What's the main aim of the chapter? To show how the concept of structure can solve some philosophical problems. IN particular there are four problems that are addressed:
Laws of nature
Reference-fixing
Confirmation
The structure of physical space.

Though the notion of structure is primitive for Sider, it's clear that he takes it to be connected with the predicates used to capture properties and relations in the world. The thought is that these predicates must capture 'natural' properties, where for S. this means 'joint-carving properties, i.e. properties that carve the world at its joints.

1. LAWS OF NATURE

Here the focus is on the Lewisian account of laws. (aka Mill-Ramsey-Lewis account or MRL-laws)
The key feature of this account is the denial of necessary connections in Nature; hence, the account is Humean. On Lewis's view, the world is a huge mosaic of local matters of fact: one thing followed by another.
David Lewis' Humean supervenience thesis: "all there is to the world is a vast mosaic of local matters of particular fact- all else supervenes on that" (1986, ix-x).

What are the laws of nature?
It is a law that all *Fs* are *Gs* if and only if
(i) all *Fs* are *G*s, and
(ii) (ii) that all *Fs* are *Gs* is an axiom or theorem in the best deductive system *F* (or, if there is no unique best deductive system *F*, it is an axiom or theorem in all deductive systems that tie in terms of simplicity and strength).

- **Frank Ramsey**: "even if we knew everything, we should still want to systematise our knowledge as a deductive system, and the general axioms in that system would be the fundamental laws of nature" (1928, 131).

- **David Lewis** (1973, 73) "a contingent generalisation is a law if and only if it appears as a theorem (or axiom) in each of the deductive systems that achieves a best combination of simplicity and strength".

No regularity taken in isolation can be characterised as a law (as opposed to an accident).

Lawlikeness is not a property that can be ascribed to a regularity in isolation of other regularities.
Laws are those regularities that are members of a system of regularities, in particular, a system which can be represented as a deductive axiomatic system striking a good balance between *simplicity* and *strength*.

- **Simplicity**
- **Strength**

How to balance them? *The best system*
Lewis: we should take into account all systematisations that achieve a good combination of simplicity and strength and we should take the laws of nature to be expressed by the axioms (and theorems) that are common in all those systems.
The (useful fiction of an) ideal deductive system of the world is not very far from the practice of science as we know it, nor far from what we now take the laws of nature to be.

A Problem
Natural kind predicates

- 'Goodman and the famous predicate 'is grue'.

'Grue' is defined as follows: observed before 2030 and found green, or not observed before 2030 and it is blue. Clearly, all observed emeralds are green. But they are also *grue*. Why then should we take the relevant generalisation (or law) to be *All emeralds are green* instead of *All emeralds are grue*? Goodman argued that only the first statement ('All emeralds are green') is capable of expressing a law of nature because only this is confirmed by the observation of green emeralds. He disqualified the generalisation 'All emeralds are grue' on the grounds that the predicate 'is grue', unlike the predicate 'is green', does not pick out a **natural kind**. As he put it, the predicate 'is grue' is not projectable, i.e., it cannot be legitimately applied (projected) to hitherto unexamined emeralds. So, whether or not a generalisation will conunt as lawlike will depend on what kinds of predicates are involved in its expression.

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The very idea of lawlikeness requires a theory of what *predicates* can be constituents of lawlike statements. The predicates suitable for lawlike statements (statements that express laws of nature) must pick out natural kinds.

The same need arises in connection with the MRL view of laws.n

It is perfectly possible that the simplest and strongest deductive systematisation may be effected by 'unnatural' predicates, that is, predicates that do not pick out natural kinds.
Then all sort of odd regularities would end up being laws, since they would be captured by axioms or theorems of the 'best system'. Hence, the prospects of a

theory of lawlikeness are tied with the prospects of a theory of natural-kind predicates.

Natural properties (or classes) that are distinguished from each other by objective sameness and difference in nature.
But: this notion of **naturalness** is hard to define—Lewis takes it as an unanalysed, yet indispensable, primitive. Indeed, if we try to explain similarity as sharing of natural properties, then we cannot analyse naturalness in terms of (objective) similarities.
According to Lewis, the inventory of perfectly natural classes (properties) is (or will be) delivered by fundamental physics. But even allowing for perfectly natural properties, naturalness is a matter of degree.
Eg. green is less natural than spin

Some conception of **similarity** becomes necessary in thinking about which regularities are laws.
If similarity is **not a fully objective relation**—in that the respects and degrees of similarity are not fixed by the world—this is an entry-point for subjectivity into laws.
Perhaps, as we go down to the level of atoms and **elementary particles** and their properties, this element of subjectivity is diminished.

