1 Introduction

Water boils. Trees rustle. Children are born and grow. Change is everywhere in nature, and many ancient Greek philosophers made change central to their reflections on the natural world. One important class of change is relative change. Simply, a relative change occurs when an object changes a relation. At the beginning of the year, the young man Theaetetus is shorter than Socrates. By the end of the year, Theaetetus has grown taller than Socrates. Socrates has become shorter than Theaetetus without Socrates changing his height.

Notice that in this example, several changes take place. Let's stipulate that Theaetetus grows, rather than the rest of the world shrinking, and that Theaetetus' growing is a non-relative change. Theaetetus would grow, in the sense of increasing his bulk, regardless of any relation to Socrates, so Theaetetus growing is a non-relative change. As well as this non-relative change, *two* relative changes take place. First, Theaetetus becomes taller than Socrates. This is a relative change because Theaetetus' relation to Socrates has changed. Theaetetus was shorter than Socrates but became larger than Socrates. This first sort of relative change seems untroubling. Theaetetus grew; he became taller than he was; became taller than Socrates.

But a second sort of relative change hovers around this example. Just as Theaetetus becomes taller than Socrates, Socrates becomes shorter than Theaetetus. Although Theaetetus grew, Socrates has not decreased in height. Theaetetus underwent a non-relative change (growing) and a relative change (becoming taller than Socrates). But Socrates merely underwent a relative change with no corresponding non-relative change. Socrates changed without changing! At least, Socrates changed relatively without changing non-relatively. When I need to distinguish between the two kinds of relative change, I'll call the second 'mere relative change'.

Relative change generates changes where we don't expect them. Theaetetus is a certain distance in time and space from any person you choose to mention. Suppose Theaetetus moved a metre to his left while everything else remains as it is. Theaetetus changed his relation to every other person in the world. But at the same time, every other person in the world underwent a mere relative change. Theaetetus turns out to be incredibly powerful! Indeed, so powerful that he can move a mountain. Simply by moving closer to the mountain, Theaetetus moved the mountain – relative to himself, at least.

Many philosophers look askance at mere relative change.[1] But why? We could put the problem as an inconsistent triad. The following three claims all seem plausible, but cannot be true together:

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[1] Geach (1969, 71). Geach is famous for introducing the expression, 'Cambridge change'. According to Geach, Cambridge philosophers articulate a condition on change such that if

(1) No relative changes are intrinsic changes;
(2) Only intrinsic changes are proper changes;
(3) Some relative changes are proper changes.

This triad problematises relative change in general, not only mere relative change. But mere relative change shows the puzzle starkly. In response to this inconsistent triad, we need to reject one of (1), (2), or (3).

We already have a grip on change and relative change. But (1) and (2) refer to 'intrinsic change', which needs some explanation. Let's stipulate that something changes intrinsically if and only if that thing changes some intrinsic property. That's true, but doesn't help much, since we still need to know what an 'intrinsic property' is.

We have an intuitive grip on which properties are intrinsic: being red is intrinsic; being large is not. But philosophers need a fuller story. Whatever modern philosophers might have to say about intrinsic properties, we can think about the views of ancient philosophers this way. In some exemplary cases, a thing has an attribute because of the presence of some stuff in that thing. My coffee is sugary because of the presence of sugar in my coffee. Philosophers tend to call this the 'inherence' picture of attribution. Put more precisely:

(Stuff Inherence) 'x is F' is true because F stuff is present in x.

For example, 'the coffee is sugary' because sugar is present in the coffee. This model works only for those cases where a physical stuff is present in an object. With some violence, one can extend the Inherence model to the attribution of qualities more generally. For example, we might think that the sugar is sweet because of the presence of a quality in the sugar, namely, sweetness.

This generalisation would give us the qualities in things model of attribution:

(Quality Inherence) 'x is F' is true because F-ness is present in x.

