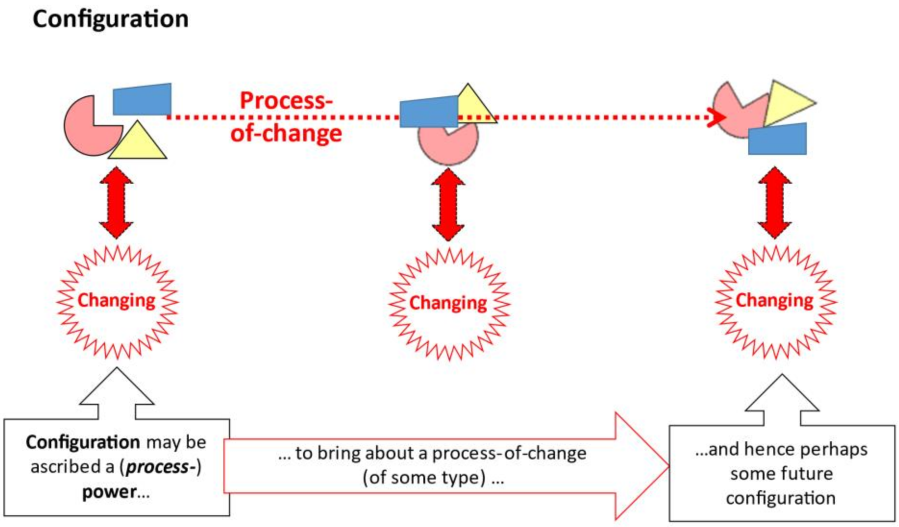

Figure 12.3: Process-power of a configuration

We may take the manifestation of a process-power to be the process-of-change which occurs. In practice, it is often some later stage (or some aspect of that stage) of this process-of-change which is salient for our purposes – we may often then focus on this particular aspect in talking of the manifestation as being this (aspect of the) later stage. (Such talk does not, of course, alter the fact that the underlying ontology of the manifestation is a process.)

Examples of manifestations of process-powers that are *beginning-to-end* processes[207] include: a vending machine with coin inserted giving rise to a process resulting in a drink in the output bin; a neuron receiving neuro-transmitter particles giving rise to the firing of that neuron; or a person with a headache swallowing an aspirin giving rise to a process resulting in the cessation of that headache. Examples of manifestations of process-powers which are *on-going processes*[208] include the swinging of a pendulum, or the running of an engine.

Where a configuration has a process-power, we may ascribe a power to a part of that configuration which is the power of that part to fulfil its role in bringing about the process (which is the manifestation of the process-power) – I dub such a power of the part a '*process-part-power*'.

[207] Section 9.1, criterion (d).
[208] Section 9.1, criterion (d).

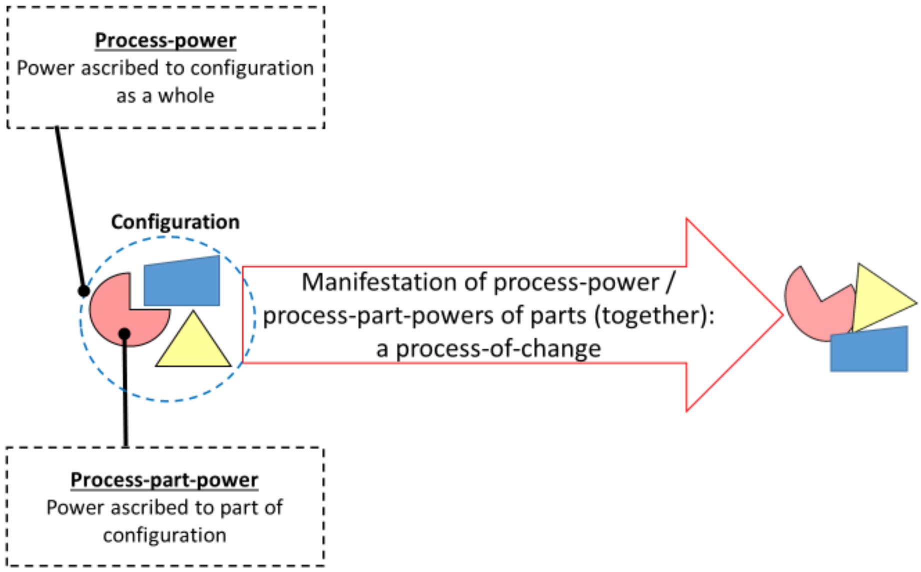

Figure 12.4: Process-part-power of a part associated with a process-power of a configuration

As an example of a process-part-power, consider the power of an aspirin to cure a headache. The relevant configuration, which has the (process-) power to give rise to the process-of-change which results in the cessation of a headache, is a person with a headache swallowing an aspirin. The relevant process-of-change transitions through a series of stages involving the actings of different parts of the configuration (the human body and the aspirin), as shown (roughly) in Figure 12.5.

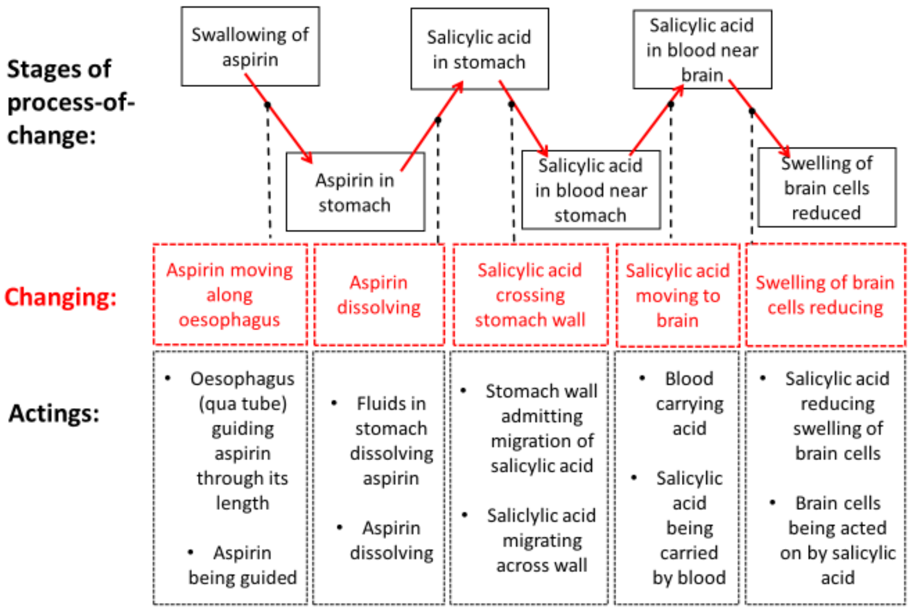

Figure 12.5: Process-of-change of aspirin curing headache

Each stage of the process involves certain parts of the overall configuration (person swallowing aspirin) acting together to give rise to changing. For example, at an early stage, the aspirin (a small solid object) and the oesophagus (a tube) act together to give rise to the moving of the aspirin within and along this tube. At the next stage, the fluids in the stomach act to dissolve the aspirin and the aspirin acts by dissolving – over time the process of the aspirin dissolving occurs. Further stages are as in the diagram. The changing at each stage is, over time, a process-of-change which leads on to the next stage. It may be noted that the original parts may not survive through the changing of the configuration over time: here the aspirin ceases to be a unity when it dissolves, giving rise to the dissolved salicylic acid, which then takes part in the remaining process stages.

We may suppose that the aspirin has the (process-part-) power to cure a headache even when it is in its bottle – but this power cannot be manifested unless it is swallowed by someone with a headache, i.e. it is in a configuration of the right type.

We may talk, somewhat loosely, of the manifestation of the process-part-power of the aspirin being the curing of a headache, as this is generally salient for us – but ontologically the manifestation of this power is a process of which the cessation of a headache is a later stage.

Although a configuration may have a process-power, the process which is the manifestation of that power may not happen if interference occurs.

Diachronic powers arise from arrangements of actors and their actings through time – hence they arise from the base ontology: they are features of the super-ontology.

12.3 Non-powers

Many of the characteristics described in chapter 9 may often be deemed non-powers, especially characteristics of how the actor is at some stage (where this stage is chosen as sufficiently brief to allow the actor to be adequately characterised in the relevant respect by a static snap-shot), e.g., the nature of the parts acting at this stage (criterion (a)) and their spatial arrangement (criterion (b)). Where many small parts are acting, as in the case of an iron knife (i.e. the iron atoms), we may often usefully summarise the arrangement by way of a macroscopic shape.

These properties, i.e. arrangement of parts / shape, offer clear immediate examples of ones that arise from arrangements of actors, i.e. from the base ontology – and hence are features of the super-ontology. All properties that may reasonably be regarded as non-powers characterise how actors are. For composite-actors, these properties are dictated by the arrangement and nature of the parts of each actor, and hence by the base ontology: they are features of the super-ontology. The characteristics of elementary-actors, too, arise within the base -ontology.

12.4 Resultant novelty

Composite-actors typically have novel acting-powers, i.e. acting-powers which are not possessed by their parts, nor merely a 'sum' of powers of their parts[209]. For example, a knife can cut, whereas the individual iron atoms which are its parts cannot; a motorbike can accelerate a rider, whereas none of the individual parts of the motorbike can do so. These novel powers of the composite-actor result from the powers of the parts in their given configuration and context: the acting together of these spatially-located parts licenses resultant novelty. The spatial locations of the parts may determine their exact acting (e.g. the strength and direction of their attracting / repelling). Importantly, these spatial locations establish, too, how the powers coordinate together spatio-temporally. How the (bearers of the) powers are spatial organised is, in general, crucial to the changing which occurs. Super-subtle-existences in particular play a central role in change. The notion of resultant (as opposed to 'emergent') novelty may seem puzzling where the implication of the spatial locations of (the bearers of) the powers is not fully recognised.[210]

Process-powers may also typically exhibit resultant novelty. A process-power characterises a type of configuration as bringing about a type of process. Typically the individual parts of such a configuration cannot bring about such a process on their own – bringing about the process requires the spatio-temporal coordination of actings of the parts (in the given context). The ability to bring about this type of process is, then, novel (as regards consideration of the abilities of the individual parts). Yet the process arises straightforwardly from the spatio-temporal coordination of the acting of the parts in this context – it is resultant

Characteristics commonly ascribed as non-powers may also exhibit resultant novelty. As a simple example consider a bundle of a large number of iron atoms such as may be formed by pouring molten iron into a mould and cooling it. The bundle may be spherical or perhaps knife-shaped, depending on the shape of the mould used. Neither 'spherical' nor 'knife-shaped' are properties of individual iron atoms. Again, the novelty arises from the spatial organisation of the parts and their acting together in this spatial arrangement – it is resultant novelty. We may note that these novel properties (commonly taken to be non-powers) may be closely associated with novel characteristics typically taken to be powers: e.g. the ability to roll, the ability to cut.

We may note too that composite-actors may also exhibit novel yet resultant behaviours – i.e. patterns of change over time. A simple pendulum, for example, may

[209] Novel powers of a composite-actor are, I take it, generally different in kind from the powers of their parts. We may, for example, allow that the mass of a composite-actor is merely the sum of the masses of its parts.

[210] Note the contrast here with mosaic accounts of composition in which higher-level properties are typically taken to 'supervene' on a set of base properties, and the focus is typically on compresence of these base properties at a (plurality of) spatial-temporal point(s). See e.g. Kim 2005. In positing spatial locations of properties and focusing on these putative locations, such approaches typically omit consideration of the locations of the bearers of the salient properties (which are generally not located at a single point) and, importantly, the roles played by the spatial arrangement of these property-bearers (which typically have extended / complex spatial locations).

exhibit swinging. This swinging can be simply explained in terms of the parts and their powers (e.g. the mass of the bob, the strength of the string tying the bob to the pivot, etc.) acting together in the given spatial set-up, but none of the parts individually (e.g. the bob, the string) can exhibit such swinging.

Might it be objected that the 'novel' properties and powers that we are considering, given that they are resultant, can simply be 'reduced'[211] to properties and powers of their parts? (The suggestion being that these properties and powers are not then novel after all.) In response to this suggestion we should note that a composite-actor exists just when the acting-together of its parts is surviving – and when this is the case, we may characterise the composite-actor as having the spatial arrangement of parts which it has – we have called the nature of the existence of this arrangement 'super-subtle-existence'. This spatial arrangement is novel in the sense that this arrangement does not characterise any of the parts individually. There is not, I suggest, any meaningful sense in which this spatial arrangement is ontologically 'reducible' – it exists qua characteristic of a composite-actor. Perhaps some may claim that the arrangement is epistemically reducible, in some chosen sense, on the grounds that given an account of each of the individual parts and their positions, we may derive the overall spatial arrangement. Even if such claims of epistemic reducibility were to be granted, they would not license ontological reducibility. The (novel) arrangement of parts exists (qua characteristic of composite-actor) when the composite actor exists. It is the existing of this novel arrangement, this super-subtle-existence, which underwrites the existing of novel properties (including powers) and behaviours.

12.5 Powers of composite-actors do not engender a causal exclusion problem

It seems that the changing (e.g. becoming divided, by cutting, of some ham) which is brought about by a thing (e.g. a knife) may be associated with both the acting of (1) the thing (e.g. the knife) and (2) the parts of the thing (e.g. the iron atoms which are parts of the knife). Does this threaten something akin to causal overdetermination and hence engender causal exclusion problems?[212]

No. The salient acting of a thing as a whole (i.e. the acting in respect of some salient changing of some larger configuration) is just the collective salient acting of the parts of the thing (where these parts are acting together, e.g. binding together).[213] (Neither the acting nor the power to act are entities.) There is no tension between (1) ascribing responsibility for the salient changing (of the larger configuration) to the thing as a whole (i.e. to all of the parts acting together) and (2) ascribing responsibility to the totality of parts (which are acting together in this configuration)

[211] I do not ascribe any meaning to 'reduced' within my own account – rather I take this term to have the meaning ascribed to it by others.
[212] Causal exclusion problems of the kind raised by Jaegwon Kim; see e.g., Kim 2005, Kallestrup 2006.
[213] Recall that I do not posit any 'emergence'.

– these are merely differing descriptions of the given circumstances. (The thing as a whole, recall, is just the acting together of the parts in this context.) [214]

As we have seen, diachronic powers piggyback on acting-powers – there is no scope for causal exclusion problems to arise at the derivative level of diachronic powers.

12.6 Conclusion

We have set out in this chapter our account of properties, our first example of a feature that arises from the base ontology to be a feature of the super-ontology. This example illustrates how the twin eponymous keystones of AAO, acting and arrangement, combine to license composite beings and yield resultant novelty whilst avoiding causal exclusion problems. We have shown, too, how we can have properties (of the kind posited) in AAO without having property-entities in the base of the ontology (or, indeed, anywhere in the ontology).

[214] The whole is one and the parts are many: the unity of the whole is the subtle unity of the surviving acting together (of the parts) in the prevailing context – an entity with subtle-existence. Note how this differs from the (purported) solution to the problem of the one and the many (see e.g. Harte 2002) offered by Lewis: that composition is 'like identity' (Lewis 1991, page 82). As Harte explains, if composition is identity, then the problem of the one and the many remains unsolved: how can the composite (taken to be one) be identical to the parts (which are many)? On the other hand, if composition is only like, but not quite, identity, then how exactly does it differ from identity? Lewis's 'solution' is at best enigmatic.

13 Knowledge

This chapter focuses on a further feature of AAO super-ontology: knowledge. The next chapter will focus on the associated features language and truth.

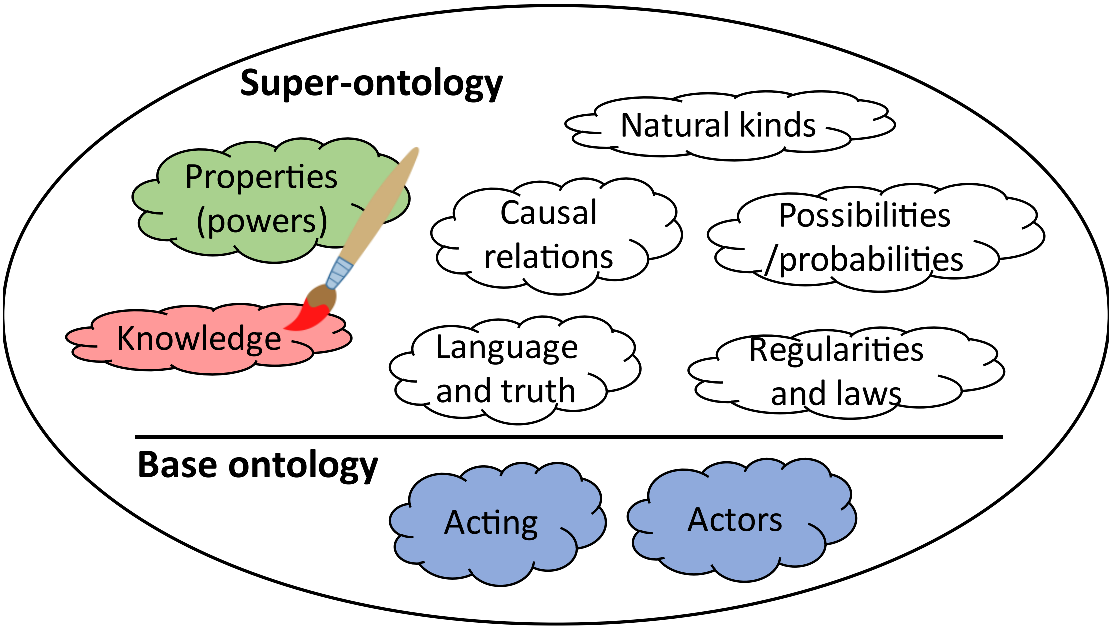

Figure 13.1: This chapter sketches knowledge as a feature of the super-ontology

An account of both knowledge and the acquisition of knowledge are required for our purposes. I present both accounts here – they are naturally interlinked.

The account of knowledge is required to show how knowledge is derivative with respect to the AAO base ontology – it arises from arrangements of actors so that it is a feature of the super-ontology. In order to show this, I set out what type of actors, and which aspects of these actors, comprise knowledge – hence showing how knowledge obtains on account of the base ontology. In the following sections of this chapter I characterise and introduce terms for certain types of actors and certain aspects of these types of actors. I shall then use these terms to set out an account of knowledge in terms of these aspects of the base ontology.

An account of the acquisition of knowledge is required in order to enable me to show that the methods that I employ in this thesis are consistent with this account of the acquisition of knowledge. Such consistency is required to render plausible the claim that this thesis develops knowledge of the world. I shall argue for this consistency in the review of AAO in chapter 19.[215]

I use the term ‘knowledge’ more broadly than do many other accounts - I include machine knowledge and knowledge of non-human organisms, as well as human knowledge, within this term. My account draws no principled distinction between machine and organism knowledge, although it recognises major qualitative

[215] Section 19.3.

differences arising from the fierce complexity of many organisms including humans, as I shall explain.

The account of knowledge that I set out here is consistent with empirical observation: wherever we attend to the referent of the term ‘knowledge’, we find physical patterns of the sort which I identify as knowledge.

13.1 Encodings and encoding-actors

An *encoding* is a *pattern*[216] of some sufficiently stable parts of an actor (an *encoding-actor*) which corresponds[217] to some feature of the world.[218] The pattern may, for example, be logico-mathematical (e.g. the pattern of an ordered series of switches or bits) or spatial (e.g. the pattern of a sketch of some spatial features – perhaps a map). The encoding pattern / arrangement may be abstracted from the relevant parts of the encoding-actor by paying selective attention to their spatial locations (and perhaps – in the case of patterns – focusing on features of this abstraction). For example the salient parts of the encoding-actor may be an ordered sequence of (physical) switches and the pattern an associated binary number; or the parts may be the cones of a retina being stimulated by red light and the pattern an oval shape.

An actor which has parts which are an encoding is, then, an *encoding-actor.* An encoding-actor (e.g., a data store) may often be a part of a larger actor (e.g., a device with a data store).

13.1.1 Auto-encodings and auto-encoding-actors

An auto-encoding-actor is an actor in which an encoding (an *auto-encoding*) of some aspect of the world is brought about directly by that aspect of the world.