Sider's way-out: natural = joint-carving.
Also: Laws are not necessary for a good scientific theory. There are various elements of a good theory which are not laws; eg., the principle of relativity, or the past hypothesis, viz. That the universe started in a low entropy state.
What's important for Sider is this: "good scientific theories, whether or not they cite laws, must be cast in joint-carving terms. We may put this in terms of explanation: "theories" based on bizarre, non-joint-carving classifications are unexplanatory even when true. Theories whose basic notions fail badly to carve at the joints fail badly as theories, even if they are exemplary from an "internal" point of view, for their inner workings fail to mirror the inner workings of the world. (p.23)

2. REFERENCE-FIXING

The question: What do our words refer to? What "semantic glue attaches them to the world?
Radical SEMANTIC scepticism
The context: Quine's radical translation theory. What does 'gavagai' refer to?
Kripke's Wittgenstein on Rule-following: what fixes the meaning of 'plus'. Why is someone wrong when he says that plus is given by the following function?
For numbers less than 1,000,000 it is like plus

But for numbers more than 1,000,000 it always yields 1,000,001.

What fixes the interpretation of a language?
Putnam’s model-theoretic argument
Envisage an ideal theory T of the world; a theory that satisfies all operational and theoretical constraints; that possesses any property that we can imagine or please except objective truth—which is left open. E e
Putnam’s argument is a *reductio* of the realist thesis that T might still (in reality) be false.
Suppose T says that there are infinitely many things in the world. T is consistent (by hypothesis) and it has only infinite models. By the Löwenheim-Skolem theorem, T has a model of every infinite cardinality (greater than or equal to the cardinality of extra-logical symbols of the language of T). Now, pick a model M of T, having the same cardinality as the WORLD. Devise an one-to-one mapping **m** of the individuals of M onto the pieces of the WORLD and map the relations between the individuals of M directly into the WORLD. These mappings generate a satisfaction relation (in Tarski’s sense)—call it SAT*—between (sets of) pieces of the WORLD and terms and predicates of the language of ‘ideal T’ such that T comes out true of the WORLD. (That is, the WORLD is isomorphic to the model M in which T is true.)
The ideal theory has been shown to be true of the WORLD. **Then how can we claim that the ideal theory might really be false?** This would be just absurd.

Putnam's challenge
is that the very notion of a unique interpretation fixed by the world makes no good sense. Moreover, Putnam quickly
anticipated an objection that a realist would have. A realist could object that a causal theory of denotation would show that, and explain why, a particular referential scheme for a language L—call it the intended interpretation—is picked out, thereby refuting Putnam's argument. However, Putnam argued, a causal theory of reference wouldεπ be of no help to the realist. For the model-theoretic argument can be extended
to words like 'cause': 'cause' can be reinterpreted no less than other words; in each model M, referenceM will be defined in terms of causeM.

The reply:
The world should not be merely seen as *a set of individuals*, i.e., as a model-theoretic *universe of discourse*. The world is a **structured whole**. Its individuals stand in specific relations to one another, or to subsets of individuals. In
other words, the model-theoretic description of the world must not be just a universe

of discourse, but rather a structured universe of discourse. In particular, a realist would assert two things: (1) the constituents of this universe (individuals and properties/relations) are independent of any particular representation we have of it; (2) whereas Putnam's assumption is that the language precedes the universe (domain of discourse) and 'structures' it, the realist position is that the universe is already structured, independently of the language. Then, a realist could argue that the model-theoretic argument fails. For, an interpretation of the language, i.e., a referential scheme, either matches the language to the existing structured universe or it does not. If it does not, then there is a clear-cut case in which even an ideal theory might be false. In particular, if the WORLD is a structured domain, then in order for Putnam to have his model-theoretic argument, he would have to show that the mappings from a model M of T onto the WORLD are structure-preserving. Yet, it simply is not always possible to produce structure-preserving isomorphisms.
It’s been suggested that any proposal as to what distinguishes between properties and pseudo-properties amounts to a provision of a constraint, call it C, upon the semantics of T. But then, we are back in square one: we add more theory to our theory of the world. The conjunction of T and the semantic theory of C—call it CT—has a model, if both T and C are consistent. Hence, Putnam's model-theoretic argument applies to CT, in such a way as to establish that T is true of the real world and that it is true in a faithful interpretation. So, the realist way-out is neutralised.

Lewis’s (1984) point is that when one suggests an extra constraint—call it C-constraint—in order to fix the intended referential scheme, what one suggests is that in order for an interpretation to be intended, it must conform to C. Then, the real issue is not whether the theory of C will come out true under unintended interpretations. Rather, it is what exactly C is and how it operates. In the light of this, Lewis's suggestion is that the appeal to causal considerations in fixing the intended referential scheme is not just adding more theory but offering constraints to which an interpretation must conform in order to be intended.