In both cases, the presence of something (a stuff or a quality) in the object explains the attribution. Greek philosophy entertained this thought from the

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some x satisfies a predicate F at t_1, but not at t_2, then x has undergone a Cambridge change. Many people hold that Cambridge change is necessary but insufficient for change: proper change requires some change of intrinsic properties. Some scholars use the expression, 'mere Cambridge change' to pick out those changes captured by Geach's definition but not by some stronger account of change.

I distinguish relative change from mere Cambridge change. Many examples of mere Cambridge change will be relative changes: Socrates changing from being taller than Theaetetus to being shorter than Theaetetus is both a relative and a mere Cambridge change. But not all relative changes are mere Cambridge changes, because some intrinsic properties are relational properties. Having longer legs than arms is intrinsic to Theaetetus. If he changed to have longer arms than legs, he would have undergone a relative change, but not a mere Cambridge change, since he changed an intrinsic, albeit relational, property.

time of Anaxagoras.[2] Plato (*Lysis* 217c–e, *Euthydemus* 300c–301a, *Sophist* 247a5. Cf. *Parmenides* 131c–e) and Aristotle (*Cat.* 1 1a20–28) both discuss the inherence picture. Both models take the 'present in' relation as basic. Attribution is analysed in terms of inherence, but no further analysis of the inherence relation is given.

Of course, if you're attracted to the inherence picture, you need to say more about the idea of inherence, even if you do not analyse it into other notions. In particular, the inherence picture must stipulate that simple containment is not sufficient for inherence. The fact that liquid is contained in the mug does not entail that the mug has the attribute of being liquid. The inherence picture must also give some way of dealing with incompatible qualities. Coffee is black because of black stuff in it; milk is white because of white stuff in it. Add milk to coffee and on the inherence picture, the coffee has black stuff and white stuff in it; so it is both black and white. But that seems like a contradiction. What's more, we can see that it is false: coffee with milk is neither black nor white, but brown.

But, these drawbacks notwithstanding, the inherence picture does give us a way to understand intrinsic properties. The intrinsic properties are just those that an item has because of the presence of something in that item. Honey is intrinsically sugary because of the presence of sugar in honey. We also get an account of intrinsic change. An item changes intrinsically when what is present in the object changes. Thus, a sponge changes intrinsically from being wet to being dry when the water evaporates. There are problems with the inherence account of intrinsic properties (and the inherence account of properties more generally). For one thing, an item can have contrary, but intrinsic properties. Coffee with sugar is inherently bitter, because of the presence of acid in the coffee, but also inherently sweet, because of the presence of sugar in the coffee. But it seems at first sight strange to say that something can have contrary intrinsic properties. There is also something strange about this as an account of intrinsic change: when I add sugar to coffee, the coffee continues to be bitter but also becomes sweet. So it is hard to see this as a change from being sweet to being bitter. Nonetheless, the inherence view of intrinsic properties was taken seriously by ancient philosophers, even if we do not want to accept it outright.

On the inherence view of intrinsic properties, the inconsistency of the triad I set out earlier is even more pressing. On the inherence picture, (1) seems

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[2] This is true whether you think that Anaxagoras holds that the 'roots' are stuffs (e.g. gold) or whether you think roots are qualities (e.g. being metallic): 'That of which each thing contains the most, this is what it is and was most manifestly' (DK A41= Laks Most D2. Trans Laks & Most). On this point, see Furley (1989, 62–5) and Menn (1999, 218) who cite him. Dancy (1991, 23–53) attributes a similar view to Eudoxus, and Menn (1999) attributes this sort of view to the Stoics. Thanks to George Boys-Stones for pressing this point.

obvious. Relative changes do not appear to be inherent changes. In the case of a mere relative change, Socrates becomes shorter than Theaetetus, but not because Socrates has gained or lost any inherent property. Arguably, Theaetetus gained some inherent property. He's grown, and going from one height to another is to gain an inherent property. But even though Theaetetus has become taller than Socrates, Socrates has not gained or lost an inherent property. Relative changes seem to be precisely those changes that do not involve gaining or losing inherent properties.[3]