A simple mercury thermometer is an example of an auto-encoding-actor. The height of the column of mercury corresponds to the local ambient temperature (at least when the temperature is sufficiently stable). The height of the mercury column is brought about by the local ambient temperature: the acting together of the mercury in the thermometer and the local atmosphere bring the mercury to (roughly) the

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[216] A *pattern* is an arrangement – so that these two terms are largely interchangeable. I use the term ‘pattern’ where the focus tends to be on selected features of the arrangement – e.g. the rough shape of the region occupied by the many small parts of an arrangement, the on- / off-ness of a series of switches (rather than their precise spatial locations), the relative spatial locations of selected features (as in Ordinance Survey map, say), or the connected-ness of selected features (as in a topological sketch map, say).

[217] I do not suppose that *correspondence* can be rendered in terms of other more basic concepts, but rather I explicate correspondence by way of examples.

[218] I do not suppose that it is a determinate matter ontologically whether some pattern is an encoding - some cases may seem clear-cut, e.g., certain bit-patterns within a computer memory, but many others may not - so that there are borderline cases.

same temperature as the local atmosphere over time – the mercury expands or contracts accordingly to yield a certain height of mercury column.

A bimetal strip is another simple example of an auto-encoding-actor. The strip consists of two strips of different metals (often steel and copper) which expand at different rates as they are heated. The strips are attached together so that as the temperature changes the curvature of the strip changes. The shape of the bimetal strip – the degree to which it is curved – is an auto-encoding of the local temperature[219]: the shape of the strip corresponds systematically to this local temperature (the shape covaries with this temperature). We may say it *encodes* this local temperature.

The retina of an eye is another example of an auto-encoding-actor. The pattern of light falling upon the eye from moment to moment brings about a corresponding pattern of chemicals across the retina.

Similarly the film in a camera is an auto-encoding-actor.

An actor which has a part which is an auto-encoding-actor may often transmit the auto-encoding to another part which records the auto-encoding over time. For example, the pattern of chemicals across a retina (which encodes the local pattern of light falling upon it) may be transmitted via electrical signals (perhaps in an optic nerve) to another part of the brain and there recorded – perhaps just partially recorded. Such recordings are also encodings.

Measurement or recording devices and organisms with sensory ability have parts which are auto-encoding-actors and typically have parts which transmit and record the auto-encodings from these auto-encoding-actor parts. The recorded patterns are encodings. For example, an audio recording made by an electronic device may share a temporal pattern of frequencies with the sound that is recorded – so that it is an encoding of (aspects of) that sound. An electronic thermometer may measure the temperature of some thing or region and store the result in local digital memory. This local digital memory is then an encoding-actor – a part of the thermometer. The digital pattern recorded in the memory is then the encoding which corresponds to the measured temperature (at the time of recording). The thermometer converts the temperature measurement into suitable digital format for storing, and may typically retrieve the digital record and exhibit it on some suitable display. In this case, the correspondence (which underlies the encoding) relies upon the algorithm which converts the temperature reading in to digital format.

13.1.2 More derived encodings

Auto-encodings and their recordings are tied quite directly to simple aspects of the physical world – those aspects which can bring about the given auto-encoding, e.g.

[219] See Chang 2004 for an excellent discussion of temperature.

local ambient temperature, a pattern of light, a pattern of frequencies of sound waves over time. However, many encoding-actors have the ability to manipulate encodings so as to bootstrap derived encodings which may correspond to more conceptually advanced or complex aspects of the world.

In a next step towards more derived encodings, auto-encodings may be cross-referenced – and perhaps entities (e.g. concrete things) posited as a source of the auto-encodings.

An example of such a cross-referencing of auto-encodings is provided by a self-driving car. In this case the various detectors of the car may detect things (of sufficient size) in the locality of the car – and may measure and record over time, inter alia, their position, size, shape, velocity, and acceleration. As new things are detected, they may be established as entities within the car's digital memory, and the measurements associated with that entity (over time) recorded. Such a car typically has many detectors which take many measurements over time – the information concerning the entity may typically be refined and updated within the digital memory over time. For large static entities, the car may cross-refer, too, to external data sources, such as GPS maps - for example, information on local buildings or road intersections may be cross-referenced. The car's digital memory is then an encoding-actor, and the digital pattern stored within this memory is then (in part) an encoding of a map of local things and their movements – together with salient features of those things, e.g. shape, size, mobility (static, fast-moving, slow-moving, etc.), etc.

Organisms provide yet more complex examples of encoding-actors. The auto-encodings of an organism resulting from their senses (such as sight, hearing, smell) may be processed, perhaps with specific features selected and cross-referenced, so as to form more derived encodings – again entities (such as concrete things) may be posited. And such encodings may be developed over time using experiences from differing occasions. Often encodings can be developed by exploration, e.g., by looking from different angles, poking, smelling, sucking, dropping, or by more sophisticated experiments.

Which parts of an organismic brain respond to which sensory inputs and how is a topic of intensive neuroscientific research. But whilst some limited progress is being made, detailed knowledge is to a large degree still beyond current science. Nevertheless, that organisms have structures (i.e. encoding-actors) such as inter-linked neurons which maintain patterns corresponding to sensory inputs, and to more derived encodings, is largely uncontroversial.

13.1.3 Stand-alone encoding-actors

Some encoding-actors are standalone - they are not parts of a larger actor. Some standalone encodings are encoded by an encoder (e.g. a certain human). For example, a map or a scale model (e.g. of a plane, ship, or building) has a correspondence to the region that is mapped or the thing which is modelled: certain aspects of the spatial pattern of features is, at least roughly, shared by both. A drawing or sculpture may have a correspondence to what is being drawn or sculpted – again such correspondence may involve a sharing of the spatial patterns of features, although in some cases more roughly. Such maps, models, drawings, and sculptures are examples of stand-alone encoding-actors. Salient patterns of the parts of these encoding-actors are encodings, e.g. a pattern of lines on a map which correspond to the pattern of roads in the region mapped.

13.1.4 Meta-encodings

Some sophisticated encoding-actors have the ability to set up encodings about encodings, *meta-encodings* say. In relation to encodings of sensory experiences, such meta-encodings may perhaps relate to the context in which the encoding was formed - e.g., when it took place, how close the percept was, the quality of the light obtaining, other actors around, etc. A yet wider range of meta-encodings seems common for more derived / complex encodings, e.g., encodings of things or processes – these meta-encodings may concern the assessed reliability of the encoding, cross-references to other encodings, and many other matters.

Meta-encodings may also be used to help form new constructs. For example, an encoding of a thing might be qualified by a meta-encoding which posits a counter-factual change of some property of the thing, e.g., its colour, size, shape, structure, components, typical behaviour, etc. Meta-encodings may thus facilitate construction of possible things[220] and fictions (which might be ascribed as 'possibility' or 'fiction' respectively). For example, an atom with an atomic weight of 117 (tennessine) or a horse with a tusk.[221]

13.1.5 Linguistic encodings

I set out in the next chapter an account of language and how it licenses more complex encodings as well as the communication of encodings.

13.2 User-encoders

A user-encoder is an encoding-actor whose behaviour may be guided by certain encodings – commonly the encodings encoded by that user-encoder (whether these are set-up within parts of the user-encoder or externally).

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[220] Possibilities are addressed in chapter 18.

[221] Encodings qualified by such meta-encodings do not correspond directly to the world – there are no tusked horses and there was no tennessine before recently – but nevertheless I will for simplicity include these as encodings as the nature of the correlation between the modified encoding and the world is made clear by the meta-encodings.

In the case of the digital thermometer, the encoding of the temperature in digital memory is typically accessed periodically and displayed – the display is guided by the encoding of the temperature in digital memory, i.e. this encoding determines the number displayed. The behaviour of the self-drive car is more complex – the car may behave so as to drive to a destination encoded within its memory.

It may be supposed that a rat has encodings of a familiar local environment which allows it to navigate to find target destinations, although the details of the relevant encodings of the rat and how they are used remains largely obscure.

Organisms, especially humans, may use encodings in highly complex ways - they may manipulate encodings of the world, perhaps using logic, mathematics, Gigerenzerian heuristics[222] or other algorithmic methods, to form derived encodings which may help to guide action.

User-encoders may also use stand-alone encodings e.g. a book, model, map, a bee-dance. To use such an encoding, the user must know to what aspect of the world the encoding corresponds (which may be indicated by the encoding itself), and the encoding (encryption) algorithms which apply.

13.3 Knowledge

Knowledge comprises encodings which may be used by user-encoders.[223]

Some patterns of the parts of a user-encoder, such as the neuronal patterns of organisms that encode aspects of their external environment (which may license their successful behaviours), and perhaps the bit patterns of computer memory used to store salient information about the world, may be considered good candidates to be knowledge.

Encodings are licensed by things which maintain sufficiently stable arrangements of their parts. These stable arrangements of parts may license the exhibition of stable patterns – such stable patterns are a prerequisite for useable encodings. AAO recognizes that some things may have very large numbers of parts which are maintained in sufficiently stable arrangement, for example neurons within a brain, or linear sequences of bit-storage in a computer. These large stable arrangements of parts license the storage of highly complex patterns, and thus underwrite the possibility of complex encodings and hence complex knowledge.

Consider again a self-driving car. We may suppose that some particular pattern of bits of its memory corresponds to the speed of some particular local object, a bicycle say. For this correspondence to be of good use to the car:

[222] Gigerenzer et al 1999.

[223] We need not suppose a clear-cut boundary between encodings that may and may-not be used by user-encoders – there may be borderline cases.

- In practice, the bicycle must be an entity in the car's database. And this requires a whole host of encodings of the bicycle position, speed, and characteristics over earlier periods to license the construction of the bicycle as an entity within the database.
- The data storage management system of the car must pick out these right bits just when it is appropriate to employ an encoding corresponding to the speed of the bicycle.
- Any encryption / decryption algorithms used must be consistent.

In general, for an encoding to be correctly used by a user[224], it must be a part of an appropriate web of encodings of that user (e.g. the speed of the bicycle must be part of a web of knowledge which includes knowledge of the bicycle). Each component of knowledge is the knowledge that it is on account of the encoding obtaining within the context of the user's full web of encodings. The knowledge of a user comes as a package whole, then, comprising the full web of knowledge encodings of the given user. And this web of knowledge rests on the systems for setting up, storing, manipulating, and using those encodings of the user.

In recognising that knowledge is irremediably tied to a user's whole web of knowledge, and to the user's systems for setting up and manipulating knowledge, we recognise that it is user specific – each user has their own knowledge. How does this fit with the idea that different users can have knowledge of the same specific aspect of the world, the same fact we might say - e.g. know the speed of the bicycle? Differing users can pick out specific aspects of the world, such as the speed of the bicycle, and have encodings which accurately corresponds to that aspect – so that their knowledge in this respect may agree, at least to a good approximation.

As knowledge is physical, its accuracy and quality are dependent on the physical patterns of each user. Where a device uses digital patterns as the encoding (e.g. sequences of switches or bits), the encoding may be immune to the details of each physical digit insofar as it can be clearly set as on or off (with no ambiguity) – this is one reason why digital patterns are popular for data storage. (Language, which we address in the next chapter, is another means of helping to protect knowledge from physical-dependency.) But where analogue physical patterns are used, the exact physical pattern will in general influence the details of the knowledge – a variation in the physical pattern varies the (details of the) knowledge. Variation in a sketch map of some locality, for example, may vary the relative distances between points implied by the map.[225]

For a complex user-encoder, many of its encodings are often continually changing, so that behaviour may be impacted by processing times.

In the case of organisms, the total pattern of encodings may be fiercely complex – especially for humans. This total pattern includes not just that of neurons, but also

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[224] I shall abbreviate user-encoder to 'user'.
[225] This may not be the case if the map is topological.

that of sense receptors and other states of the body. Here, too, this total pattern of encodings together with the systems for setting up, storing, manipulating, and using these will be relevant to the user-encoders behaviour. (Behaviourist theories[226] are, then, very wide of the mark – behaviour generally reflects a myriad of evolving internal states of a user).

This account of knowledge accords with knowledge as we find it in the ontology of the world – it aligns with empirical observation: whenever we attend to the referent of the term 'knowledge', we find physical encodings and user-encoders organised just as our account entails. Calling suitable encodings 'knowledge' is generally consistent with the common usage of this term (although explicit accounts of knowledge may more typically attend to concepts that are not transparently physical[227]).

13.4 Acquisition of knowledge

On this account of knowledge, a starting point for the acquisition of knowledge is auto-encodings – such knowledge is acquired via a physical process: it is acquired empirically. More derived encodings are then developed progressively in the ways described – these derived encodings are more complex knowledge that are built (in part) by the cross-referencing and manipulation of simpler encodings. The acquisition of such knowledge involves bootstrapping from simpler knowledge. In this way, highly complex encodings (and hence knowledge) may be bootstrapped into existence – encodings whose correspondence to the world depends on a large web of other encodings that correspond to related aspects of the world. More detailed or complex knowledge can only be developed once more basic knowledge on which that more complex knowledge depends is in place.

I shall set out in the next chapter ways in which the use of language is an encoding tool which licenses a major increase in possible encodings, and hence underwrites significant development of fiercely complex encodings and hence more advanced knowledge. In particular, language licenses improvements in the communication of knowledge – this adds a further very important method of knowledge acquisition.

We see that this empirical / bootstrapping account of the acquisition of knowledge fits with the claim that knowledge of a user-encoder comes as a whole package – the totality of all a user-encoders' encodings and abilities to process those encodings.

13.5 Conclusion

Knowledge comprises encodings which may be used by user-encoders.

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[226] See for example Graham 2023.

[227] Philosophers do not generally offer an account of what knowledge is physically – but prefer to attend to definitions in terms of other abstract notions taken to be antecedent such as 'belief' and 'truth'.

This account explains knowledge as we find it in the ontology of the world and aligns with empirical observation: wherever we attend to the referent of the term 'knowledge', we find encodings and user-encoders organised just as our account entails.

Encodings are features of the ontology of the world – they are stable patterns of parts of certain actors (encoding-actors) which correspond to aspects of the world. User-encoders are actors and hence entities within the base ontology. Knowledge, then, obtains on account of the obtaining of aspects of the base ontology, i.e. user-encoders and their encodings – it arises from arrangements of actors. Knowledge, then, is a feature of the super-ontology.

14 Language and truth

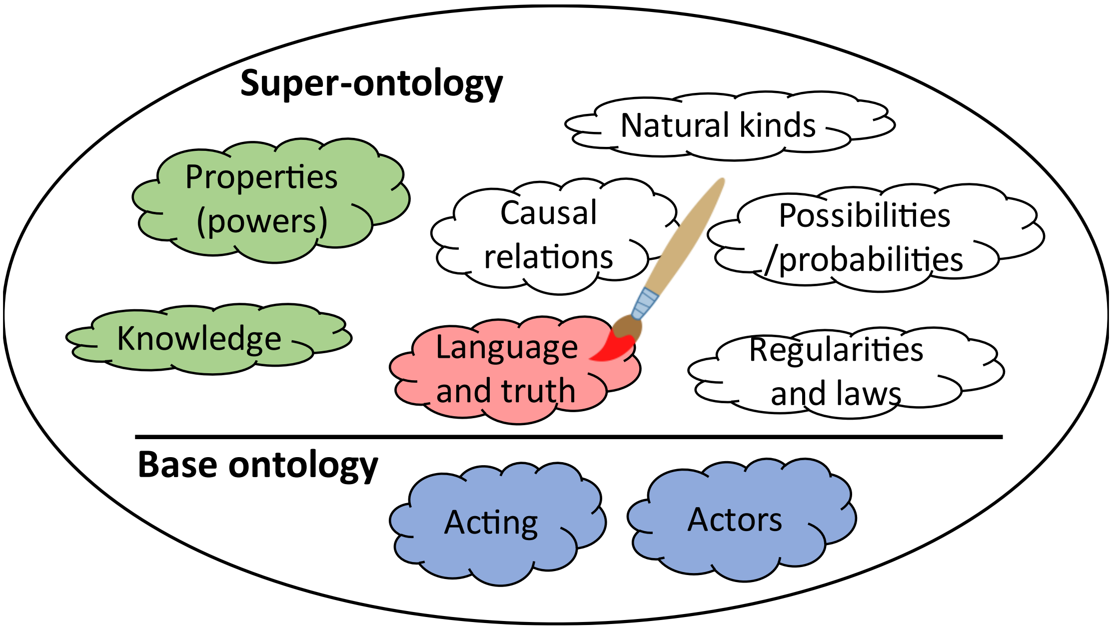

Figure 14.1: This chapter sketches language and truth as features of the super-ontology

This thesis is expressed in language. And it is true[228] (in a sense I shall make clear in this chapter). If language or truth were, or implied the existence of, entities that did not arise from the base ontology (the physical), then the project of this thesis would fail: we would be required to admit entities into the ontology of the world that lie beyond the super-ontology. It seems that, to avoid paradox, I must therefore show that language and truth do arise from the base ontology (so that they are within the super-ontology). That is the task of this chapter. In order to achieve this I shall show how language and truth, on the AAO account, arise from the base ontology.

On the AAO account, language is a tool used in certain encodings by certain complex users[229], principally (on Earth at least) humans and certain computers / machines developed by humans. Language is thus an aspect of a very narrow part of the ontology of the world: just that part comprising the encodings of certain complex users. It is, then, a part of the super-ontology.

Truth, on the AAO account, is a meta-encoding (an encoding about another encoding) of a certain type (and perhaps an abstraction associated with encodings of that type). An encoding of some aspect of the world may typically be ascribed as true by some user when it is held to correspond to the world sufficiently accurately in

[228] This statement makes explicit a claim that I take to be implied by the text of this thesis as a whole.
[229] I shall abbreviate user-encoder to 'user'.

some sense preferred by that user.[230] No encodings, no truth.[231] Truth, then, is also an aspect of a very narrow part of ontology – just that part which comprises encodings. It, too, is a part of the super-ontology.

Recall that the formal aim of this thesis is to sketch AAO and argue that it is plausible.[232] For AAO to be plausible it must be internally consistent, I take it. So that my claim in respect of this chapter is that the account of language and truth that I set out renders AAO internally consistent, and that these accounts of language and truth are plausible.

Section 14.1 addresses language, 14.2 truth, and 14.3 concludes.

14.1 Language

I focus here is on language which uses words, which is the salient form of language for our purposes.

14.1.1 Words and word-symbols

A word is an abstract entity created and sustained by a group of users – it is designated by a word-symbol and is taken to have a meaning. Word-symbols may be, inter alia, verbal (i.e. spoken words), written (written words) or signed (as in sign language). The existence of an (abstract) word is afforded by the (physical) encodings formed by users of that (abstract) word. We may suppose that one part of an ability to use language is the ability to form encodings for abstract entities such as words, where such encodings for specific words encompass reference to encodings for the associated word-symbols and word meaning. Word-based language, then, rests on (physical) encodings of users of words.

It is central to the use of language that word-symbols can be recognised by users to be of the word-symbol type intended by their authors with a high degree of reliability. For example, English speakers may typically be able to recognise speakers saying the word 'dog', or writers writing the word 'dog', as saying or writing the (abstract) word 'dog'. The reliable recognition of word-symbols has been considerably aided by the advent of writing – this has helped to facilitate the standardisation of word-symbols across large groups of users and to stabilise the word-symbols over time. The ability of users to recognise word-symbols establishes a basis for their use as a communication tool.

[230] I am focused here on truth as it is ascribed to encodings of the world, *empirical truth*, say. I do not address here other uses of truth, such as truth used as the value of a variable in formal systems, or as used in relation to pure mathematics.
[231] Some philosophers prefer that only linguistic encodings may be ascribed as true. Others do not, so that a map, for example, might be ascribed as true. I impose no restrictions here.
[232] See chapters 1, 19 and 20.

14.1.2 Word meanings rest on non-linguistic encodings

Biology suggests that the human brain, although it has evolved additional functions, retains many features which are similar to those of other higher mammals. Other mammals do not have (word-based) linguistic ability, so that we may suppose their encodings are non-linguistic. Empirical evidence shows that these non-linguistic encodings support many successful activities, e.g. recognising individual family members, friends, members of tribe; catching a ball; identifying types of smell; distinguishing suitable food from inedible material; navigating through a known territory to a target destination. It seems reasonable to suppose that humans' ability to perform these tasks rests, in some part at least, on use of these older parts of the brain, and on their abilities to establish and use such non-linguistic encodings.