On the inherence picture, (2) asserts that only changes of inherent properties are changes. Thus, my coffee changes from being bitter to sugary if at first my coffee contains no sugar but later has sugar present in it. This interpretation puts pressure on (2). After all, why think that only changes of inherent properties are changes? My coffee might move from my left to my right. Movement is a change; but not a change of a property inherent in the coffee. So, at least some changes are not changes of inherent properties. This Element shows that, while some ancient philosophers take the obvious approach of denying (2), some prominent ones do not.

Finally, (3) seems true, as can be seen from the way we talk about change. When Theaetetus grows taller than Socrates, we say that Theaetetus changes because Theaetetus becomes taller than Socrates. So some relative changes are proper changes. Indeed, some mere relative changes are proper changes. When Theaetetus grows taller than Socrates, we say that Socrates changes because Socrates becomes shorter than Theaetetus. To reject (3), one would need to offer an account of change such that relative changes are not 'proper' changes. But whether one can resolve the inconsistent triad by rejecting (3) would turn on the plausibility of that account of change.

In sum, if we hold that the intrinsic properties are just those present in an item, we could reformulate the inconsistent triad this way, substituting 'inherent properties' for 'intrinsic properties':

(1) No relative changes are changes of inherent properties;
(2) Only changes of inherent properties are proper changes;
(3) Some relative changes are proper changes.

I will argue that Plato, Aristotle, and the Stoics each reject one of these claims. Plato rejects (1). At least, when Socrates discusses relative change in the *Phaedo* and *Theaetetus*, he assumes that relative change is an intrinsic change of a certain kind. Aristotle rejects (3). Aristotle characterises relative changes as

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[3] There are some tricky cases here. Depending on how one thinks about locomotion, locomotion may be a non-relative change that does not involve gaining or losing an inherent property. Thanks to David Ebrey for this point.

'incidental', that is, improper, changes. This is because Aristotle holds that relative changes involve an existential change – a change from existing to not existing or the reverse – of an item present in a subject of change. Stoics reject (2). Stoic ontology introduces relative dispositions, which allow the Stoics relative, non-intrinsic changes. Finally, we will see that Sextus does not reject any of the three but deploys relative change in a sceptical argument against the existence of relations.

This Element focuses on relative change in Plato, Aristotle, Stoics, and Sextus. But there are fascinating discussions of relative change elsewhere in ancient Greek philosophy, especially in later writers, such as Plotinus, Themistius, and Simplicius. I have chosen to focus on Plato, Aristotle, the Stoics, and Sextus for two reasons. First, these four show a range of approaches to relative change and which factors might impact on an approach to relative change. Second, later ancient thought about relative change comments on and engages with Plato, Aristotle, and the Stoics. Understanding the later treatments starts with understanding the earlier treatments. So the earlier treatments seem most appropriate for an Element. That said, I by no means ignore these later thinkers. The Element makes use of later reflection on Plato, Aristotle, and the Stoics as a central part of its argument. It would be fascinating for someone (maybe you!) to extend the study of relative change into late antiquity. But for now, let us turn to the first thinker to puzzle over relative change.

2 Plato

My discussion of Plato falls into two sections. Section 2.1, on *Theaetetus* 155a–155c, discusses the earliest articulation of a relative change puzzle. Socrates points out that three seemingly plausible claims about change form an inconsistent triad when we consider relative change.[4] I argue that Socrates introduces the Twin Offspring Theory to solve this puzzle. The Twin Offspring Theory invites us to accept that relations constitute their relata and that items such as Socrates are bundles of such relata. (That's right: Socrates presents a theory that includes Socrates himself as an example.) When relations change, the relata cease to exist. So, some property present in Socrates has ceased to exist. So, Socrates has undergone an intrinsic change. Section 2.2, on *Phaedo* 102–3, argues that Socrates deploys relative change in a similar way, but to serve the particular argument of the *Phaedo*. The notorious 'inherent relata', such as the 'largeness-in-Simmias', are constituted by the relations they bear to each other.

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[4] To be explicit, although both have a trilemma structure, Socrates' puzzle is different from my programmatic trilemma.

Therefore, a relative change amounts to an existential change of an inherent relatum.

2.1 The *Theaetetus*: Puzzles, Offspring, and Relativism

In the first part of the *Theaetetus* (151d–186e), Theaetetus defines knowledge as perception (*Theaetetus* 151e1–3). Socrates supports Theaetetus' definition with the point that perception, like knowledge, is always of what is and is infallible (*Theaetetus* 152c5), in turn supported by Protagoreanism and a radical flux theory (*Theaetetus* 153a–d).[5] Socrates returns to the infallibility of perception, saying that a perceptible quality is neither 'that which impinges, nor that which is impinged upon, but something that has come into being between the two' (*Theaetetus* 154a1–3). What impinges is whatever produces the sound, image, smell, or taste; what is impinged upon is the perceiver. Socrates develops this view with two moves. The positive move preserves the infallibility of perception through the Secret Doctrine and the Twin Offspring Theory, roughly that the perceptual relation constitutes *both* the perceptual state *and* what is perceived (*Theaetetus* 155e–157c). Before that, the negative part argues that perceptible qualities – 'size or warmth or whiteness' (*Theaetetus* 153b2) – are neither in the perceived object nor in the perceiver. Socrates intends that the puzzles of relative change show that we end up in an absurdity if we assume that qualities like size belong to the object rather than being constituted by a relation between objects. The text hints that the Secret Doctrine solves the puzzles (*Theaetetus* 155d5–7), but how it might do so is unclear.[6]

But first, how do the puzzles work? Socrates points out that he can undergo a mere relative change. At the beginning of the year, Socrates is taller than Theaetetus; at the end of the year, Socrates is smaller than Theaetetus:

> T1 [Socrates to Theaetetus] [. . .] while being just this size, without growing or undergoing the opposite, I can within the space of a year both be larger than a young man like you, now, and smaller later on—not because I've lost any of my size, but because you've grown. (*Theaetetus* 155b6–155c1, abridged. Trans. McDowell)

In T1, Socrates mentions three conditions on this mere relative change. Socrates changes relatively from t_1 to t_2 if:

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[5] This way of taking the structure of the first part of the *Theaetetus* follows Burnyeat (1982), developed in more detail in Burnyeat (1990, 8–65). Denyer (1991, 83) and Sedley (2004, 40) agree that radical flux is necessary for the infallibility of perception.

[6] Burnyeat (1990, 19) holds that the puzzles provide a 'perspicuous model' for Protagorean relativism, but this can't be right, since Protagorean relativism is supposed to *resolve* the puzzles. Sedley (2004, 44) correctly says that endorsing the Secret Doctrine is supposed to address the puzzles but does not explain in detail how.

i. Socrates is larger than Theaetetus at t_1;
ii. Socrates is not larger than Theaetetus at t_2;
iii. The change described in (i) and (ii) happens because Theaetetus *grows*, not because Socrates *shrinks*.

Socrates' other example involves quantitative change, rather than qualitative change:

> T2 Here are six dice. If you put four next to them, we will say that the six are more than four, that is, one-and-a-half times as many. But if we put twelve next to them, we will say the six are fewer, that is, half as many. (*Theaetetus* 154c1–4. My translation)

Relative change is a familiar phenomenon. The puzzle arises when Socrates asks Theaetetus: is it possible for any thing to become larger or more numerous except by being increased? Theaetetus wants to answer both yes and no. No, generally, nothing becomes larger or more numerous unless increased. But yes, in these cases, the six dice seem to become more without being increased, when four dice are placed next to them, because the six dice become one and a half times four (*Theaetetus* 154c10–d2).