I suppose that encodings of the meanings of many words employ (in part at least) non-linguistic encodings. To suppose that language-speakers have no non-linguistic knowledge is to suppose a radical abandonment of pre-linguistic skills within very recent human evolution - this would seem extraordinary, implausible and is not argued for by biologists. To suppose that linguistic knowledge is maintained wholly separate from a body of non-linguistic knowledge seems equally implausible. Words whose meanings employ non-linguistic encodings directly might include those for concepts which are used by other mammals. Although we do not know the nature of these concepts, we may reasonably conjecture some rudimentary concepts are used in supporting the behaviours of such mammals which are successful in interacting with their local world. These concepts might be in areas which relate to types of sensory experiences (e.g. colours, smells, sounds, tastes, feels), particular things (e.g. family members), particular places (e.g. home), particular objects, familiar types of things (e.g. types of tools, food, predators, prey), familiar behaviours (e.g. walking, eating, chasing, sweating), and familiar gestures (e.g. waving, nodding, pointing). The development of such non-linguistic conceptual knowledge is prima facie consistent with the acquisition of knowledge through auto-encodings (which are non-linguistic) and the bootstrapping of derived encodings from auto-encodings – i.e. with the account of knowledge and the acquisition of knowledge set out in the last chapter. (Nothing in this account presupposes the use of language.)

It would, though, seem that many words, particularly words for complex concepts, do not plausibly have meanings which correspond directly with non-linguistic encodings of the sort found in non-human mammals. Such words may be defined in terms of other, perhaps simpler, words – and iteratively in terms of the words used in the definitions of these words. To at least some extent, it would seem that the meanings of more complex words bootstrap from the meanings of simpler words – where the encodings of the meanings of these simpler words may, in part at least, use non-linguistic encodings[233]. The manner of this bootstrapping is likely highly complex – a matter suitable for careful empirical investigation. As many word

[233] Perhaps the meanings of some words may be derived without recourse to experientially derived encodings – words for mathematical concepts may be examples, e.g. numbers and shapes.

meanings are linked in this way to non-linguistic encodings, they generally depend (in part at least) upon the non-linguistic encodings of the individual user.

Words are commonly listed in dictionaries by way of their written word-symbols in alphabetic order with a brief description of their meaning. Nevertheless, we do not posit word meanings as deriving from other word meanings in some ungrounded circle. Rather, like knowledge, word meanings rest on the vast web of encodings of each user – they derive in part at least, perhaps via iterative bootstrapping, from non-linguistic encodings of the meanings of simpler words.

14.1.3 Use of words

Words are typically used within sequences (typically of more than one word). Somewhat complex rules, including grammatical rules, are applied to help derive the meaning of word-sequences from the meanings of the individual words in that sequence. Using word-sequences vastly increases the range of meanings that are achievable (relative to using just single words).

We may suppose that word-based language enhances our encoding ability – perhaps in respect of precision, accuracy, complexity, abstraction, systematisation, or recallability.

14.1.4 Communication and word meanings

For words to be an effective communication tool, there must generally be a sufficiently high degree of similarity between the meanings ascribed to them by users, at least within each user-group. Such similarities are facilitated by the learning of meanings by members of a user-group, sometimes by explicit teaching, but more often by engaging with other competent language-users over time. Learning the meanings of words in light of one's own experience, and in communication with other users, is a skill – an advanced skill at which humans excel. Still, there are undoubtedly differences in the precise meanings that differing users ascribe to each word. Toddlers in sub-Saharan Africa, the Amazon rainforest and London are likely to ascribe somewhat differing meanings to the term 'dog', for example, each based on local experience of dogs. As children grow older, they may typically broaden their understanding of meanings of words, perhaps from discussions, books, films, etc. and perhaps from travel. But, nevertheless, it is not plausible to suppose that any two given users ascribe identical meanings to a given word – meanings derive in part from non-linguistic encodings and these vary from user to user.

We may be able to render the meaning of a word as used within a user-group of that word by way of a definition. But this definition must in turn use words whose meanings are user-dependent (dependent on the encodings of individual users).

As noted in the last chapter, user-encoders may use stand-alone encodings – and this includes word-symbol sequences, including writings such as papers and books. The usefulness of such linguistic stand-alone encodings rests on the skill of users in ensuring that the meanings that they ascribe to the given words / word-sequences in the stand-alone encoding accord sufficiently closely with those ascribed by the writer and other users. In practice, the context for a given stand-alone encoding (e.g. other related texts) may help users to fix the meanings they ascribe to the words of that encoding.

Of course, users of language can make mistakes – they may sometime ascribe meanings to encodings which differ from those ascribed by other users – and this may engender costs.

By facilitating communication of complex ideas, language radically enhances an ability to learn about the world from other language users.

14.2 Truth

Consider a stand-alone encoding comprising a sequence of word-tokens (either abstract word-tokens or physical word-tokens) which a group of users takes to relate to some (putative) aspect of the world.

Typically, such an encoding may be taken to be true by some user when the meaning of that encoding is deemed by that user to correspond sufficiently accurately with how the (relevant aspect of) the world is. Such an encoding is taken to be an *empirical truth* (by that user), we may say. Empirical truths are posited by many differing groups – e.g. children, politicians, scientists, philosophers, logicians – and for various differing purposes. What constitutes a sufficiently accurate correspondence, or meets other criteria sufficient for truth, may vary across and within these user-groups. As the ascription of empirical truth depends upon both meaning and a judgement concerning sufficient accuracy of correspondence (or the meeting of other criteria), it is user-dependent in at least these two ways.

That truth is user-dependent does not imply that the world itself is in any sense dependent on human judgement. AAO supposes that the base ontology is – the ontology of the world does not depend upon language or truth.[234]

As noted in the last chapter, knowledge typically includes sophisticated meta-encodings, encodings about encodings. Truth is a meta-encoding – but meta-encodings typically go well beyond a simple ascribed truth-value. Such meta-encodings may, for example, include encodings concerning the provenance of the encoding in focus, its author, users who subscribe to its truth or falsity, evidence advanced to support (or not support) it, its contexts of use, the type of context of

[234] So that in contrast to Wittgenstein's claim that 'The world is all that is the case. The world is the totality of facts not things' (Wittgenstein 1961, 1-1.1), AAO takes the world to be, roughly, the totality of things and processes in space-time.

use assumed by various users and typically related assumptions, etc. These meta-encodings may often support the more careful and appropriate use of the encoding than would be afforded by a simple true / false ascription.

14.2.1 Logic

The user-dependent nature of empirical truth implies that caution is appropriate in applying logic to such truths with the aim of deriving further empirical truths. Where the aspect of the world to which a claim relates may be represented sufficiently accurately for the proximate purpose by logico-mathematical formalisms, then derivations may often be acceptable as truths. We might, for example, accept as true a claim that the distance between opposite corners of a room is 5 metres, given that we accept as empirical truths that the room is rectangular and has sides of length 3 metres and 4 metres. Similarly, we may often apply logic successfully when set-theoretic models are applicable, e.g. in dealing with numbers of things within overlapping sets. But the broader application of logic in deriving empirical truths is limited and must be treated with caution. This accords with the subsidiary role of the use of logic that we find in the work of the empirical sciences, e.g. physics, chemistry, biology, geology, etc. – the focus is more often on the empirical testing of proposed models, perhaps by experiment, with attention being paid to how local things in the world are. We typically do not find pure logicians within teams at the cutting edge of developments in empirical science.

14.3 Conclusion

Language is a tool used by some complex users to enhance their encoding ability and facilitate communication – and hence license major advances in achieving knowledge. The meanings of words (and word sequences) are user-dependent. Skills in ensuring that the meaning ascribed to a word accords sufficiently closely with that of some salient user-group establishes a basis for communication about the world using language.

Truth is a meta-encoding of encodings – it is an ascription of sufficient accuracy of an encoding by some user for some purpose. Truth, too, is user-dependent.

Language and truth are aspects of a narrow part of the ontology of the world: the ontology associated with encodings. Language and truth obtain, in the sense described, on account of the obtaining of the obtaining of encodings – and these depend in turn upon the obtaining of the base ontology. No encodings, no language and no truth. Language and truth are, then, features of the super-ontology.

15 Natural kinds

I continue here with the investigation of features of the AAO super-ontology - in this chapter I focus on natural kinds.

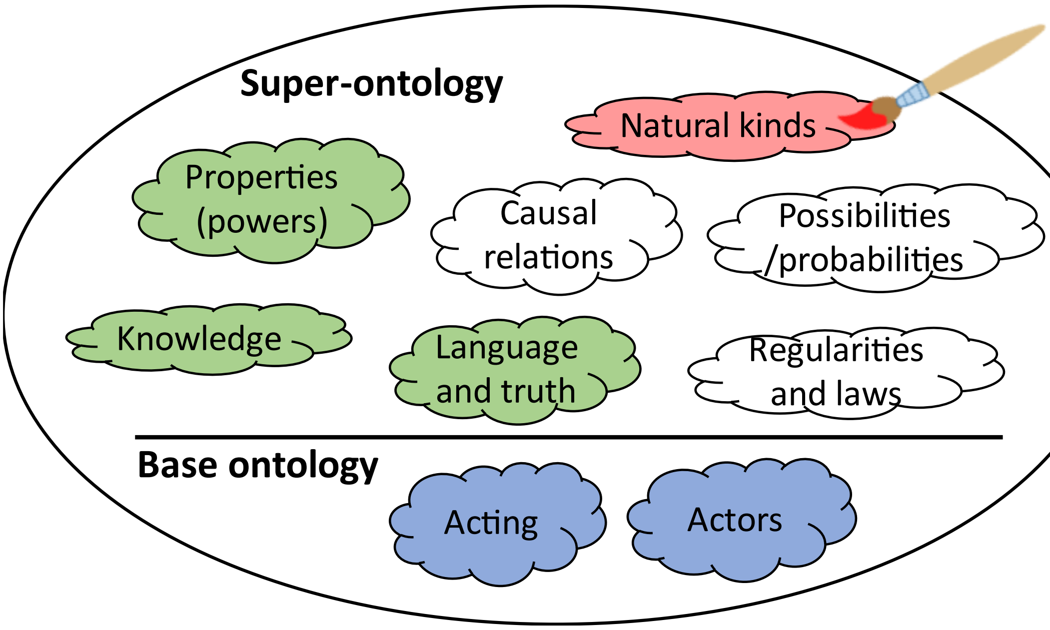

Figure 15.1: This chapter sketches natural kinds as a feature of the super-ontology

I shall show that the nature of actors brings about the clustering of at least many composite actors into clusters that may be picked out by choosing salient characterising properties, often taxonomic properties of the kinds listed in chapter 9 (e.g. the nature of the parts and their arrangement-type, the nature of originating actors).[235] I set out examples below. I take it that whenever scientists (perhaps in biology, chemistry, astronomy, geology, etc.), folk or perhaps philosophers reasonably identify a natural kind[236], it is generally[237] based on some such cluster. On the AAO account, there is no more to a natural kind than such a cluster of actors. As these clusters arise within the base ontology, they are features of the super-ontology.

15.1 Elementary-actor cluster kinds

[235] As John Dupre stresses (e.g. Dupre 1993) the boundaries of clusters are in general not clearly defined – that is why we talk here of clusters of actors rather than sets of actors say.
[236] For a discussion of natural kinds see Bird and Tobin 2023.
[237] An exception is provided by cases where a family of natural kinds allows natural kinds to be identified as members of that family, even in the absence of numerous instances of that natural kind in the world. For example, atoms with some atomic specified number that is not found naturally in the world may be posited as a natural kind, and perhaps even later created, in the absence of a naturally occurring cluster of atoms with that atomic number.

Elementary-actors may or may not cluster. If elementary-actors do cluster, then the account of the clustering of low-level actors which I offer below follows, and hence a more complete account of the clustering of actors. If elementary-actors do not cluster, then my account of clustering of actors is limited to that of higher-level composites[238] – still, this provides an account of very many clusters.[239]

Here are a couple of plausible reasons for supposing that elementary-actors cluster which many might accept. It might be supposed that elementary-actors in being elementary are relatively simple, so that they have few dimensions in which their properties may vary – and this may provide some grounds for supposing limited variety - and hence their clustering into kinds. Alternatively, we might be persuaded of the clustering of elementary-actors on empirical grounds: the available candidates for elementary-actors posited by contemporary physics, such as the particles of the Standard Model (or low-level composites of such particles), do, according to scientific consensus, fall into a limited number of very narrow clusters – indeed, perhaps members of such clusters are qualitatively identical.[240]

15.2 Composite-actor cluster kinds

The clustering of composite-actors follows from the nature of their composition which entails that they are *life-cycled*: they come into existence, exist and then (generally) go out of existence (see section 10.3.4). Therefore, for composite-actors of some kind to obtain in the world:

1. The world must afford the bringing about of composite-actors of this kind: there must be suitable *originating-actors*[241] in the world, and the world must afford the coming together of these originating-actors (perhaps by accident or through the acting of one or more other actors) in a way which leads to the formation of composite-actors of the given kind.

2. Actors of this kind must survive after their formation (at least for some period) within the contexts in which they obtain.

The world determines the composite-actors that obtain by determining the composite-actors which are brought about and which survive. This accords with Darwin's account of organisms within the biological realm – indeed, we might dub AAO *Super-Darwinism.* Ceteris paribus, the more actors of a kind which are brought

[238] The argument for higher-level clustering does not appeal to the clustering of elementary-actors.
[239] On my reading natural kinds are typically a brute fact on popular accounts – so explaining many such kinds is a relative strength.
[240] Whilst empirical evidence supports the proposition that, for example, any electron has a mass, charge, etc. which is very close to a standard value, this evidence does not establish the stronger claim that these values are identical. The masses of electrons, for example, may simply fall into some very narrow range of values – a range which is too small to allow different values to be distinguished under currently available measurement methods.
[241] See Section 9.1, characteristic (e).

about, and the longer these survive, the more actors of this kind there will be in the world (i.e. the larger that cluster will be).

The coming-into-being and surviving that underwrites the obtaining of a cluster differs markedly according to the kind of cluster in focus – the following sections provides a sketch of how this goes.

15.3 Low-level composite-actor cluster kinds

This argument rests on the assumption that elementary-actors fall into clusters. If so, there will be a limited number of types of pairs, triples, etc. of elementary-actors.

It might be that two elementary-actors of distinct kinds might act together in differing ways to give rise to many differing kinds of composite-actors. But, given that elementary-actors are simple, in respect of their lack of parts for example, we might expect them to act in simple ways – and such simplicity of acting accords with evidence concerning available candidate elementary-actors (e.g. they attract, repel with strengths which accord with simple formulae). We might, therefore, expect the composite (i.e. acting-together) of any two elementary-actors of some given kinds to fall under just a single kind, or perhaps a small number of kinds, of composite-actors. If this is so, it would provide a reason for there being only a limited number of low-level composite-actor cluster kinds. Moreover, the typical narrowness[242] of elementary-actor clusters might suggest that these low-level cluster kinds (the composites of two elementary-actors) might also be fairly narrow.

Candidate low-level composite-actor natural kinds that we find in empirical practice are those of physical particles (e.g. protons, neutrons) and chemical structures (e.g. atoms, molecules). In this case, physicists typically suppose that the world brought about high densities of particles of the Standard Model at an early stage in its existence, and that many of these combined together over time to form stable actors (e.g. combinations of particles of the Standard Model, atoms) – and that these form the members of cluster kinds we find in the world today. We see that this account fits with the AAO account: the clusters of low-level composite actor kinds exist on account of having come into existence through the combining of their originating-actors – and then their robust surviving through time.

There would seem to be good empirical grounds for supposing that there are indeed a limited number of such kinds at each (low) level (e.g. a limited number of kinds of atoms) and that these kinds are indeed narrow (the variation between atoms of some kind is narrow - perhaps, indeed, all such atoms are qualitatively identical).

As the number of parts increases, we find examples where the same parts can form more than one kind of composite-actor. For example, 4 carbon atoms and 10 hydrogen atoms can act together to form both butane and isobutane – 2 distinct

[242] I.e. the members have a narrow range of salient properties.

kinds of molecule with different structures which behave in different ways. AAO makes sense of such duality: butane and isobutane have different configurations of the same types of parts, and the composite-actors associated with both configurations are robust (in a way which is consistent with a standard account of the parts, the carbon and hydrogen ions, and how they can act).

In summary, if elementary-actors cluster, then we have reasons to expect clusters of low-level composite-actors too.

15.4 Higher level actor natural kinds

As low-level composite-actors (and perhaps elementary-actors) act together they form higher level composite-actors; and as these actors act together, they form yet higher-level actors. Actors at higher levels, on account of having parts of parts, and parts of parts of parts, etc., and perhaps having a greater number of parts, have the scope to exhibit considerable variety. This scope for variety means that clustering of higher-level actors does not follow from the clustering of elementary-actors in the way in which it does for low-level actors. Nevertheless, empirical evidence suggests that higher-level actors do cluster – and this is surely supported, inter alia, by the long-standing commitment of scientists (e.g. biologists, astronomers) and philosophers to higher-level natural kinds.

Where a thing (or a stage of a process which survives for a long period compared to the typical timescale of human observation (e.g. stars, mountains)) is in focus, the characteristics which may reveal a cluster may typically include those associated with the nature of the parts and their arrangement (i.e. characteristics (a) and (b) in chapter 9). Where a process with a shorter timescale (e.g. neuron firing) is in focus, the characteristics which may reveal clustering may typically include those associated with change through time (i.e. characteristic (c) In chapter 9).

In general, clusters of higher-level actors may:

- exhibit considerable diversity between members of the cluster – indeed, a cluster may itself be a cluster of narrower clusters;
- have borderline cases, so that the boundaries of the cluster are not clearly demarcated;
- be picked out by differing criteria e.g. salient morphological properties and / or according to originating-actors (the boundaries of the cluster may differ somewhat under these differing criteria - consider, for example, the complex relationships between morphological and cladistic clusters in biology).

There are differing ways in which the world brings about each kind of higher-level actor, and how an actor of this kind survives – and these differing ways of coming about and surviving result in differing qualities of the resulting clusters. The following briefly considers some leading examples of higher-level clusters that we find in the world which may often be taken to be natural kinds, noting their differing ways of coming about and cluster qualities in each case. Each of these accounts shows the way in which the existence of the cluster in focus follows from and is explained by (aspects of) the AAO base ontology – its existence is not merely happenstance.

15.4.1 Astronomic kinds

The starting point for the formation of stars is a diffuse nebula, an interstellar cloud of matter. Diffuse nebulae comprise debris left over from previous astronomic events in an otherwise unoccupied region of space – they arise commonly within the Universe. If the mass of a diffuse nebula is sufficient, the matter may collapse together due to gravity into agglomerations which give rise to a star. Astronomists provide an account of the process of star formation, existence, and death – each stage involving the acting together of parts (e.g. their mutual gravitational attracting) which give rise to changing and hence over time the next stage. Depending on the mass of the diffuse nebula, the stages may be: diffuse nebula, star, red giant, planetary nebula, white dwarf; or perhaps diffuse nebula, massive star, red supergiant, supernova, neutron star. The members of each astronomic kind (e.g. star, red giant) have similarities in respect of salient characteristics (whilst also exhibiting differences). For example, a star has a very large number of parts of certain types (e.g. hydrogen, helium ions), is roughly spherical, is hot (has a surface temperature in the range 3,000^{o}C – 10,000^{o}C), etc.

Astronomic kinds provide a good example of how the life-cycledness of actors, which is entailed by the nature of AAO composition, licenses an account of the obtaining of many similar actors (e.g. stars), and hence clusters which may be identified as natural kinds. The obtaining of many stars in the world (and hence a cluster of actors with star-like characteristics) follows from (1) the obtaining of many diffuse nebulae which are not too large (that arise naturally as a result of earlier processes), (2) the robustness of the process of star formation from diffuse nebulae and (3) the considerable temporal duration of each star. This is how cluster patterns follow from, and are explained by, the base ontology in this case – and hence are features of the super-ontology.

15.4.2 Biological kinds

Although the nature of the circumstances in which the earliest self-replicating actors (which led on to biological kinds on Earth) came in to being remains a matter of debate, it seems likely that they arose by accident from within a soup of relevant chemicals. Such accidental formation of self-replicating actors was, it would seem, a chance event with very low probability – such an event may likely have occurred only once, although possibly a small number of times. The widespread occurrence of such organic actors rests on the ability of these actors to survive in the context in which they obtained and to self-replicate (i.e. to produce new actors which are similar to themselves) – it is not supposed that the world affords the frequent chance formation of new self-replicating actors of given kinds.

The story of evolution supposes that chance mutation of such self-replicating organic actors sometimes occurs and gives rise to new different, perhaps more complex actors. Such mutations are also low probability events. Again, it is the ability of such mutated actors to survive in their context and to self-replicate which underwrites the obtaining of clusters of actors of this kind. (Self-replication entails an entity bringing into being a new entity of the same kind as itself.)

The biological case has, then, its own distinctive story of the coming about and survival of organisms, which are some of the important actors within its domain. This story was told by Darwin and has been developed in recent years as knowledge has developed of the gene-based processes for self-replicating. This Darwinian account of coming about and survival is just the AAO life-cycle account in this context, so that support for the Darwinian account is support for the AAO account too.

Importantly, the Darwinian (and AAO) account of these clusters explains not just the obtaining of these clusters (of organisms) but also the key characteristics of these clusters. For example, such clusters feature a range of members with properties that may differ considerably – although on certain key dimensions salient for identification of the cluster, this range is limited (in the sense that the great majority of members may fall into a fairly narrow range on these dimensions, e.g. the great majority of tigers have stripes). Biologists account for the significant variation within the cluster in terms of the advantages conferred by genetic variation on the ability of a cluster to survive. Biologists account for the limited variation within the cluster on salient dimension in terms of the advantages of certain characteristics (which are apparent on that dimension) for the survival of population members. Clusters also commonly have the characteristic of drifting in quality space over time: certain characteristics salient for the identification of the cluster may change progressively over time (in the sense that the aggregate or average value of these qualities for the population as a whole changes). Biologists often account for such drift by reference to adaptation of the population to changing environmental conditions, e.g. the evolving presence and behaviour of competitors. Each of these characteristics of clusters of organisms is thus accounted for by biologists in terms of supporting the surviving of each cluster, in line with the Darwinian (and AAO) account.

We see particularly clearly in the case of biological organism kinds that both the clustering, and the nature of the clusters that we find in the world, follow from, and are explained by (through the well-known story of Darwinian coming about and surviving) the nature of the actors and their consistent acting: these clusters are features of the super-ontology.

15.4.3 Animal (including human) artefact kinds

Animal artefacts are other commonly found kinds of composite-actors, e.g. bird's nests, wasps' nests, beaver dams, and human artefacts such as bags, fridges, chairs, etc. Artefacts are, typically, bundles[243], that is to say they involve parts held together by ties, glues, inter-weaving, interlocking of congruent shapes, bolting, screwing, nailing, etc. – the parts may often be further bundles.

Clusters of artefacts may typically be best characterised by their function, i.e. the purpose they serve for the animal that produces them – members of such clusters may then differ markedly in terms of characteristics such as the nature of their parts, their shape, their size, etc.

The existence of such clusters rests on the repeated production of artefacts of the given kinds by certain kinds of animals, and the survival of such artefact through periods which are typically at least sufficient to meet the function. These artefact kinds come into being and obtain just when and where the animal kinds which produce them obtain (and remains of such artefacts may obtain for periods thereafter).

Again, the existence and nature of the clusters follows from, and is explained by, (on account of life-cycledness) the consistent acting of certain actors (in this case animals) – i.e. by the base ontology – so that the cluster are features of the super-ontology.

In practice artefact kinds are less commonly taken to be natural kinds: there are many clusters of actors that we may take to be kinds that are not generally taken to be natural kinds. In practice a natural kind designation is typically reserved for actors that occur naturally.

15.4.4 Other natural kinds

Rivers may be considered another natural kind. As outlined in chapter 9 (see characteristic (k)), a river is a type of *constrained crowd* process. The occurrence of such processes arises from (1) the natural occurrence of river basins (the contours of any region of land naturally divide it into distinct river basins), i.e. the relevant *constrainers*, and (2) the natural occurrence of rain and snow, i.e. the repeated delivery onto the river basin of a crowd of water molecules. The stability of a river basin over an extended period (together with sufficiently stable climatic conditions) is the basis for the surviving through time of a river, so that rivers are brought about and survive in their own distinctive way.[244] A similar story may be told about glaciers.

[243] See chapter 8, especially section 8.1 (d).
[244] We may or may not choose to identify different periods of flow interrupted by dry periods as the same river.

The Earth produces other distinctive process kinds and licenses their survival through periods of time: e.g. lightening, thunder, volcanoes, earthquakes, cyclones, etc. In each case, we may set out the circumstances under which processes of the given kind come about, and recognise that the Earth often gives rise to such circumstances. And we may recognise that processes of each kind survive over some (perhaps brief) period.

In each case, we see that the obtaining of the cluster of actors that underwrites the natural kind may be accounted for by the regular occurrence of circumstances that afford the coming about of actors of the given kind and their surviving through time.

15.4.5 Summary of higher-level actor natural kinds

The above subsections set out some examples of higher-level actor natural kinds whose members are common features of our world - this is by no means intended as a comprehensive list, of course. In each case the world brings about actors of the given kind, and provides contexts in which actors of this kind survive sufficiently robustly, in line with the AAO account. The story associated with this coming to be and surviving differs significantly from case to case.

In the case of particle and atomic kinds, the account involves the obtaining of high-densities of particles of the Standard Model, the combining over time of these into stable particles / atoms, and the robust survival of these particles / atoms. In the case of the cluster kinds associated with stars, the story involves the widespread occurrence of diffuse nebulae (arising from the debris of previous processes) and then the robust (and long-lasting) process of mass agglomeration and star formation which arises from diffuse nebulae. In the case of organisms, a simple version of the (complex) story involves the happenstance occurrence of organisms of some kind, the sufficiently robust survival of organisms of this kind, and the bringing about by these organisms of further organisms of this (and occasionally similar) kind by self-replication. The other examples of cluster kinds above indicate the stories of the coming about and surviving appropriate to each case.

15.5 Conclusion

AAO provides an account of why composite-actors cluster (on salient criteria), so that natural kinds are not just an inexplicable happenstance. This account follows from the fact of composite-actors being *life-cycled:* in order to exist, composite-actors must be brought about and then survive – only certain limited types of composite-actors can be brought about within the world (e.g. ones for which potential parts are available), and only some of these actors can survive robustly. The composite-actors that we commonly find in the world are of kinds which can be brought about and survive.

The qualities of the natural kinds that we find in the world fit with this Super-Darwinian account. For example: Low-level composite-actor clusters are narrow; high-level actor clusters may exhibit greater variation; clusters of organisms may change progressively (drift) over time; artefact clusters (at least for new members) coincide temporally and in their location with the clusters of organisms which produce the artefacts.

We see that the clusters (that are sometimes deemed natural kinds[245]) obtain, and are to be expected, on account of the obtaining of the base ontology[246] - they are features of the super-ontology.

[245] Of course, opinions differ significantly as to which clusters should be ascribed the status of natural kind.

[246] Many metaphysical accounts of natural kinds suppose that they are written into the base ontology itself – perhaps via substance universals (see e.g., Aristotle's Metaphysics or E. J. Lowe 2006) or via property universals (see e.g., Armstrong 1997). Richard Boyd (1991, 1997) suggests *homeostatic mechanisms* underwrite cluster kinds, but the nature of these mechanisms and how they operate is obscure, so that it is unclear to what extent Boyd's account overlaps with that outlined here. Boyd assumes a mosaic base ontology, as I understand, so his account certainly does differ from that of AAO in important respects.

16 Causal relations

This chapter focuses on a further feature of AAO super-ontology: causal relations.

AAO, as we have noted, posits the consistent acting of some actors across contexts of given types[247]. On account of such consistent acting, the base ontology sometimes underwrites certain relations[248] – I shall call such relations underwritten by the base ontology *ontological-relations*. Ontological-relations are not (of course) entities, but, as they arise from the base ontology, they are features of AAO super-ontology.[249]

Ontological relations include relations between cluster kinds and properties typical of members of that cluster kind[250] - but these are not the relations in focus here. I am interested here in ontological relations that may be used for causal purposes (e.g. for prediction, control, assignment of blame[251]), I set out some leading examples of such ontological-relations below so as to indicate a key part of the range of such relations. As one example of such an ontological-relation (see section 16.2), an actor (a process or a thing) underwrites a relation between an earlier stage of that actor and a later stage – the relation of being stages of the same actor. The nature of that relation is then determined by the nature of that actor (which may depend in turn, in part at least, on the context in which that actor obtains).

Causal methods typically involve empirical investigation (of some sort) to identify a type of relation to be used for causal purposes (within some target domain) – the type of relation then being deemed a 'causal relation' by that user. Such causal methods may be successful, on the AAO account, when (1) a relation is picked out for causal use that is underwritten by the ontology (i.e. is an ontological-relation), and (2) where the aspects of the ontology which underwrite this relation remain sufficiently stable into the target domain (i.e. the domain where the causal relation will be used). If a relation is not underwritten in some way by the prevailing ontology, or if the prevailing ontology that underwrites the relation does not remain sufficiently stable into the target domain, then the use of that relation for causal purposes will not be reliably successful.

AAO allows that such practical use by science, commerce and folk determines the scope of the term 'causal relation', save that where a relation is not reliably useful for the proximate purposes in the circumstances at hand (i.e. the user has made a

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[247] As we have noted, it is this consistent acting that licenses the characterisation of actors by acting-powers - see chapters 6 and 12.
[248] I use the term relation as having its received philosophical meaning – see for example MacBride 2020.
[249] Why, then, have I not included ontological-relations amongst the features of the super-ontology sketched in our picture? Because the class of ontological-relations is not a feature widely embraced by metaphysicians (or indeed folk). Rather, metaphysicians more typically embrace natural kinds, causal relations, regularities and laws – features that are closely related to ontological-relations. For expository purposes I include these other features and outline their connection to ontological-relations or clusters, etc.
[250] See previous chapter.
[251] My use of the term 'blame' follows that of Richard Sorabji (Sorabji 1983).

mistake in choosing their relation) then it is not correctly a causal relation (for this purpose in this circumstance).[252]

Causal relations, then, are ontological relations – and hence they are features of the super-ontology.

Sections 16.1 to 16.4 undertake the task of explicating various types of ontological-relations, and noting ways in which these relations are often useful for causal purposes.

Section 16.1 focuses on (what I dub) *acting-changing relations*, i.e. relations between certain acting and certain synchronic changing. For example, the relation between my pedalling (my pushing on the pedals) and the accelerating of my bike – a relation I make use of whenever I cycle.

Section 16.2 considers *single-process relations*: a relation between an aspect of an earlier stage and an aspect of a later stage of a single process (i.e. an actor that may be characterised by its changing through stages[253]). Science (in its broadest sense) commonly focuses on processes which are of some type whose repeated instances can be explored. When an earlier stage of a process of some process-type obtains (i.e. the first relatum), the occurrence of an instance of the later stage (i.e. second relatum) may be (defeasibly) predicted. Bringing about this earlier stage, may be (defeasibly) a way of bringing about an instance of the later stage. For example, inserting a coin into a vending machine may bring about a drink in the output bin.

Section 16.3 explains how a plurality of processes of a certain process-type may underwrite another different type of relation, which I dub a *setting-outcome relation,* e.g. the relation between the setting on my toaster and the brownness of my toast over repeated uses of this toaster. Such relations may also often be used successfully for causal purposes.

Section 16.4 explores briefly various other types of relations which are underwritten by the base ontology and which may, in practice, often be used successfully for causal purposes.

As users of popular causal methods do not embrace AAO, how can it be that these methods are successful as often as they are, given my supposition that to be successful these methods must pick out (for causal use) relations underwritten by the base ontology of AAO (i.e. ontological-relations)? Section 16.5 considers causal methods used in practice, and suggests that they do often (but not always) pick out ontological-relations, even though AAO is not explicitly embraced.

Section 16.6 concludes: the AAO base ontology underwrites relations, ontological-relations, that may sometimes be successfully used for causal purposes. Where a

[252] Note then that what may be correctly counted as a causal relation depends on the proximate purpose and circumstances of use.
[253] See chapter 9.

user employs an ontological relation for causal purposes (thus ascribing it as a causal relation, I suppose) the relation (being ontological) is underwritten by the AAO base ontology, i.e. it obtains on account of the obtaining of the base ontology, and it is thus a feature of the super-ontology.[254]

16.1 Acting-changing relations

Chapter 6 (especially section 6.2.1) considered the stable relations that obtain between certain types of configuration and the synchronic changing that occurs to those configurations – this led to the explication of *acting* and *acting-powers.* When an acting-power obtains, we posit a relation between the acting (associated with this power) and the associated changing that occurs – we may dub this an *acting-changing relation*. For example, the relation between the gravitational attracting of the Earth by the Sun, and the accelerating towards the Sun by the Earth (which underwrites its elliptic orbit). Such relations are underwritten by the AAO base ontology, i.e. by actors and their acting.

Acting-changing relations are often used in practice – many common examples of such use involve our own acting (e.g. pushing or pulling things) and the concomitant changing. To get a puppet to dance we know to manipulate the strings (over some period); to drive a car we know to act on the accelerator, brake pedal and steering wheel (episodically over the period of driving); to produce a slice of bread we know to saw the loaf with a knife (over some period), to accelerate a bicycle we know to pedal. We may learn skills such as puppeteering, driving, cutting bread and cycling on the basis that these skills allow us to act (through time) in certain ways, where this acting has a stable relation with certain changing, so that our acting-through-time may bring about certain changing-through-time and hence certain target effects (e.g. driving / cycling to some target destination, obtaining a slice of bread).

16.2 Single-process relations

When a process obtains, an acting together of parts at an earlier stage survives through time in the prevailing context to give rise to a later stage. In Figure 10.1, which depicts a composite-actor that we may take to be a process, stage P_1 gives rise to stage P_2. We have rejected the idea that P_1 and P_2 are connected by a relation of numerical identity[255]. We may, rather, posit a relation between the earlier stage and later stage of a process (e.g. between P_1 and P_2) allowing that the nature of this relation derives from the nature of the process, and is an empirical matter. I call such a relation a *single-process relation*.

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[254] How about a user that adopts a certain relation for causal purposes that is not an ontological relation? The use of that relation for the given causal purpose will not generally be successful (except perhaps by chance). I take the view that we should not regard the adopted relation as being a causal relation (although it has been mistaken for such, and likely labelled as 'causal', by the user).

[255] See Section 10.4.2.

In practice, in regard to causal relations, the focus is often not on the configuration of the process as a whole (e.g. P_1, P_2), but on some salient aspect of this configuration which, in line with common usage within science and every-day, we may call *events*. Types of event may include a changing of a part (e.g. a lever turning), an acting of a part (e.g. a coin pushing on a lever), a part having some property (e.g. a lever being in the depressed position), the obtaining of an arrangement of parts (e.g. a coin touching a lever), parts moving relative to each other in some way (e.g. a coin dropping on to a lever), etc. Such events are spatio-temporally located features of the ontology. It may often be helpful to pick out such a salient feature of the ontology (of some process-stage) and to recognise it as an event, perhaps an event of some event-type, but to do so is not to posit that the event is any addition to ontology.

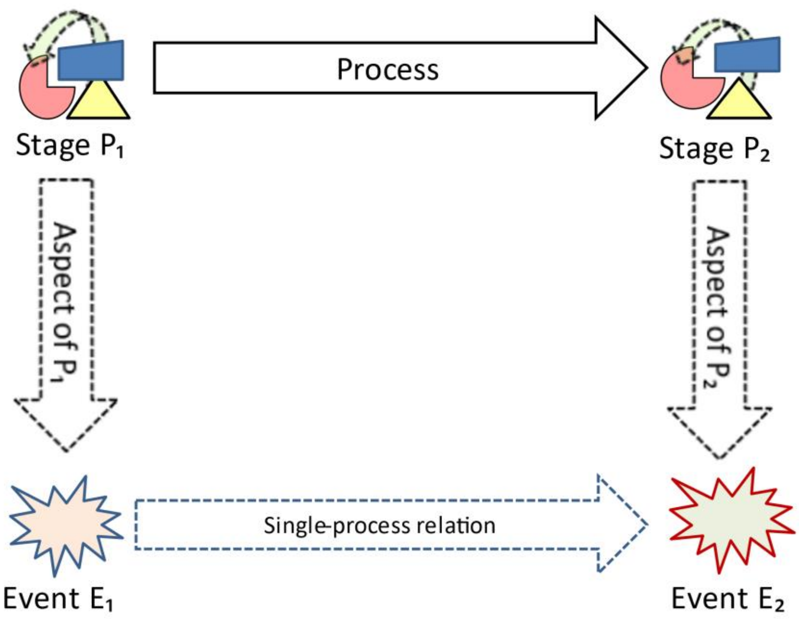

Figure 16.1: Single-process relations

Events E_1 and E_2, as illustrated in Figure 16.1, are related by a single-process relation just in case E_1 is an aspect of an earlier process stage P_1, E_2 is an aspect of a later process stage P_2, and P_1 and P_2 are stages of the same process.

Processes, acting-togethers which transition through stages, are entities within the base ontology of AAO – so that the obtaining of the sequential stages, and hence events which are aspects of those stages, arise within this base ontology. These events, and relations between them, are, then, features of the super-ontology.

That such relations are sometime useful for causal purposes may be established by reference to some examples of such relations which illustrate the familiarity of such relations within causal practice:

- The inserting of a coin in the slot of a drink machine → the arrival of a drink in the output bin
- The release of neurotransmitter particles into a synapse of a neuron → the release of neurotransmitter particles from the other end of that neuron
- The sparking of a mixture of hydrocarbons and air → an explosion of this mixture
- The taking of an aspirin (by someone with a headache) → the cessation of that headache
- Raining on the hills behind Bill's house → rising of the water level in the river next to Bill's house

In each case we may explicate the acting-together of parts and their changing which links the process stage that encompasses the first event with the process stage encompassing the second event – i.e. explicate this process as an AAO composite-actor. To make use of such relations in a new domain, the consistent acting of the salient types of parts, that underwrote the ontological-relation during the period it was discovered, must continue in the new domain of use – e.g. the drink machine must continue to work in order that inserting the coin brings about the arrival of our drink.

For single-process relations to be useful for prediction, it is helpful if the event-type of the earlier (cause) event is a good marker for the process (i.e. when an event of this type occurs, a process of the given type often occurs). For single-process relations to be useful for control, bringing about an event of the earlier (cause) event-type should (sufficiently) often bring about a salient process. Some event-types associated with a process-stage may occur even when the process is not occurring (e.g. the scraping of a coin on the side of the coin-slot, which may occur even when the coin is not inserted). Thus only some event-types that may be relata of single-process relations may be useful for causal purposes.

16.3 Setting-outcome relations

Setting-outcome relations are underwritten, not by a single process, but by a plurality of processes of the same type (or types). Examples include:

- Setting of a toaster → brownness of toast produced by that toaster
- Length of a pendulum → time period of that pendulum
- Angle of an incline plane → initial acceleration of a frictional mass released on that plane[256]
- Type of treatment given to patients (e.g. size of dosage of some prescribed drug) → (change in) measure of health at later stage of treatment
- Amount of rainfall during storm → amount by which height of water level in adjacent river rises
- Amount of rainfall in growing season → crop yield

[256] See e.g. Woodward 2003, section 1.4.

Setting-outcome relations are atemporal functional relations, not event-event relations– the relata are not events, but rather values of logico-mathematical variables associated with each process, perhaps with some stage of that process. Although the value of each relatum may obtain at a certain temporal stage, the focus here is on the values taken by the relata, rather than on the event of these values obtaining. Such functional relations may often be represented graphically, for example by a line on a 2-dimensional graph where standardly we might take the value of the former relatum (i.e. the *setting*) as the x-coordinate and the latter relatum (i.e. the *outcome*) as the y-coordinate.