Socrates diagnoses this contradiction as arising because 'three agreed propositions fight it out in our soul' when we consider these cases (*Theaetetus* 155b5). In other words, Socrates sets up an inconsistent triad because cases of mere relative change show that three plausible propositions about change are mutually inconsistent. As I say, Socrates' triad differs from the one which I use to structure this Element.

First, nothing could have changed in quantity, while remaining equal in quantity to itself:

> T3 When we look at the first of them, we'll say, I imagine, that nothing could ever have become larger or smaller, either in size or in number, as long as it was equal to itself. (*Theaetetus* 155a1–5. Trans. McDowell, modified)

With a bit of scrubbing, we could articulate this principle in the following way:

(EQUALITY) For any x, if, through the period between t_1 and t_2, x's size or number remains equal to x's size or number at t_1, then x has not become larger or smaller in size or number between t_1 and t_2.

Equality implies that there is no 'becoming' in quantity. 'Equal' here must mean something other than identity. The identity over time of Socrates and Theaetetus is not at stake (at least, not yet). Equality asserts that any thing retains the same size or number as itself over time, unless it undergoes some becoming.

Second, Socrates articulates this proposition:

> T4 And, second, that a thing to which nothing is added and from which nothing
> is taken away undergoes neither increase not diminution but is always equal.
> (*Theaetetus* 155a7–9. Trans. McDowell)

More explicitly:

(HOMEOSTASIS) For all x, if x has nothing added or removed through the period t_1
to t_2, then x remains equal to x through the period t_1 to t_2.

Again, 'equal' here means equal in size. Homeostasis asserts that something to
which nothing is added or removed through a period remains the same size as
itself through that period.

Third, Socrates gives this final proposition:

> T5 Moreover, third, that it's impossible that a thing should be, later on, what it
> was not before, without having become and becoming?
>   Tht. It certainly seems so to me. (*Theaetetus* 155b1–2. Trans. McDowell)

Or, formulated explicitly:

(BECOMING) For all x, there is some F, such that (if x is F at t_1 and x is not F at t_2)
then x undergoes some becoming between t_1 and t_2.

Difference over time implies becoming. If something has some property at one
time but lacks that property at a later time, then it has undergone some process of
becoming, presumably between those two times.

Separately, Equality, Homeostasis, and Becoming each seem plausible to the
characters in the dialogue but together form an inconsistent triad, given the
existence of relative change. To see this, consider the cases of mere relative
change Socrates described in T1:

1. At t_1, Socrates is larger than Theaetetus.   [Premise]
2. At t_2, Socrates is smaller than Theaetetus.   [Premise]
3. Socrates has nothing added or removed between t_1 and t_2.   [Premise]
4. If Socrates has nothing added or removed through the period t_1 to t_2, then
    Socrates remains equal to Socrates through the period t_1 to t_2.
    [Homeostasis]
5. Between t_1 and t_2, Socrates remains equal to Socrates.   [MP 3,4]
6. If, through the period between t_1 and t_2, Socrates' size or number remains
    equal to Socrates' size or number at t_1, then Socrates has not become larger
    or smaller in size or number between t_1 and t_2.   [Equality]
7. Socrates has not become larger or smaller in size or number between t_1 and
    t_2. [MP 5,6]

8. If Socrates is larger than Theaetetus at t_1 and Socrates is not larger than Theaetetus at t_2, then Socrates undergoes some becoming between t_1 and t_2. [Becoming]
9. Socrates has undergone some becoming between t_1 and t_2. [MP, 1,2,8]
10. Contradiction on 7 and 9.

(7) should contradict (9), but (7) and (9) follow from the undisputed premises in T1 and the three principles of Equality, Homeostasis, and Becoming. If a contradiction results, the three principles cannot all be true together.