A determinate value of the setting obtains on each salient token process (of the relevant process-type), and that process gives rise to some determinate value for the outcome. Each such process thus provides a related pair of values of *setting-outcome* which we might enter on our graph. For example, each time I use my toaster, the knob on the side numbered 1 to 5 is set to some value, and the toast produced on that run has some degree of brownness, we may suppose. The repeated use of my toaster over time might then give rise to a relation between the number to which the knob is set, and the brownness of the toast which results – a relation that we might capture on a graph of knob number vs. recorded brownness. We might perhaps show the correlation between knob number and brownness to be significant using statistical methods.

Setting-outcome relations are typically not exact (we should not, in general, expect all points to lie exactly on our graph line) but rather statistical – demonstrating the obtaining of such a relation may require careful statistical analysis, and the obtaining of a putative relation may be controversial even amongst salient experts.

A randomized control trial for a treatment programme for patients with a certain medical condition may provide another example of a setting-outcome relation. The patients may be divided in to groups which are treated with different treatment programmes, i.e. have a different setting of their treatment programme. Figure 16.2 illustrates the case of 2 such groups.

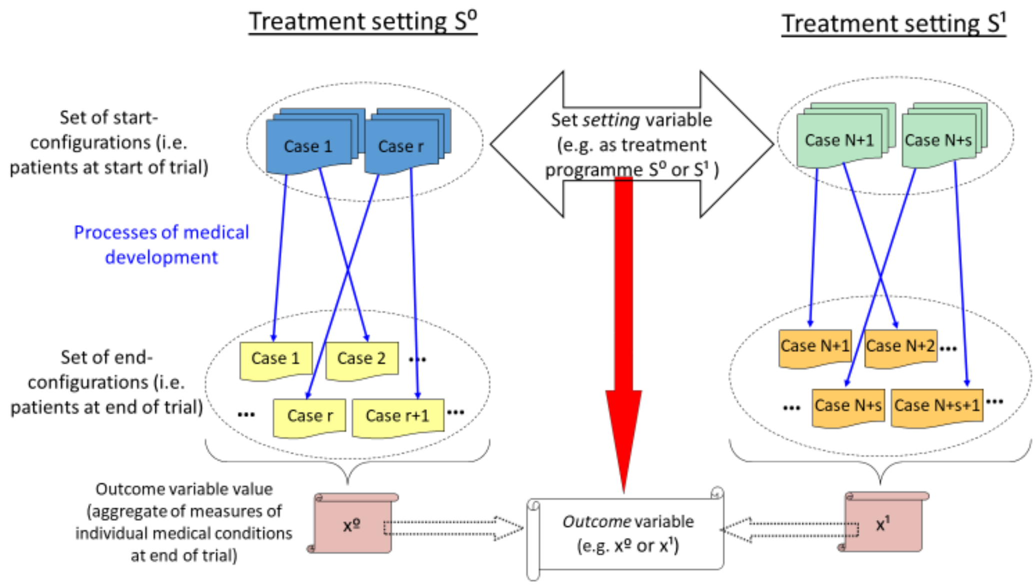

Figure 16.2: Plurality of processes underlying the relation between treatment setting and outcome variable (aggregate of measures of individual medical conditions at end of trial)

The blue arrows in Figure 16.2 show the relevant processes in the underlying ontology: these are the process of development of each patient under their ascribed treatment programme. The patients are composite actors – they obtain and develop over time – and fall within the base ontology of AAO. At the end of the trial, a salient measure of the medical condition of each patient may be made – these individual measures may then be aggregated for each of the two treatment groups to provide an overall (perhaps average) measure for each group. A functional relation between the *setting* variable (which represents the chosen treatment programme, e.g. S^0, S^1) and the aggregate outcome variable (for the group to which each treatment programme is applied, e.g. X^0, X^1) may be explored, perhaps using statistical methods. Where the setting variable takes a numeric range, e.g. the dosage amount of a drug treatment, the functional relation between the setting and outcome may be graphed. The pattern of processes which underlies the regularity captured in this functional relation is the plurality of medical development processes of each of the patients in the trial, represented by the blue arrows in Figure 16.2. These processes fall within the base ontology.

Setting-outcome relations too can be used for controlling aspect of the future. I may for example set the brownness setting on my toaster to a higher number in order to increase the crispiness of my toast on future mornings. Or a doctor might determine the form of a treatment programme (e.g. the dosage level of some drug) to be used for patients with a certain condition with the aim of improving some aspect of the future medical condition of those patients that are treated.

16.4 Other relations

There are many other types of relations that are underwritten by the base ontology. Many of these may be associated with specific types of patterns of processes of certain process-types. The following are a couple of examples selected as ones which are closely associated with problem cases much discussed in the causation literature.

16.4.1 Parallel-process relations

One such type of relation is associated with a pattern of parallel processes, as in Figure 16.3 – such patterns are often associated with cases dubbed 'causal overdetermination'.

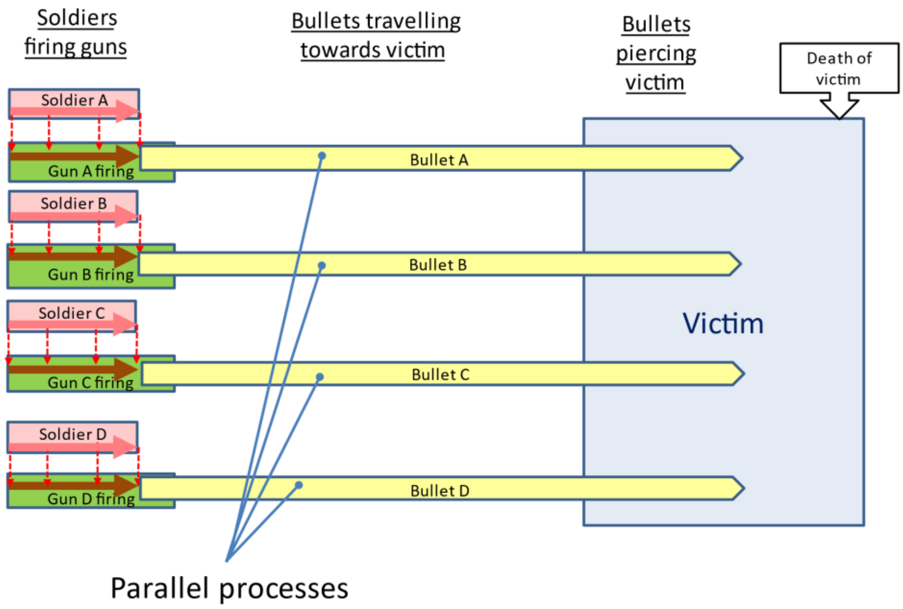

Figure 16.3: Parallel process example: a firing squad shooting a victim

In Figure 16.3 a number of soldiers, who constitute a firing squad, fire their guns in response to a command to fire at the victim - it is supposed that the victim dies shortly after. The firing of their gun by each soldier and the consequent flying of the bullet towards the victim and the piercing of the victim by that bullet is a process (within the base ontology of AAO). The multiple firings in tandem of the members of the firing squad are then parallel processes we may say, as illustrated in Figure 16.3.

The relation typically in focus, which I dub as being a *parallel-process relation*, is that between the gun firing of Soldier A, say, and the death of the victim. Considerable effort has been expended by philosophers to determine whether this should be classified as a causal relation. On the one hand, the process (in the everyday folk sense of 'process') connecting the events (the firing by soldier A and the travelling of this bullet into the victim), is taken as supporting the view this is a causal relation. On the other hand, the failure of the relation to satisfy a counterfactual criterion (i.e. if A had not fired, the victim would not have died) is taken to support the view this is not a causal relation.

AAO does not suppose that there is a clearcut answer to the question of whether this relation is causal or non-causal (this depends, inter alia, on purpose) – or, indeed, that this is a very helpful question. Rather, AAO recognises the underlying pattern of processes, and hence underwrites a more nuanced and accurate framework for possible (causal) uses of the relation, e.g. assessing whether bringing about the firing of soldier A will bring about the death of the victim, or whether we should ascribe blame to soldier A for the death of the victim.

16.4.2 Relations between later-stages-of-consequent-processes

Sometimes a process may give rise to further processes, *consequent processes* say. It may be that in such cases an event at a later stage of one consequent process (an A-event say) is followed by an event of a later stage of another consequent process (a B-event, say). We may then identify an ontological relation between the A-event and the B-event – this too is a relation which arises from a certain type of pattern of processes, as illustrated in Figure 16.4.

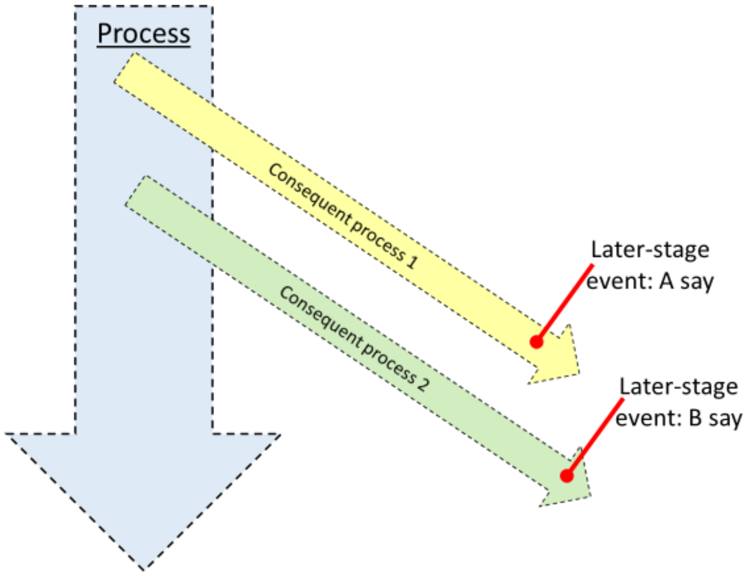

Figure 16.4: A later stage of consequent process 1, an A-event, is followed by a later stage of consequent process 2, a B-event.

As an example, a process of atmospheric pressure dropping may lead to a turning of the needle on a barometer and to a storm. We might take the barometer process which features the turning of the needle as *consequent process 1* (in Figure 16.4), with the dropping of the needle to a lower value as an *A-event*. We might take the process of storm formation as *consequent process 2*, perhaps with rain as a B-event. The dropping of the barometer needle to a lower value (A-event) may be followed by rain (B-event).

As another example, a piece of equipment may be designed so that a rise in temperature of some critical part leads to the illumination of a warning light – an A-event, say. This process of rising temperature may also give rise to other events, such as the formation of condensation on some casing – a B-event, say. We might then posit a type-level relation between the illumination of the warning light and the formation of this condensation.

The pattern of processes underlying *relations of later-stages-of-consequent-processes* is captured in Figure 16.4 – it involves a process and 2 (or more) consequent processes which arise from that process. Such relations may often be useful for purposes of prediction: the falling barometer may, perhaps with limited reliability, be used to predict forthcoming rain; the warning light on the machine may be taken to indicate a likely build-up of condensation, and perhaps more serious consequences if corrective action is not taken.

We should note that *relations of later-stages-of-consequent-processes*, whilst often useful for prediction, are not useful for control: pulling round the needle of the barometer will not lead to rain. Here these is no underlying process directly connecting the relata, so that (unlike in the case of single-process relations) bringing about the earlier relatum cannot bring about a process of some salient type that may lead on to the latter relatum.[257] Because such relations are not useful for control, they have typically been classified as non-causal. The question as to whether the relation is causal or non-causal is largely unhelpful - recognising the underlying process pattern provides a sounder basis for considering various possible (causal) uses of such a relation.

16.4.3 Other cases

Myriad other specified types of process patterns, perhaps highly complex patterns, may give rise to types of ontological-relations. For example, a pattern of processes which interlock in a way which gives rise to cases typically dubbed 'causal pre-emption'.

Where the pattern of processes underlying these relations is sufficiently stable, the relations may be useful for purposes such as prediction or control, but focusing on whether to ascribe the relation in question as causal or non-causal is likely to prove unhelpful.

[257] We might, of course, bring about A by bringing about the process which leads to both consequent processes pictured in Figure 16.4. Bringing about A in this way may indeed succeed in bringing about B. But bringing about A in other ways will not generally succeed in bringing about B.

16.5 Why the causal methods used are often successful in practice

As users of causal methods do not embrace AAO, how can it be that these methods are successful as often as they are, given my supposition that for a relation to be useful for causal purposes it must be underwritten by the base ontology of AAO (i.e. be an ontological-relation)? I shall argue that causal methods used in practice often pick out ontological-relations (on the AAO account) – and typically ones which have a high degree of stability.

In practice, users of causal methods typically use one or both of two distinct criteria for selecting relations for causal use:

1) sufficient stability;
2) evidence of a well-established and stable ontological link between the relata (e.g. a mechanism or process connecting them[258]).

We may suppose that a relation is stable either due to the underlying ontology or by chance: convincing chance regularities are infrequent, so picking out stable relations often picks out relations underwritten by the ontology.

The latter criterion (2) may be to the fore in cases where the ontological link is transparent and licenses a compelling account of how the ontology supports the relation. For example, given a bicycle: turning the pedals, turns the cog, which pulls round the chain, which turns the rear wheel – we have a compelling account based on transparent ontology of how the turning of the pedals causes the turning of the rear wheel. Such an ontological link is a 'mechanism' in the terminology of the new mechanists.[259]

These twin criteria are in accord with the Russo–Williamson thesis that to establish a causal relation requires both regularity (statistical) evidence and evidence for the existence of a mechanism.[260] Moreover, they are invariably the criteria underlying the methods for picking out causal relations which are identified by Nancy Cartwright in her excellent book *Hunting causes and using them*[261], e.g., randomised control trials (RCTs), multi-regression analyses, econometric methods, natural experiments, process tracing, and Bayes-net methods[262]. Some of these methods rely more on stability (criterion (1), e.g. multi-regression) and others more on the ontological link (criterion (2), e.g. process-tracing) – but both criteria are invariably in play to some extent.

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[258] Where the determination of whether there is such a mechanism or process is typically made using folk or everyday science criteria.
[259] Machamer et al 2000, Bechtel & Abrahamsen 2005, Glennan 2002, Illari & Williamson 2012, Cartwright, Pemberton & Wieten 2020 page 1.
[260] See Russo & Williamson 2007, Illari 2011, Parkkinen et. al. 2018.
[261] Cartwright 2007. See also Cartwright & Pemberton 2023.
[262] See also Spirtes et al 1993, Pearl 2000.

If a relation is stable across the domain of discovery, this not only provides some prima facie evidence that the relation is underwritten by the ontology there, but may provisionally (albeit defeasibly) suggest that this stability may obtain more widely - perhaps into the target domain, especially where the target domain is thought to be similar in salient respects to the domain of discovery. The stability criteria ((1) above) may thus supports the selection of relations that may be underwritten by the ontology within the target domain.[263] In practice, the ontological link cited in criterion (2) is often an AAO process or pattern of processes (such as those patterns described in sections 16.2 – 16.4), so that appeal is, in fact, made to elements of the AAO base ontology.

In many practical cases, especially in areas such as medicine, economics and social policy, the underlying ontology is often opaque and highly complex, so that it is unclear whether it affords a stable 'mechanism' that supports the relation in focus. One response to such opaqueness of the ontology is to focus more heavily upon the historic stability of the relation – a response that may be encouraged by ever increasing data availability and ever lower costs of data processing. We may then project an historically stable relation into the target domain of use, even in the absence of any clear account of the ontological links between cause and effect. Such methods may frequently (but not always) be successful in fields where the (unknown) underlying ontology is sufficiently stable – but much less so elsewhere. Nevertheless, such methods are fraught with danger: although such methods may often (i.e. when the hoped for stability does obtain) yield conclusions which are roughly right, sometimes (i.e. when the hoped for stability breaks down) they may yield conclusions (perhaps policy recommendations) that are disastrously wrong and, worse still, the methods provide no clues as to when they will be wrong.[264]

Existing causal methods do often succeed in picking out stable ontological-relations, even if errors are sometimes made. Recognizing AAO explicitly may help to pick out instances where the ontology is likely to be stable (in the right ways) in a target domain – and thus help the success of such causal methods. I shall pick up this point concerning practical implications of AAO for empirical methods in future work – work that will further develop my work with Nancy Cartwright in support of Cartwrightian methods.[265]

16.6 Conclusion

A causal relation (as I propose the term be used) is an ontological-relation (i.e. underwritten by the base ontology) – and hence a feature a of the super-ontology.

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[263] Not infrequently the requisite form of stability does not hold in to the target domain – and then costly mistakes may be made.
[264] See Pemberton 2005.
[265] See section 20.1.4.

17 Regularities and laws

This chapter focuses on regularities and laws, showing that the regularities and laws recognised by AAO are features of the super-ontology.

We noted in last chapter that the base ontology (on account of the consistent acting of actors) underwrites various relations – we have termed these *ontological-relations* and have set out some examples of types of such relations. I discuss in section 17.1 how multiple instances of an ontological-relation type underwrite regularities involving instances of their relata. As the ontological relations arise from the acting of actors, the regularities which follow from these ontological relations follow from the consistent acting of actors, and hence are brought about by the base ontology – and are thus features of the super-ontology.

However, these regularities are in general ceteris paribus (CP) regularities, not strict regularities.[266] To show that these CP regularities are features of the super-ontology, we must show that the pattern of variation from strict regularity (which is the subject of the CP condition) also[267] arises from the base ontology. If this pattern of variation could not be shown to arise from the base ontology, it would be unexplained and the claim that the CP regularities are features of the super-ontology would not yet be justified. To show that the pattern of variation from strict regularity arises from the base ontology I turn to recent work of Nancy Cartwright and myself that shows how such variations (that are the subject of CP conditions) arise from the local ontology.[268] This is the task of section 17.2.

17.3 explains that laws, as recognised by AAO, are also features of the AAO super-ontology.

Section 17.4 concludes: both CP regularities and laws are features of the AAO super-ontology.

17.1 Regularities

We have identified various ontological-relation types in the previous two chapters. In chapter 15 we discussed clusters in property-space (which may often be picked out by users as natural kinds). These clusters (which are underwritten by the consistent acting of actors within the base ontology) may underwrite relations (ontological-relations), such as the relation between membership of a cluster and properties associated with members of that cluster - for example, between a cluster of instances of phosphorous and being flammable; or between a cluster of tigers and having stripes. And in chapter 16 I outlined a number of types of ontological-

[266] CP conditions, which are often regarded as obscure, and perhaps even vacuous or incomplete, are now a topic of considerable philosophical interest and debate - see for example Reutlinger and Unterhuber 2014.
[267] I.e. as well as the regularity from which there is variation.
[268] Most notably in Pemberton & Cartwright 2014.

relations that may be used for causal purposes (e.g. relations between earlier and later stages of a process-type).

Where many instances of an ontological-relation of some type obtain, regularities of the relata of this relation-type will obtain. For example, the obtaining of a plurality of single-process relations[269] of some type entails the obtaining of the regular occurrence of earlier and then later stages of that process-type. An ontological-relation type[270] arises from the consistent acting of actors, we may suppose – and hence a fortiori from the acting of actors, i.e. it arises within the base ontology. These regularities, then, arise within the base ontology, and hence are feature of the super-ontology.

Other regularities may arise within the base ontology by chance. For example, sometimes when a coin is tossed 10 times it lands heads every time: within such a trial, there is a regularity to the pattern of outcomes, and this regularity occurs by chance. We may note that AAO underwrites a principled distinction between ontological-regularities, which arise from the consistent acting of actors, and accidental regularities, which arise by chance. I shall not focus further here on chance regularities.

17.2 Ceteris paribus conditions

We have noted that the regularities in focus are generally CP regularities rather than strict regularities. As noted, we must show how the base ontology can give rise to the variations from strict regularity (which are the subject of the CP conditions), in light of the consistent acting of actors which is the source of the underlying (strict) regularities. Using the ontological-relations that I have described in the previous two chapters by way of examples, I will show below how such variations do arise from the base ontology. I consider these examples in turn in the subsections below.

17.2.1 Acting-changing relations

As we have noted[271], acting-changing relations are synchronic. For example, the relation between the gravitational attracting of a planet by a star, and the accelerating of that planet. As Nancy Cartwright notes[272], strict regularity laws associated with such relations hold only under ideal conditions in which (inter alia) no other sources of acceleration of the planet are present, e.g. electrostatic forces, other gravitational forces (e.g. from other planets). Variations from such ideal conditions are, then, appropriate subjects for CP conditions: CP, the accelerating of

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[269] See section 16.2.

[270] I. e. a number of similar of ontological-relations with characteristics that we regard as sufficiently similar that we choose to classify them as being of the same type.

[271] Section 16.1.

[272] Cartwright 1983, Essay 3.

the planet is given by GmM/r^2 (usual notation).[273] The CP condition here rules out (inter alia) other sources of acceleration arising from the planet's star (e.g. electrostatic forces), and sources of acceleration from other local actors (e.g. gravitational attraction of other local masses). In general the CP conditions required for acting-changing relations relate to the possibility of (and ruling out of) synchronic acting (other than that allowed for) which affect the salient changing of the actors in focus in the regularities. That is to say, the CP conditions relate to salient acting of actors other than that provided for in the strict regularity. The pattern of variation from strict regularity (addressed by the CP conditions) thus arises from the acting of local actors - this is certainly the case in all the examples that I know (including those set out by Nancy Cartwright and I[274]). It thus arises from the base ontology.

17.2.2 Single-process relations

Consider again some examples of such relations:

- The inserting of a coin in the slot of a drink machine → the arrival of a drink in the output bin
- The taking of an aspirin (by someone with a headache) → the cessation of that headache
- Raining on the hills behind Bill's house → rising of the water level in the river next to Bill's house

Note that the description of each event-type above is rough and crude, amounting to no more than a few simple words. Although these descriptions might be refined, a degree of roughness in defining relevant event-types is in practice quite general, and probably unavoidable. This roughness of specification licenses one source of variability across such event-types that is salient for the variability of the associated regularity. Consider, for example, the event-type: *inserting of a coin in the slot in the machine.* This might reasonably be taken to include events in which a coin is banged in hard and as a result fails to follow the usual trajectory within the machine. It might include too events in which a sticky coin is inserted, which gets stuck in an internal slide. In general, the actual events which may reasonably be included in this inserting-coin event-type cluster will vary across dimensions which include the following:

<u>Differing things[275] in the event.</u> To count as an event of the given event-type, the things involved must be of some prescribed type (e.g. a suitable coin) - but they may vary from case to case (e.g. differing £1 coins with differing wear and tear and stickiness).

[273] In practice, this may more often be expressed by way of Keppler's CP law: CP, the planetary motion is elliptic.
[274] See, for example, Pemberton & Cartwright 2014.
[275] Things are a subset of actors, as discussed in chapter 9.

Differing changing of things in the event.[276] E.g. differing velocity or rotational velocity of the coin being inserted.

Differing arrangement of things in the event. E.g. the coin might be inserted in different sides of the slot, or at differing angles.

Only some events of the earlier event-type may lead on to the start of a process of the salient type. Where they do not, an instance of the ontological-relation between these events (i.e. an instance of the associated regularity), does not (except perhaps by chance) obtain. We see that these sources of variability (noted in these 3 bullet points), which may be the appropriate subject of a CP clause, are all aspects of the base ontology.

Another group of reasons for variability in the event-event regularity (which may appropriately be the topic of CP clauses) is the possible interruption of the process (once started) by external factors before the latter event occurs. In the drink machine example, such external factors might include external things jamming the machine, a power cut, or a local explosion. Again, such variation (addressed by CP conditions), in these examples at least, arise from things (actors) and arrangements and changings of these things – that is to say they arise within the base ontology.

17.2.3 Setting-outcome relations

Consider as an example a functional relation between the dosage of some drug and the change in some measure of health of patients who take the drug where, over some salient range, higher dosage yields more health improvement.

Now consider a patient Irene who starts to take the drug. The functional relation points to an expected improvement in Irene's health condition: ceteris paribus Irene's health condition should improve by this amount. In practice, of course, this may not occur: Irene's health may improve more or less than indicated, and perhaps even deteriorate.

One source of variability appropriately addressed by the CP condition is that amongst the individual patients which take the drug. Although we may suppose that these all have relevant health conditions, they will form a varied cluster on other dimensions which may be relevant to the effectiveness of the treatment, e.g. they have differing levels of salient hormones, differing auxiliary drugs, differing susceptibility to allergic reactions. Another source of variability may be the circumstances under which they take the drug, e.g., in hospital, at home with a qualified carer, at home without supervision. Again, differing circumstances may befall patients during the period of treatment, e.g. they catch a virus, they eat well or not, they exercise well or not.

[276] We might, of course, take such changing to be a property of a thing and hence to be included in the first bullet – but as we have noted in Section 1, adopters of the at-at approach eliminate changing from their ontology, so I include changing here explicitly.

In all cases, within this example, we see that the variations addressed by the CP conditions arise from the base ontology.

17.2.4 CP regularities associated with natural kinds

As we have seen in Chapter 15, clusters in property-space (that may often be identified as natural-kinds) arise from the base ontology. These clusters typically admit variability amongst cluster-members. Given some cluster, we may often identify properties which members of that cluster typically have – but generally there will be some exceptional members that lack this property.[277] For example, we may posit a law that dogs have four-legs – but some dogs exceptionally do not have four-legs, perhaps because they have lost a leg in an accident, or perhaps because of some glitch in the gene-expression of that dog. CP dogs have four-legs. When we look at the exceptions which the CP condition covers, we find straightforward explanations, e.g. loss of leg in an accident – explanations that can invariably be rendered in terms of actors and their experiences, i.e. in terms of the base ontology.

17.2.5 Summary

We have considered each of the various types of ontological-relations noted previously in turn - in each case all the examples that we have identified support the view that the variation (which is the appropriate focus of CP conditions) arises from the base ontology. In these cases, then, the CP regularity arises as a pattern within the base ontology and is thus a feature of the super-ontology.

It might be urged, however, that offering such examples is unpersuasive and insufficient – what is required is to identify principles which govern (in some sense) such variations, and then to analyse these principles to show that the variations follow from them. Unfortunately, though, the variations in question are notoriously unruly – their source may typically be interference from outside of a system which is in focus, where the possible sources of such interference are open-ended and vast, perhaps infinite, in scope. It does not seem that the variations fall under some tidy set of principles in a way that would be helpful – so that the consideration of examples would seem to be the best we can do. Here, and in my previous work with Nancy Cartwright, I offer a wide range of examples. Nevertheless, no set of examples can be exhaustive. There remains the possibility of some example coming to light in which the variation does not arise from the local ontology – if it were to do so, my argument would need to be amended.

[277] As is noted and well discussed in Dupre 1993.

17.3 Laws

Philosophical accounts of laws vary greatly[278], so that a great many putative laws of differing types are posited by philosophers. AAO recognises only some of these as laws. Firstly, the CP regularities that arise from ontological relations that we have discussed in section 17.2 may (if we wish) themselves be called laws. As we have noted, these CP regularities are features of the super-ontology. Secondly, a claim that such a regularity obtains[279] may be called a law. Such a claim is an encoding of the regularity in focus – as we have discussed in chapters 13 and 14, such an encoding of the empirical world is itself a pattern in the base ontology, and hence a feature of the super-ontology. In either case, the laws recognised by AAO are features of the AAO super-ontology.

17.4 Conclusion

Regularities that arise from ontological relations, and laws associated with these regularities, are features of the super-ontology.

[278] See for example Carroll 2020 and Maudlin 2007.

[279] Such a claim may concern a potential regularity rather than one which is instantiated. Salient instances of the relata may not in practice be instantiated (so that the associated regularity is not instantiated), but we might suppose that if instances of salient relata were to be instantiated then the associated regularity pattern would obtain. Perhaps, for example, our knowledge of the parts of a configuration of actors which is (or which underwrites) one relatum implies a process-power which points to a later stage which is our other relatum.

18 Possibilities and probabilities

For many accounts of ontology, possibilities may be read directly from what exists in the foundation of the ontology. Mosaic ontologies, as I note in section 18.1 below, are leading example of such ontologies. Aristotle's ontology is another example: Aristotle supposes that being potentially sits alongside being actually as one of the many ways of being.[280]

In setting out an account of the base ontology, AAO makes no appeal to possibilities (as we see in the earlier sections of this thesis). AAO rejects the view that possibilities may be read directly from what exists in the foundation of ontology. Rather, possibilities are in general putative ways in which (aspects of) the world (i.e. the base ontology) may be which have regard to how it is (or has been) and how it may change.[281] Such possibilities may be expressed by meta-encodings (e.g. the meta-encoding "is possible") of encodings (often linguistic encodings) concerning the world.

Recall our account of process-powers in chapter 12 (section 12.1.2) – these characterise a configuration as having the ability (within a suitable context) to give rise to a process of some type. Aspects of future stages of such processes are (roughly) possibilities that may be brought about by a configuration with that process power (within a suitable context). I shall call these *process-power possibilities* (PPPs), and set out a careful account of them in section 18.2. PPPs are the manifestations of process-powers, we may say[282]. For example, the swallowing of an aspirin by someone with a headache may give rise to a process which ceases the headache – when such a possibility occurs, it is a manifestation of the power of the aspirin to cure a headache (when swallowed by someone with a headache).

We recognised in chapter 12 that process-powers piggyback on acting-powers – so that process-powers obtain on account of the base ontology, they are features of the super-ontology. PPPs may be understood as arising from process-powers, so that they too hold on account of the base ontology (given some configuration with a process-power) – and they too (like process-powers) are features of the super-ontology. As with process-powers, the obtaining of PPPs is consistent with the only type of ontological modal principle being acting – these possibilities arise from acting (the acting upon which the identified process-power piggybacks): such possibilities do not suppose some other (presumably diachronic) modal principle within the base ontology.

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[280] See for example Aristotle Metaphysics Θ, especially part 7.

[281] As we have noted, change arises from changing through time. Changing reflects velocities, acting and arrangement.

[282] I acknowledge my debt here to Aristotle's subtle account of how powers give rise to possibilities. See for example Metaphysics Θ and Stephen Makin's discussion of Aristotle's recognition of non-standard capacities in which φ-ing does not imply an ability to φ (Makin 2006). See also Aristotle's account of chance (e.g. Dudley 2012).

I note in section 18.3 that many other types of possibility are widely posited. As I shall illustrate, the term ‘possibility’ is used in many differing ways in areas such as, for example: science, commerce and by folk. Many of these uses of ‘possibility’ are rough and ready and often express only loosely-defined, or perhaps even ill-defined, views about how the world may be, so that varying opinions as to what is possible are commonly allowed in such usage. Such usages of the term ‘possible’ in loose or ill-defined ways need not concern us here as we set out an account of the ontology of the world. Other accounts of possibilities pay careful regard to the ontology of the world and have practical uses, e.g. for planning future actions. I outline briefly some examples of these latter, focusing on examples of possibilities that are derived with the use of expert judgement. Such possibilities may often be in the past or present.

Section 18.4 looks briefly at probabilities, noting their connection to possibilities. I describe briefly what I take to be the most commonly used type of probabilities – the probabilities associated with future outcomes from some target circumstance – noting how these relate to PPPs.

Section 18.5 concludes.

18.1 Mosaicist possibilities

Mosaicist philosophers typically advance their own distinctive account of possibility. In mosaic ontology, it is typically supposed that, for example, ‘Fa’ is possible (where ‘F’ is some property and ‘a’ is some object) just in case we can find a tile within the mosaic (of this and certain other possible worlds) where there is an ‘a’ which is ‘F’. The details of such accounts vary. Possibility is in this sense a matter of existence[283]: Fa is possible just in case an instance of Fa exists (in the sense intended by the person using this notion of possibility).

AAO, by contrast, does not posit the existence of mosaic tiles, so that possibility is viewed very differently from the perspective of AAO, as I explain.

18.2 Process-power possibilities

Possibilities (and associated probabilities) are often used by science, commerce and folk for practical purposes, such as the planning and management of their affairs for the future. Such possibilities typically focus on the future of some target circumstance[284], often (but not always) a current circumstance. Typically, a circumstance (or some aspect of a circumstance) in the future of the target

[283] On Lewis’s account, these possible worlds exist in a full-bloodied sense, whilst on other mosaic accounts possible world ‘existence’ is typically more qualified.

[284] A circumstance may be understood as a configuration in some context (chapter 10 – especially fir page - sets out my use of the terms ‘configuration’ and ‘context’). As I shall explain, our standard methods for ascribing future possibilities to some token target circumstance treat the circumstance as being of some circumstance-type (typically a configuration-type in a context-type).

circumstance is deemed a possibility where it is viewed that the target circumstance may change over time to give rise to this circumstance. The change that is in focus in deriving such possibilities is that which arises from the target circumstance. At least often when these methods are most successful, the possibilities identified are PPPs. I shall demonstrate this by way of a discussion of methods used in practice.

Consider a world that is deterministic so that there is only one way in which it may evolve over time - there is just one possible future. To fix the future of some token local circumstance requires fixing the state of the world in some large space around that locality (perhaps the salient light cone). Practical methods, for epistemic and manageability reasons, do not engage with such complete states of vast spaces, but rather focus on simplified circumstances. In practice, the simplification of the circumstance involves focusing on some local configuration of actors central to that circumstance. In new mechanist terms, this is the mechanism arrangement (at some stage). We may then characterise two aspects of the circumstance simplification:

1. Everything outside of the configuration – the *context* – is either set aside from our consideration entirely, or is perhaps reduced to one or a small number of actors in the vicinity that may act with the configuration. For example, the context may be taken to be simply a constant downward force of gravity (e.g. in the case of a pendulum).
2. Idiosyncrasies and imperfections of the configuration itself are set aside (these, too, are too complex to know exactly) so that an idealised version of the configuration is considered. This amounts to a move from a consideration of a target configuration to consideration of a configuration-type.

Such methods take a circumstance to be a configuration in some context.[285] The necessary (for practical reasons) simplifications we note above mean that methods for identifying possibilities associated with a token circumstance generally start by ascribing the token circumstance to some circumstance-type – and then ascribing possibilities associated with this circumstance-type. The operation of moving from a token circumstance to a circumstance-type is unavoidably crude – it cannot be specified with any precision. Once we are dealing with circumstance-types, an assumption as to whether the world is deterministic or not has no practical import for the ascription of possibilities: it does not matter for this purpose whether each token circumstance within our identified circumstance-type has one or many possible futures.

Identifying future possibilities associated with circumstance-types is generally a highly challenging task which requires difficult judgements. What makes it feasible at all is the consistent acting of actors across differing configurations of the same type. Various strategies have been developed both by scientists and non-scientists to render this task tractable, at least in some salient cases (although even here the identification of possibilities typically rests on considerable judgement). To sketch

[285] See the introductory remarks in chapter 10 for an account of the terms ‘configuration’ and ‘context’.

these strategies, the following (partial) taxonomy of ways in which a circumstance (configuration + context) may be characterised is helpful[286]:

1. Point to some configuration in the world at some time as being the salient configuration, and decree that:
    a. The context is of the same type as that which obtains in this token circumstances. (Or perhaps is the token context which obtains on this occasion.)
    b. There is no context. (Or perhaps a context comprising only some minimal standard features, e.g. the obtaining of a usual downward gravitational field.)
2. Specify (to some preferred level of detail) the configuration as comprising some types of actors and the type of arrangement in which they obtain – and:
    a. Suppose that the context is of a type in which such circumstances typically obtain.
    b. Suppose no context. (Or perhaps there is a context comprising only some minimal standard features.)

2(b) generally offers the most tractable characterisation of a target circumstance-type – we may understand this as specifying a type-level mechanism (in the sense of the new mechanists) whilst setting aside interference. Consideration of the manifesting of powers (interactions, on some accounts) of the parts of the mechanism-type may allow the types of activities / behaviours / change-processes of the mechanism-type to be identified, and hence the later stages of such activity-types to be ascribed as possibilities. I have noted in earlier chapters, especially chapter 9, many examples of mechanisms and their associated process-types (e.g. the operation of a vending machine, the firing of a neuron). Such mechanisms are often isolated and/or shielded (these are practical ways in which the impact of the context may be reduced, perhaps to a level that is negligible) thus perhaps rendering the setting aside of the context as a plausible practical approach. Typically the focus is on mechanisms that are sufficiently robust to ensure they work in just one way (or a limited number of ways) – this limits the range of possible outcomes to just those of the 'correctly' working mechanism and this, too, is central to tractability.

Nevertheless, although more tractable, such a specification of the circumstance may be too limited in practice: many of the possibilities associated with the future of a target circumstance may arise from the context of the mechanism – in particular from the acting of powers of actors in the locality that we may generally deem interference (e.g. objects which may strike the mechanism and hence interrupt its operation).[287] To allow for these we must extend our characterisation to include the context, e.g. we may typically adopt 2(a).

[286] Note that each of these identifies a circumstance-type – and that in each case the circumstance-type is crudely (rather than precisely) specified. These specifications perhaps indicate the sense in which the operation of ascribing a circumstance to a circumstance-type is necessarily crude.

[287] Aristotle points us towards consideration of possibilities arising from interference (i.e., from the acting of actors outside of the configuration that is in focus) in his account of occurrences that happen by chance. The meeting with the debtor in the marketplace happens by chance – it is due to the

Other possibilities may be associated with the idiosyncrasies of a particular token mechanism picked out in 1 (a or b).[288] As noted in relation to ceteris paribus conditions in chapter 17, such variation can qualify the regularities that occur – that is to say, give rise to differing possible outcomes (which are then exceptions to the regularity). Such variation can arise from how the machine is. For example, perhaps a storage box in the vending machine has not been filled, so that the machine turns so as to empty the contents of the box in to the output bin but there are no contents to be had. Or the variation might arise from the context. For example, perhaps there is a power cut so that when I push the button on the vending machine nothing happens. Allowing for the idiosyncrasies and fuller context of a particular token machine may introduce possibilities that are not in focus in the descriptive type-level circumstances (specified in 2). Focusing on specific mechanisms in this way is a feature of empirical research, including the use of experimental methods.

In the blousier world of folk more generally, the focus is typically on less tractable circumstances specified (perhaps implicitly) by approach 1(a): the outcomes of sports matches, elections, economies, health programmes, world development, etc. Here the assessment of what to count as possibilities generally appeals to rougher methods, perhaps resting on experience (e.g. known patterns of outcomes of circumstances which are taken to be similar in relevant respects) – and ascriptions of 'possible' are typically more controversial.

In general we see that what is allowed as possible depends in part on what range of contexts is entertained – the broader the range of contexts, the broader the range of possibilities. In everyday usage, restrictions on the contexts are typically not explicit – and intuitions / preferences may differ as to what is allowable as a context – so that opinions may often differ as to what is possible.

We see that in each case the future possibilities identified by these common methods have regard to some initial target circumstance and the change which can arise from the acting of actors within the target configuration (perhaps together with its context). These possibilities are, then, process-power possibilities associated with the target circumstance – and hence are features of the super-ontology.

18.3 Other possibilities

Many other types of possibilities are posited by differing groups of people and for differing purposes. Many of these types are implied by informal usage of the term 'possibility' and may often be only loosely defined, or perhaps ill-defined, and perhaps only useful for social, fun or dialectic purposes. For example, '*a talking donkey is possible'* is a phrase that may be used, but which fails to specify clearly

intersection with actors outside of the configuration in focus (i.e., the intentioned visitor to the marketplace). Aristotle, Physics, II.5, especially 196b33-197a5.

[288] In practice we can include in our characterization of the token mechanism (which specifies our mechanism-type) some but not all of its idiosyncrasies.

what should count as an instance of a talking donkey (e.g. must it have a brain no larger than existing examples of donkeys, must it be genetically related to existing donkeys, what degree of linguistic ability is required to count as 'talking'?) – such a putative possibility is ill-defined.