One obvious problem with Socrates' line of thought is that (7) and (9) *don't* contradict each other. Socrates became smaller, not than himself, but than Theaetetus. The problem arises because Equality is underspecified. Properly specified, Equality could mean either:

(Equality₁) For any x, if, through the period between t_1 and t_2, x's size or number remains equal to x's size or number at t_1, then x has not become larger or smaller *than itself* in size or number between t_1 and t_2

or

(Equality₂) For any x, if, through the period between t_1 and t_2, x's size or number remains equal to x's size or number at t_1, then x has not become larger or smaller *than some other thing* in size or number between t_1 and t_2.

Equality₁ is true but does not result in a contradiction. Equality₂ results in a contradiction but is false. All that follows from Equality₁ is that during the year, Socrates does not become larger or smaller than *Socrates*. But this is compatible with Socrates becoming larger or smaller than *Theaetetus* during the year. On the other hand, Equality₂ would result in a contradiction, if Theaetetus were the other thing in question, since Equality₂ would entail that Socrates does *not* become smaller than Theaetetus during the year. But Equality₂ is false, since something can remain equal to itself and yet become larger or smaller than some other thing.

This underspecification, then, undermines Socrates' claim that Equality, Homeostasis, and Becoming form an inconsistent set. On one specification of Equality, the triad is inconsistent, but Equality false; on the other specification, Equality is true, but the triad consistent. One reaction is that Socrates simply misses this underspecification. Silly old Plato doesn't understand relational notions properly, and so his character Socrates mixes up two different concepts of equality: the first where remaining equal to itself entails that something has not become larger or smaller *than itself*; the second where remaining equal to itself entails that something does not become larger or smaller *than*

some other thing. Socrates wrongly treats these ideas of equality as equivalent.[7]

Socrates is not likely confused. In this passage, Socrates aims to distinguish qualities that an object has in itself, which cannot change simply by changing relations, from qualities which depend on a relation to something else, which can change simply by changing relations (*Theaetetus* 154b1–c1). Furthermore, Socrates moves to a picture where perceptible objects and perceptible qualities do depend on relations and change just by changing relations (*Theaetetus* 155d5–8; 156d3–c5). So Socrates cannot simply be confused about relational notions.

A better way to understand Socrates' point is that Becoming is more inclusive than Equality and Homeostasis. Becoming includes mere relative change in the class of coming to be; but Homeostasis and Equality exclude mere relative changes from the class of coming to be.[8] For example, at the beginning of the year, Socrates is taller than Theaetetus; at the end of the year Socrates is smaller than Theaetetus. So, by Becoming, Socrates has become smaller than Theaetetus. So, a fortiori, Socrates has undergone becoming between these times. But Socrates has not had anything added or removed, either in himself or relative to Theaetetus, between the beginning and end of the year. So, by Homeostasis, Socrates remains equal to Socrates. Socrates has undergone no net increase or decrease in size between those times, so, by Equality, he has not undergone becoming between those times.

On this approach Plato does not confuse Socrates being equal to Socrates and Socrates being equal to Theaetetus. The upshot is that Becoming includes mere relative changes as instances of coming to be, while Equality and Homeostasis entail that mere relative changes are not instances of coming to be. Equality and Homeostasis together require that an object has something added or removed, in order to undergo coming to be; Becoming makes no such restriction. Mere relative change need not involve addition or removal, to count as coming to be, on Becoming. But mere relative change does not count as coming to be on Equality and Homeostasis.

You might think, again, that this contradiction is merely apparent. Plato could solve the problem by distinguishing 'real' coming to be from 'mere relative' coming to be.[9] However, this approach does not tell us which of Equality, Homeostasis, and Becoming to reject. Nor does this approach account for the fact that Socrates supposes that the Secret Doctrine and the Twin Offspring Theory resolve the conflict between the three theses (*Theaetetus* 155c5–156a1).

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[7] McDowell (1973, 135) gives reasons for dissatisfaction with this reading.
[8] McDowell (1973, 136–7) makes a similar point in terms of 'Cambridge coming to be'.
[9] As McDowell (1973, 137).