One group of possibility-types (and associated probabilities) that is widely used for practical purposes with considerable success appeals to the use of expert judgement – typically the expert judgement involves, inter alia, consideration of some local ontology. Many such possibilities may be located in the past or present. Here are some examples of such possibilities – they are intended to help illustrate the variety of types of possibility we find in common use.

i. Confronted with a crime scene, a detective aims to work out what has happened: who has committed the crime, where, when and how. The detective may construct putative accounts of the crime which she takes to be possibilities as to the who, where, when, and how. For an account of the crime to be admitted as possible, it must be the case that the current crime scene is a future possible circumstance with respect to the circumstances of the crime on this account.

ii. Confronted with a newly-presenting patient, a doctor aims to work out the nature of the underlying condition that is bringing about the patient's symptoms – she constructs accounts of possibilities for the underlying condition. For the account of the underlying condition to be considered a possibility, it must be consistent with the symptoms to which it gives rise (on the basis of available medical knowledge).

iii. A team of investigators with limited knowledge of some scientific phenomenon may aim to provide a fuller explanation. For example, the early investigators of the operation of a neuron knew that neurons fired as part of the operation of the brain, but the details of the firing were unknown. (Later the diagram in Figure 9.1 above and the associated story was developed and evidenced.) The investigators may typically advance accounts of the phenomenon in focus which they consider possibilities given the available knowledge – and then perhaps seek to explore further or experiment to test whether the mooted possibility is plausible.

In each of these cases, the range of possibilities is dependent on certain available empirical knowledge and the limitations of this knowledge, as well as expert judgement.

Where a mooted possibility is not actual (e.g. it is a false account of a crime, it is a misdiagnosis of a medical condition), then it obtains only in the sense of being an encoding (which does not correspond to actual circumstances). Where the mooted possibility is actual, then that possibility (an instance of the possibility-type described) obtains as an actual circumstance in the ontology. Possibilities obtain within the super-ontology in differing ways.

18.4 Probabilities

Commonly-used probabilities (perhaps those most-commonly used) are associated with circumstance-types that may arise in the future of some target circumstance. Most typically the circumstance-types in focus are PPPs. Such probabilities express the expected frequency with which the future circumstance-type comes to obtain given the obtaining of that target circumstance (treated as a circumstance of target circumstance-type). I take it that the target circumstance-type together with associated future circumstance-types (possibilities) is a 'chance set-up' as explicated by Ian Hacking[289] and as perhaps commonly understood.

Such probabilities are, in a primary sense, associated with a target circumstance-type: they relate to type-level possibilities associated with that target circumstance-type. A probability may then be associated with a token circumstance derivatively when it is appropriate to characterise that token circumstance as being of the identified circumstance-type. (Such classification may not be appropriate where the token circumstance may be characterised as being of some more detailed circumstance-type.) We may then associate the target circumstance-type probabilities with the token target circumstance ex ante and use them as a guide to the likelihood – the relative frequencies - of the relevant possibility-types occurring in this case.

Many of the methods used to assess such probabilities follow closely from the methods outlined above to identify PPPs. Again such methods often focus on the change which may arise from actors within a target circumstance and perhaps its context – the characterisations typically follow approaches of 1 or 2 (a or b). In the approach we noted as the most tractable and popular for identifying possibilities, 2(b), we typically idealise the circumstance in setting out a type level description. For example, we may posit a spin of a perfect roulette wheel, or a run of an experiment set up in accord with a precise prescription. Often these idealised descriptions may present symmetries – for example the spin of an idealised roulette wheel presents the symmetry of the ball landing in each numbered slot – which licenses direct calculation of the probabilities on symmetry grounds. Still, probabilities derived from such idealised descriptions do not accurately capture actual relative frequencies – in this sense they are not accurate probabilities. For example, we might ascribe a probability of a ball landing in a numbered roulette slot 1/37 (supposing that there are 37 symmetric slots) – but this ignores the possibility of interference: perhaps a distressed gambler grabbing the ball, the croupier picking up the ball when a fire alarm sounds, an explosion which blows up the table. There are no probabilities that usefully capture such interference events.[290]

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289 Hacking 1965, chapter II; Cartwright 1999, chapter 7, especially 175.
290 As Nancy Cartwright argues, on my understanding: Cartwright 2022, 34-53.

In cases where many instances of the target circumstance-type are found in the world[291], and we have identified the probabilities sufficiently accurately, the probabilities will characterise the frequency patterns of circumstances (of the various possibility-types) within the base ontology – in this sense these probabilities are features of the super-ontology. Where circumstances of the target circumstance-type are not suitably multiply instantiated, we may nevertheless suppose that frequencies in line with the probabilities would occur if such instantiation were to occur – here too we may suppose that the probabilities are features of the super-ontology.

In general, whenever and however we identify possibilities, we may associate probabilities with these possibilities which express a view as to the likelihood of the possibility. For example, where a doctor posits possible conditions which underlie a patient's presenting symptoms, such probabilities may express her view as to how likely each is.[292] The methods for deriving such probabilities typically follow closely from the methods of identifying the given possibilities – in this doctor case, for example, these methods will rest on the expert judgement of the doctor.

In other common cases there is a focus on making a change – an intervention, we might say - to the target circumstance-type. Perhaps this concerns the running of a machine or experiment – and we amend the machine or experimental set-up. Or perhaps this is an intervention of the sort that might be adopted in the running of an RCT[293] – for example we adopt a treatment programme for some patients and see how their experience differs from those not receiving this treatment. Changing the circumstance-type may be understood as an amendment to the chance set-up. Often the range of possible outcomes before and after the amendment is unchanged – i.e. we have the same possibility space – but the probabilities of outcomes differ following our amendment of the chance set-up.

Like their associated possibilities, probabilities obtain within the super-ontology in differing ways.

18.5 Conclusion

On the AAO account, possibilities are not to be found by inspection of the foundation of ontology. Moreover, many of the possibilities posited by folk are only loosely-defined or ill-defined - and not of concern in developing an account of ontology.

[291] Perhaps they occur in nature, or perhaps it is possible to bring about repeated instances of the target circumstance-type in suitable contexts (as perhaps when we build mechanisms such as experimental laboratory set-ups and machines which are suitably shielded from interference).
[292] I do not suppose that there is any non-circular way to explicate the meaning of 'likely' in such contexts.
[293] Or more generally, we change the 'setting' of some setting-outcome relation (see section 16.3).

There are, though, possibilities which are dictated by the base ontology. Where we have a configuration with a process-power, this may give rise to a process of some type (as noted in chapter 12) – and the stages of this process-type are then possibilities underwritten by the base ontology. Such possibilities are underwritten by the acting of actors (of some type) within the target configuration-type, or perhaps its context. I dub these process-power possibilities. In practice, when science, commerce and folk use possibilities to good effect in achieving their proximate purposes (e.g. planning actions to manage the future), they are often making use of PPP.

There are many other methods for identifying possibilities. Many of these make use of expert judgement. The standing of each type of possibility must be assessed case-by-case.

Probabilities may be associated with any possibilities and express the likelihood of the possibility (where the meaning of 'likely' is implied by the nature of the possibilities in focus). Commonly used probabilities (perhaps the most commonly used) consider the possibilities that may arise from change over time from a target circumstance – the key possibilities in focus are often then PPPs.

PPPs, and probabilities associated with PPPs, obtain on account of the base ontology and are thus features of the super-ontology.

Where we have possibilities that are features of the super-ontology, AAO licenses an account of these possibilities in terms of acting (perhaps consistent acting) within the base ontology – these possibilities are not simply brute, but rather they can be explained in terms of the base ontology.

Section V: Assessment and conclusion

19 Assessment

In line with the plan set out in chapter 11, I have now sketched (in chapters 12-18) each of the main features of the super-ontology that I identified.

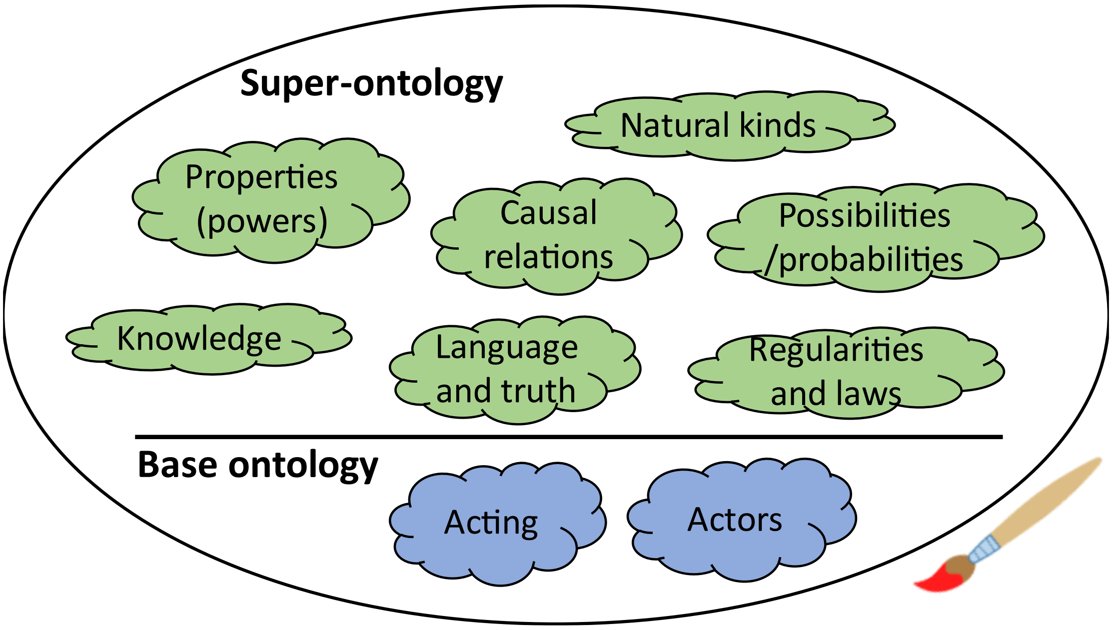

Figure 19.1: Sketch of Acting-Arrangement Ontology

I have set out how each of these features arises from the base ontology – that is from the spatial obtaining of elementary-actors and composite-actors and their acting. In doing so, I have shown how each of these features is explicable – it is not simply a brute addition to the ontology. Arrangements (both arrangements of the parts of composite-actors, i.e. super-subtle-existencies, and other arrangements of actors) have played a central role in these accounts of the super-ontology features.

Together with the account of the base ontology (developed in chapters 2-10), this sketch of the super-ontology completes our sketch of AAO within this thesis. Although considerable further work remains to be done to achieve a complete picture of AAO (as I shall outline in the next, and final, chapter), this sketch achieves the aim (laid down in chapter 1) of setting out the main pieces of AAO and showing how they fit together in a compelling way.

We are now in a position to undertake the main task of this chapter: to assess the attractiveness of AAO (as per this preliminary account), and whether it warrants further investigation. In making this assessment I will use mosaicist ontologies as the foil against which to consider AAO. As we have noted, mosaicist ontologies are popular (perhaps the most popular) contemporary ontologies – it is for this reason that I select them as our comparator.[294]

[294] See section 3.2.1 for an outline of my use of the term 'mosaic ontology'.

I will start this assessment, in section 19.1, by summarising the impressive list of reasons for preferring AAO to mosaicism that we have amassed through our work in this thesis so far. I will then, in section 19.2, make some comparisons of AAO to mosaicist ontologies. This comparison will be focused around some leading desiderata for ontologies: fit with the empirical world, coherence and parsimony. Section 19.3 explores the consistency of the methods used within this thesis with the ontology proposed, viz. AAO.

I briefly summarise this assessment and draw conclusions in section 19.4.

19.1 Summary of reasons identified in this thesis for favouring AAO

19.1.1 For lasting-changing-acting (LCA) ontologies

We started (in sections I – III) by making the case for ontologies that feature lasting, changing and acting. LCA ontologies include not just AAO, but also Aristotelian / neo-Aristotelian ontologies and perhaps other ontologies (including ones yet to be articulated). As mosaicist ontologies are not LCA, arguments for LCA ontologies are arguments for preferring AAO to mosaicism.

Perhaps the most powerful argument identified for LCA ontologies is that these features license a coherent account of the bringing about of change: acting-through-time yields changing-through-time and hence the bringing about of change over time. By contrast, mosaic ontologies preclude changing and acting, and hence have no apparent answer to the devastating challenge of no-successors (chapter 7). Other arguments for LCA ontologies that we have identified include their problem-solving power:

- Lasting solves the problem of temporary intrinsics (section 5.1);
- Changing / lasting solves the problem for those who believe physics requires instantaneous velocity to underwrite causal roles (section 5.3);
- Changing / lasting solves the rotating homogeneous disc problem (section 5.4);
- Changing and lasting support the identification of change (as distinct from difference) (section 7.1);

Further arguments presented for LCA are their accordance with folk intuitions:

- Changing accords with folk intuition (section 5.2)
- Acting accords with folk intuitions (chapter 8).

19.1.2 For AAO

In addition to the arguments for LCA, we have also identified arguments for AAO specifically – these include its fit with the empirical world:

- The AAO account of composites fits well with all examples of things and processes that we have identified (chapter 9).
- AAO provides a principled account of restrictive composition (chapter 10).
- The trajectory-acting basis of AAO fits well with contemporary physics (chapter 11).

They also include its solution of two further profound metaphysical problems:

- AAO resolves the causal exclusion problem (section 12.1.1.4)
- AAO underwrites resultant novelty – hence solving puzzles associated with 'emergence' (section 12.3).

And its ability to provide explanatory accounts of many key features of the world by reference to a parsimonious base:

- AAO provides a principled and compelling account of features of the super-ontology including properties, knowledge, language, truth, natural kinds, causal relations, regularities, laws, possibilities and probabilities (chapters 12-18).

19.1.3 Summary

The list of reasons we have already identified for favouring AAO are significant both in terms of their number and their weight.

19.2 Comparisons with mosaic ontologies

Let's look then at some comparisons of AAO and mosaic ontologies across a range of salient desiderata.

19.2.1 Fit with the empirical world

I take it that a desirable feature of an account of ontology is that it fits well with the empirical world. I shall adopt a broad interpretation of what to count as the empirical world, allowing that this includes both everyday folk experience as well as the world of contemporary science.

The centrepiece of our work towards establishing the fit of AAO with the empirical world is the review of things and processes undertaken in chapter 9. I considered a wide range of things and processes from across domains including physics, chemistry, biology and engineering showing in each case how these fitted with the AAO account of composite actors. And I failed to identify any composites that did not fit well with the AAO account.

In respect of the base ontology, we noted (section 10.1) how particles of the Standard Model in physics are good candidates to be elementary-actors – and how adopting such particles as elementary actors accords well with our standard view that things in the physical world are built iteratively by the combining of such elementary particles. Crucially, the trajectory-acting basis of AAO fits well with the Standard Model of particle physics – as we may understand this model as characterising particles by trajectories and acting.[295]

We have shown, too, how each of the features of the super-ontology obtains on account of the base ontology (chapters 12-18), and hence indirectly (as the base ontology fits with the empirical world) how each of these features fits with the empirical world.

I contend then, that I have presented arguments that AAO fits well with the empirical world.

The success of mosaic ontologies is predicated on their ability to provide a compelling account of the fit between their mosaic and the empirical world. Recently, however, critics of mosaic ontology have increasingly raised doubts as to aspects of this purported fit - for example in respect of their ability to capture quantum entanglement or holism[296]. Nevertheless, mosaic ontologies retain, as yet, the status of orthodoxy - the purported fit of mosaicism with the empirical world continues to be found compelling by its many supporters.

19.2.2 Coherence

I take coherence to be concerned, inter alia, with internal consistency. One indication that an ontology performs poorly against this criterion is that it gives rise to paradoxes, or that it is characterised by unresolved disputes concerning aspects of the ontology.

Despite prolonged and intensive research, mosaic ontologies remain subject to a many aporia (seemingly paradoxical problems) which include (amongst others) the following:

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[295] As we noted in developing our account of trajectories and acting, and hence the base ontology, in sections I-III.
[296] See for example Maudlin, 2007, chapter 2.

- Changing aporia (e.g. the problem of instantaneous velocity, as discussed in chapter 4[297]).
- Property aporia (e.g. the nature of universals (if there are such) and their instantiation. How properties combine to be continuants.)[298]
- Change aporia (e.g. how a thing can change and remain the same - the problem of temporary intrinsics[299]).
- Causation aporia (e.g. the nature of causal relations.[300])
- Composition aporia (e.g. the problem of the one and the many.[301] The special composition question[302] - how to restrict composition.)
- Causal exclusion problems.[303]
- Emergence. (Whether there is emergence, and if so its nature.)[304]

These aporia remain central to the work of metaphysics[305], of course, and subject to intense debate. Nearly all (or perhaps all) positions within these debates face powerful criticisms from alternative viewpoints, so that they are typically, at least, opposed by a majority of philosophers. Until such criticisms are resolved (which does not seem likely anytime soon), the internal consistency of mosaic ontologies must remain in serious doubt.

By contrast, AAO, is not challenged by any of these aporia. This follows from the account set out in this thesis. I have argued in chapter 4 that CLA ontologies in general provide a solution to the problem of instantaneous velocity – this applies to AAO in particular. Properties are not entities according to AAO, as discussed in chapter 12 – so that property aporia do not challenge AAO. Moreover, AAO does not posit transtemporal identity, so that the problem of temporary intrinsics[306] does not challenge AAO. Chapter 16 shows how it is that AAO, by recognising processes as entities within the base ontology, is able to provide an account of causal relations (an account which mosaic ontologies, in being unable to explicate an adequate ontology of processes, cannot replicate). Chapter 10 sets out the AAO account of composition and explains how this subtle account of composition (unlike Lewis's account of composition, for example) answers the problem of the one and the many: an acting together (a composite actor) is one acting-together, and yet is just the parts acting together, and hence is many parts. Moreover, on the AAO account, composition is restricted – the empirical review in chapter 9 shows how this restricted composition account fits with both things and processes that we find in

[297] See e.g. Arntzenius 2000, Pemberton 2021.
[298] See e.g. Orilia and Paoletti 2020.
[299] See e.g., Wasserman 2003.
[300] See e.g., Beebee et al 2009.
[301] Verity Harte 2002.
[302] Peter van Inwagen 1990.
[303] Kim 2005, 2018.
[304] O'Connor 2021.
[305] See, for example, general introductions to metaphysics such as Lowe 2002, Loux 2006.
[306] Which starts by supposing that transtemporal identity should obtain between two temporal parts of a persisting entity (see e.g. Wasserman 2003).

the world. AAO's solution to the causal exclusion problem and the challenge of emergence are set out in chapter 12.

I have then, I contend, made a case that AAO is currently at least as well-placed as mosaic ontologies in respect of coherence.

19.2.3 Parsimony

Parsimony is a widely-embraced criterion for selecting a preferred ontology: ceteris paribus, simpler is preferred to less simple.

We have shown (in section IV) how the features of the AAO super-ontology obtain on account of the obtaining of the base ontology. A God wishing to create the world need do no more than set up the base ontology. Indeed, God need do no more than set up the elementary actors (and their acting) in time and space.[307] AAO thus provides a rich ontology sufficient to underwrite a contemporary folk and scientific account of the world, but does so from a sparing ontological base. Indeed this base posits no more than entities with spatial trajectories and abilities to act. It thus achieves, I contend, extreme parsimony.

My tactic of accounting for a rich variety of ontological features (e.g. the features of the super-ontology) using only a sparing ontological base follows that of Lewis (amongst many others). Lewis uses entities which are properties at the base of his ontology. However, properties themselves, together with the ontological machinery which must be constructed to license related modal claims, introduce considerable complexity, I contend – far more complexity than has generally been admitted. In particular, mosaicists typically require many types of entity and ontologically significant principles to underwrite their ontologies – these may include:

> properties, property universals, similarity relations, instantiated properties, instantiation relations, bundling relations, natural kinds, kind universals, forms, essences, identity relations, powers, manifestations, relations, distance relations, causal relations, necessitation relations, modal relations, supervenience relations, laws, possibilities, axioms of a best system, principles of best systems axioms (e.g. simplicity, power), categories of being, knowledge, minds, consciousness, possible worlds, counterpart relations, distance metrics between worlds, facts, 'is the case' relations, linguistic objects, meanings, truth-bearers, truth, logical principles.

Of course, specific mosaic ontologies employ only a subset of these items, but nevertheless each mosaic ontology requires a significant number of the entries on this list. This list is not intended as exhaustive. A mosaicist might argue that many of these items (including, for example, best systems axioms and their associated

[307] See section 10.2.

machinery) are not actually parts of the ontology, rather they sit 'outside' of the ontology, so that the ontology itself is more parsimonious than inclusion of these items would suggest. I reject such arguments: the foundational principles are posited because they are required for the ontology to be adequate in some respect, e.g. to underwrite a modal account of the world – admitting these principles in assessing the adequacy of the ontology (e.g. in underwriting modal claims) but not counting them when it comes to assessing parsimony amounts to a sleight of hand that should be called out and not accepted. Indeed, placing items 'outside' of the ontology seems paradoxical: an ontology must surely be an account of all that there is. It introduces the problematic question as to the ontological status of such 'extra-ontological' items.[308]

The base ontology of AAO does not employ any of the items on the above list - although, as we have seen, some of them arise (in an explicable way) within the super-ontology. AAO is able to achieve far more with far less by adopting the single straightforward internal modal principle of acting which turns out, as I argue, to be able to underwrite composition and the whole super-ontology. As we have noted, much of the novelty that arises in AAO derives from arrangements and often from super-subtle-existence in particular – super-subtle-existence rests on acting as a principle in combination with arrangements.

Of course it may be argued that mosaicist ontologies, unlike AAO, avoid making an ontological commitment to principles of acting – and in this respect, at least, they are more parsimonious than AAO. Agreed. This point is certainly one which should be weighed in the mix – but it is not clear how it might be weighed sufficiently heavily to secure the balance of the scales for mosaicism.

Another dimension of parsimony that deserves consideration, yet has received little, concerns the amount of information required to characterise the world in a given ontology.

Neo-Humean mosaic ontologies[309] suppose that each point in space and time is separate and bears no necessary connections to any other spacetime point, so that how each point is (e.g. the properties instantiated at this space time point) must be specified individually. It is typically supposed there are a dense infinity of time points and a dense infinity of space points (at each time), so that the amount of information required to characterise such an ontology is vast. This amount is increased vastly more where dense infinities of possible world must also be specified.

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[308] I avoid framing my argument here in terms of number of categories of being as such framing risks masking questions about how we should count categories – in particular, how we should count the extra-ontology. AAO has one or two categories of being. Elementary-actors is one category. Composite-actors are wholly derived from elementary-actors but are not reducible to them – whether to count this as a category is moot, and probably not a helpful question.

[309] Supporters of governing-law version of mosaic ontology, such as Maudlin (see e.g. Maudlin 2007), may reasonably claim to be much better placed in respect of this issue than neo-Humeans.

The information required to characterise a particular AAO is much more modest: it is sufficient to characterise the trajectories of elementary-actors together with their acting. To the extent that the acting of elementary-actors is consistent, this acting may be summarised via an account of the ability of the elementary-actors to act. To the extent that[310] the current trajectory (i.e. current position and velocity) of each elementary-actor together with an account of its ability to act is sufficient to determine the future trajectory of elementary-actors, the required information is much more limited.

19.2.4 Comparison summary

This comparison of AAO with mosaic ontologies in respect of the three chosen desiderata (fit with the empirical world, coherence, and parsimony) suggests that AAO has considerable strengths – and that there is a case that in aggregate these strengths equal or outweigh, perhaps considerably outweigh, those of mosaicism.

19.3 The consistency of the methods employed in this thesis with AAO

Now that we have completed our preliminary account of AAO, it is time to assess whether the methods employed in developing the account of AAO in this thesis are consistent with the ontology that is proposed.

It might reasonably be suggested that any method for developing an account of ontology is allowable – what matters is whether the ontology that results is a good ontology (in some chosen senses). We might, for example, simply guess at an ontology, or employ a monkey to bash a typewriter and inspect the resulting output. If such methods were to result in an exemplary account of ontology, then so be it. Nevertheless, it would be prima facie surprising if such methods did result in a good account of ontology – and this might reasonably heighten doubts about the proposed ontology. On the other hand, where the methods used for developing an ontology are compatible with the account of how knowledge may be acquired within the proposed ontology, then the account seems to be on firmer ground.

On the account set out in chapter 13, our basic knowledge of the world is obtained empirically – and we may derive more complex knowledge by bootstrapping in the ways described. Let's call this method of knowledge acquisition *empirical-bootstrapping*.

The method employed by this thesis is just empirical-bootstrapping. In section 6.2 our starting point for positing acting was the stable correlations (that are widely cited by physicists and metaphysicians of physics) between certain types of configurations and the changing which occurs in those configurations. From our

[310] I remain agnostic here on this extent.

account of acting I derived an account of composite-actors (surviving acting-togethers of actors) – chapter 9 undertook an empirical review of things and processes we find in the world to show how these accord with the derived account of composite-actors. In section IV I considered a number of features of the world which are apparent in our experience of the world and/or are used in our empirical (e.g. scientific) methods: the features of the super-ontology. I showed in each case how these derive from the base ontology. I have throughout cross-checked our derived account of the world with broad ranging empirical examples.

I contend, then, that the methods employed by this thesis should be understood as empirical-bootstrapping – and hence as being consistent with AAO, the ontology proposed.

19.4 Summary of assessment

Although there is considerable scope to expand this assessment[311], the breadth and level of detail set out here in consideration of our preliminary account of AAO seem appropriate for this stage.

We have noted many arguments in favour of AAO identified in this thesis (summarised in section 19.1), made the case (in section 19.2) that AAO fits well with the empirical world, fares well in the face of many philosophical aporia (coherence), and is parsimonious, and (in section 19.3) that the methods employed in this thesis in developing our account of AAO are consistent with AAO.

I conclude that AAO offers a plausible account of ontology with great potential, and hence warrants further investigation.

[311] Work on doing so is included amongst the next steps outlined in the next chapter – section 20.1.3.

20 Conclusion

As promised in the introduction, I have set out a preliminary sketch of a new ontology (AAO), adumbrating the main pieces of this ontology and showing how they fit together to form a compelling whole. Our aim has been to develop this sketch to a point where we can reasonably form a preliminary assessment of the overall proposed ontology. My suggestion is that we have achieved such a point: not the completion of our account of ontology, but rather the achievement of a point at which it is appropriate to invite scrutiny of progress and seek helpful input on how to progress further from this base.

In reading through this thesis, the reader may likely have formulated unanswered questions about the areas yet to be addressed. I set out in section 20.1 a summary account of some of the main next steps that I propose to answer such questions and to further progress an account of AAO. In doing so, I point to some of the exciting opportunities which I shall explore in future work.

Section 20.2 makes some concluding remarks.

20.1 Next steps

Here, then, is a list of some of the next steps – these are in large part areas of further research which build upon and complement the ideas presented here. I would stress that this is by no means intended as a complete list.

20.1.1 Link with micro / quantum domain

I focus in this thesis upon the classical domain – a domain in which physical objects have determinate positions in space and time.[312] It seems that some metaphysicians may deny the existence of such a classical domain. Perhaps they suppose that there is merely a single point in ultra-high dimensional space[313], or perhaps that there is just a universal wave function[314] - and that objects in space and time, or perhaps space and time themselves, cannot be recovered within this ontology. It seems that such metaphysicians must surely reject my proposals. On my reading, though, the great majority of quantum metaphysicians do posit a classical domain – and, indeed, much of their work is involved with explicating how to recover objects in this classical domain from their account of the quantum domain, e.g. perhaps through decoherence approaches. After all, all empirical evidence from pixels on a photographic plate, and clicks of a Geiger-counter, to recordings in the computer databanks at CERN, are located within the classical domain. To accept scientific

[312] See Simpson and Pemberton 2022 for a recent paper addressing quantum metaphysics.
[313] See e.g. Albert 1996.
[314] Ladyman and Ross 2007 points in this direction on my reading.

postulates whilst rejecting a classical domain therefore seems problematic, perhaps even paradoxical or inconsistent. In brief, I must, and am happy to, adopt a commitment to the existence of a classical domain, which I take to be the orthodox position of contemporary physics and metaphysics.

More specifically, I suppose that there is some low level of entities (that I dub *elementary-actors*) that form building blocks for the classical domain, suggesting that some of the particles of the Classical Model of Particle Physics are candidates for such a role. It might reasonably be objected that many treatments of such particles within physics do not assign them determinate positions – they may often be treated as wave-like, for example. Is, then, the adoption of low-level entities with determinate positions compatible with physics? This is a good question. Answering the question fully would seem to require determining the nature of the quantum domain (including, it would seem, resolving the wave-particle duality conundrum) and explicating the precise link between the quantum domain and the classical domain. Of course, these are areas of considerable work by metaphysicians and physicists on which there is currently no consensus view. I certainly do not seek to answer these questions here.

One might take the view that until such questions are fully resolved, no macro-ontology is credible of sensible: i.e. that we must first (1) clarify the nature of quantum domain and (2) make precise the link between the quantum and classical domain, before proceeding. I reject such a position. My suggestion is that work on both the micro (quantum) and macro domains are to be encouraged – and that advances in both areas may help bring about understanding of the link between these domains. Indeed, I suggest that the trajectory-acting basis for the macro world advanced by AAO may facilitate advances in explicating this link. Advances on the imprecise link offered by decoherence accounts would surely be welcome.

In any case, the link between the AAO account and the quantum domain is an important area for future work.

20.1.2 The nature of the ontological priority of elementary-actors over their temporal parts

In setting out an account of elementary-actors in section 10.1, I left open the nature of the ontological priority of elementary-actors over their temporal parts, noting that this might, inter alia, be brute, sui generis, or follow from identity-dependence, causal connections or genidentity relations. The nature of this ontological priority will likely be a major factor in determining the nature of AAO as a whole. For example, if the elementary-actors may be understood as self-individuating flows that physically survive through time (insofar as they do), then perhaps AAO may be understood as having more process-like characteristics. Certain other accounts of the unity of elementary-actors might support more thing-like characteristics of AAO.

One reason for a commentator to advance a specific account of the nature of the ontological priority of an elementary-actor over its temporal parts may be to enhance the fit of AAO with certain aspects of the empirical world that that commentator takes to be important – perhaps, for example, fit with a proposed quantum domain.

In any case, exploring the various possibilities for such ontological priority is an area of further research.

20.1.3 Further comparison of AAO with other ontologies

As we have noted, in order to keep the work of this thesis manageable we have limited our comparisons with other ontologies largely to mosaic ontologies. In developing consideration of AAO, there is much that may be learned by considering comparisons with a broader range of ontologies. Making such comparisons will help to clarify an understanding of the nature of AAO and its potential.

One obvious starting point is a comparison with Aristotle's ontology. As noted, AAO adopts central aspects of Aristotle's ontology of change whilst also adopting central aspects of contemporary mathematics and physics. The relationship of AAO to Aristotelian ontology is therefore interesting. AAO's account of composition, for example, may be understood as proposing a distinctive form of holism which may be compared with Aristotelian holism.

Comparisons with other well-established ontologies are also likely to prove fruitful, including a wide range of ancient philosophies (including those of Parmenides, the atomists and Plato), specific flavours of mosaicism that we have not yet considered in detail, the ontologies (which may be implicit) of linguistic approaches to metaphysics, and process ontologies (such as those of Nicholas Rescher, Johanna Seibt, and Peter Simon).

One of the many themes that may helpfully be explored through these comparisons is the rationalist vs physicalist debate - the distinctive wholly-physically nature of AAO will license a distinctive perspective and, I believe, some interesting new ideas.

Further comment is warranted, too, on various other (than AAO) holist ontologies, perhaps most notably priority monism[315] and substantial holism[316]. These ontologies have added considerably to the contemporary debate whilst remaining principally focused on spatial parts rather than temporal parts – I will aim to show how AAO builds on these ideas.

[315] Schaffer 2010 and 2018
[316] Inman 2018.

20.1.4 Implications for empirical methods

The background to my work on ontology and change in this thesis and other recent published papers is my work in the philosophy of science focused on empirical methods. This work on methods is largely undertaken in conjunction with Nancy Cartwright[317] and continues as a major strand of my research[318]. This work on methods has its roots, in turn, in my own work in areas of financial and economic practice that led to my concern with methods in these areas.[319] An underlying motivation for my work is then, like that of Nancy Cartwright[320], a concern to improve methods in empirical practice, especially within finance, economics and other areas of social science.

The discussion of causation above (chapter 16) suggests how the recognition of the pattern of processes that underlie causal relations may strengthen causal methods, and hence points towards the link of this thesis with practical methods. In brief, if the claim of this thesis that the only type of principle of change is acting is correct, then the design of our practical empirical methods should be compatible with respect for this acting – and hence pay due attention to the nature of the actors which act and their circumstances of acting.

Developing the implications of this thesis for empirical methods, and hence working to help improve methods in the practice of science (especially social science[321]) is thus a major avenue of further work – work that will help forge more closely the link between my work on ontology here and my applied work in the philosophy of science with Nancy Cartwright.

20.1.5 Historical consideration of lasting

My discussions with a wide selection of Aristotelians points to a consensus that (1) Aristotle did take processes (kineses) and things (including substances) to be lasting; and (2) that Aristotle's commitment to lasting has not been widely remarked or discussed by commentators. Prima facie this is surprising – and it points, I suggest, to the potential value of introducing lasting into the contemporary philosophical debate, as I propose in this work.

Finding explicit articulations of lasting in the literature would potentially be helpful. Perhaps earlier discussions of lasting would add to our understanding of lasting and its limitations and potential. Therefore, a further strand of future research which I propose is an historical investigation to discover such earlier references to lasting. As

[317] See Pemberton 2011, Cartwright. & Pemberton 2013, Pemberton & Cartwright 2014, Cartwright, Pemberton & Wieten 2020.
[318] See Cartwright, Pemberton and Munroe 2023.
[319] See for example Pemberton 1997, Pemberton 1999, and Pemberton 2005.
[320] See Cartwright 1999, 18.
[321] One strand of this further work will be developing an account of the ontology of entities posited within the social sciences.

a starting point for this investigation, I provisionally propose consideration of the medieval period from around the thirteenth to the mid-seventeenth centuries – the period of great creativity and innovation in philosophy which explored so many divergent ontological ideas.[322]

20.1.6 Time

In this thesis I have considered carefully the ontology of entities that exist in time, arguing for lasting. I have avoided commenting on the nature of time itself. I take it that there are two broad approaches to tackling change and time. The dominant contemporary approach, as I understand it, first sets out an account of time (some version of eternalism is generally favoured by contemporary philosophers), and then seeks to tackle the nature of change. An alternative approach first seeks to explicate the nature of change, and then set out an account of time. The latter was Aristotle's approach – as we have noted, he took time to be the number of change in respect of the before and after. My plan is to follow this latter Aristotelian approach. In brief: I plan to argue that the lasting of entities that exist in time supports the case for an unfolding manifold of time – a version of the A-theory of time. This argument has some resonance with that of Jonathan Lowe[323].

In light of my lack of an explicit account of time as yet, is my account of lasting, which makes explicit reference to time, satisfactory – or does it perhaps engender some form of circularity?[324] Recall that we characterised[325] a lasting entity as one that:

1. *Is physical;*
2. *Exists for some period of time;*
3. *Is ontologically prior to its temporal parts.*

To assuage any concern about circularity for now, I suggest it is sufficient to note the possibility of my following Aristotle's approach to time which, I take it, is widely accepted as not being circular.

In future work, though, I plan a more explicit and revealing answer. Consider

2': Is existing through stages of change.

To be existing through stages of change entails existing for some period of time (i.e. 2) and being ontologically prior to the temporal stages through which it exists (i.e. 3), I shall argue. At first take, though, 2' seems somewhat more restrictive than 2 and 3 together: might not a lasting entity exist through time without undergoing change? The question arises for Aristotle's account, too, where one proposed solution is to

[322] See for example Pasnau 2011.
[323] Lowe, 2006a, 727.
[324] My thanks to Manuel Zambrano for raising this question.
[325] Chapter 3.

take the number of change from other contemporaneous substances in the world that are undergoing change. (Aristotle rejects the possibility of a world without any change.) To develop my own solution I propose to make explicit that the acting-trajectory basis of AAO entails that all change bottoms out in change of position. I shall make explicit, too, the sui generis holistic nature of position, hence noting the extrinsic and relative sense in which position is changing or not (whether an entity has zero velocity depends on the frame of reference chosen). Hence, I shall argue that within AAO we may equate lasting with:

1’: Is changing.

That is to say we may replace 1-3 with 1’. This is an important claim and I shall show how it casts light on the nature of AAO. In doing so I shall connect with contemporary discussions of relativity.

20.1.7 Indeterminism

We have noted ways in which composite beings within AAO (composite-actors) are indeterminate.[326] In future work I shall characterise the nature of this macro-indeterminacy, showing the sense in which it is a sui generis form of ontological indeterminacy arising from the distinctive account of spatiality, acting and surviving embraced by AAO. This account of ontological indeterminacy is, as I understand, new to the literature – one area of work will be to locate this AAO account within the existing discussion of indeterminacy.

This macro-indeterminacy marks an important sense in which AAO differs radically from most, perhaps all, other existing accounts of ontology. AAO succeeds in capturing the ontological indeterminacy of our world, I shall claim, and this is a major achievement which allows it to capture that world. I shall explain how many of the aporia of received metaphysics are artefacts of the assumption of the determinacy of being that is adopted. As one example: how the reification of identities creates artefactual aporia such as the problem of temporary intrinsics[327].

I shall explore further how this indeterminacy bears on the nature of AAO – and how AAO indeterminacy bears on the question of whether the future is determined.

20.1.8 Teleology

AAO has adopted central aspects of Aristotle’s account of change. Aristotle’s account of ontology is widely agreed to be teleological.[328] In what sense if any, then, may AAO be understood as teleological? Answering this question will help to clarify the nature of AAO and its relation to Aristotle’s ontology.

[326] See chapter 10 – especially 10.3.6 and 10.4.1.
[327] See section 5.2.
[328] See for example Johnson 2005.

At least some actings, for example attractings and repellings, are not teleological, I shall suggest. On the other hand, building (e.g. the building of a nest by a bird) is typically directed towards some goal. We have noted, too, that certain configuration-types have process-powers[329]: they point forward to processes, and hence states, that may occur. These considerations indicate that the answer to whether AAO is teleological requires careful consideration.

I shall assess AAO in the context of the existing literature on teleology, including available assessments concerning the teleological status of other established ontologies, in order to set out the senses in which AAO is / is not teleological.

20.1.9 Free will

We have seen that composition in AAO underwrites resultant novelty[330]. The iterative composition of increasingly complex actors (in terms of their number of parts, the arrangement of these parts and the numbers of levels of parts of parts) may underwrite increasingly complex novel powers. Vastly complex patterns of parts in contemporary machines underwrite highly complex powers, such as the power to play chess. I shall argue that free will is a label attached to the fiercely complex decision-making powers of higher organisms, where this power results from their fiercely complex physical structure. Hence, I shall assess the nature of such free will, showing how (in a sense that I take to be original) it is compatible with contemporary physics. I shall show, too, how such free will may be compatible with the will of God. I will explore its implications for ethical questions (e.g. animal rights, the regulatory control of artificial intelligence).

20.2 Concluding remarks

I have outlined in this thesis an original account of the ontology of the world which brings central elements of Aristotle's account of change into a parsimonious physical ontology – thus offering a middle ground between Aristotelianism (the orthodox view through to the mid-seventeenth century) and mosaicism (the contemporary orthodoxy which links back to Plato of the Timaeus). The ontology is radically new in rejecting the orthodox property-position foundation for ontology in favour of an original acting-trajectory view. It licenses a new account of restricted composition that underwrites ontological indeterminacy – a form of indeterminacy that resonates with that which we find in the world. This new ontology, AAO, achieves extreme parsimony, fits with the empirical world and is not subject to the many aporia of received accounts of ontology. I urge that this new account of ontology warrants further investigation, setting out topics within the next steps of this research.

[329] See 12.1.2.
[330] See 12.3.

In setting out this account of ontology, I hope, inter alia, to offer a fresh perspective on existing accounts of ontology that may facilitate innovative and constructive thinking on the issues in play.

More resolutely, I express my own view that the account of ontology I set out and argue for here is, at least roughly, an account of the ontology of our world.

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