Lewis also suggested a constraint on the interpretation of a language, viz. that referents must be eligible. He conceded that one can posit

putative things and classes of things at will. However, among the countless things and
classes that can be posited, “most are miscellaneous, gerrymandered, ill-demarcated. Only an elite minority are carved at
the joints, so that their boundaries are established by objective sameness and difference in
nature. Only these elite things and classes are eligible to serve as referents” (1984, 227).
In other words, Lewis idea is that from the countless things that can be posited, only a
minority is such that carves the world at its joints, in the sense of picking out individuals and properties which belong to the objective structure of the world. Lewis's eligibility-constraint is prior to the interpretation of a language and such that an interpretation must satisfy in order to be intended. Lewis does not suggest an eligibility-theory which is open to re-interpretations. He offers a constraint and suggests that we have to turn to physics and its 'inegalitarianism' in order to find the elite things and classes of things that constitute the joints of the world. Then he argues
that an interpretation is unintended—and it would be disqualified—if it employs gerrymandered referents; i.e., putative referents that do not belong to the objective structure of the world. It follows that if "we limit ourselves to the eligible interpretations, the ones that respect the objective joints in nature, there is no longer any guarantee that (almost) any world can satisfy (almost) any theory" (1984, 227).

That;s what Sider means when he says that “That constraint is not that ‘Predicates stand for natural properties
and relations’ must come out true on a correct interpretation; it is rather, and
more simply, that *predicates must stand for natural properties and relations in a correct interpretation*” (p.27

3. CONFIRMATION

How are generalisations confirmed?

To fix our ideas, let us use a toy-example: *All ravens are black*.

Nicod’s principle (In honour of the French philosopher Jean Nicod): a universal generalisation is confirmed by its positive instances. So, that all ravens are black is confirmed by the observation of black ravens.

the principle of equivalence: if a piece of evidence confirms a hypothesis, it also confirms its logically equivalent hypotheses.

Take the hypothesis (H): All ravens are black. The hypothesis (H′) *All non-black things are non-ravens* is logically equivalent to (H). A positive instance of H′ is a white piece of chalk. Hence, by Nicod's condition, the observation of the white piece of chalk confirms H′. Hence, by the *principle of equivalence*, it also confirms H, that is that all ravens are black.
The hypothesis that all ravens are black is confirmed by examining seemingly irrelevant objects (like pieces of chalk or red roses).
One way to react to this is to claim that nonblack non ravens are not joint-carving predicates.

More generally, let us look at the currently popular Bayesian theory of confirmation.

Bayesianism: Mathematical theory based on the probability calculus that aims to provide a general framework in which key concepts such as **rationality**, **scientific method**, **confirmation**, evidential support, sound inductive inference are cast and analysed. It borrows its name from a theorem of probability calculus: **Bayes's Theorem**.
Bayes's theorem (In honour of Thomas Bayes) Theorem of the probability calculus. Let *H* be a hypothesis and *e* the evidence. Bayes's theorem says: prob(H/e)=prob(e/H)prob(H)/prob(e), where prob(e)=prob(e/H)prob(H)+prob(e/-H)prob(-H). The unconditional prob(H) is called the **prior probability** of the hypothesis, the conditional prob(H/e) is called the **posterior probability** of the hypothesis *given* the evidence and the prob(e/H) is called the likelihood of the evidence given the hypothesis.
Bayes, Thomas (1702- 1761) English mathematician and clergyman. His posthumously published *An Essay Towards Solving a Problem in the Doctrine of Chances* (1764), submitted to the *Philosophical Transactions of the Royal Society of London* by Richard Price, contained a proof of what came to be known as **Bayes's theorem**.

Bayesian Confirmation: P(H/e)> P(H)
Different prior probabilities make a difference to the posterior probabilities of competing hypotheses, **even if the likelihoods are equal**.
How are priors fixedIn its dominant version, Bayesianism is subjective or personalist because it claims that probabilities express subjective (or personal) degrees of belief.

`Given this, it's possible that the choice of priors is such that a bizarre hypothesis is confirmed by the evidence.

Eg,
H:All ravens are black
H′: All ravens are blite (a la grue: black before 3000 AD, and white after 3000 AD0
If prior probability of H′ is greater then prior prob of H, then prob(H′/e) > prob (H/e).

How can we show that prob(H)> prob (H′)?
An appeal to simplicity.
But suppose we spoke a language with blite and whack as primitive predicates. Then H′ would be simpler than H.

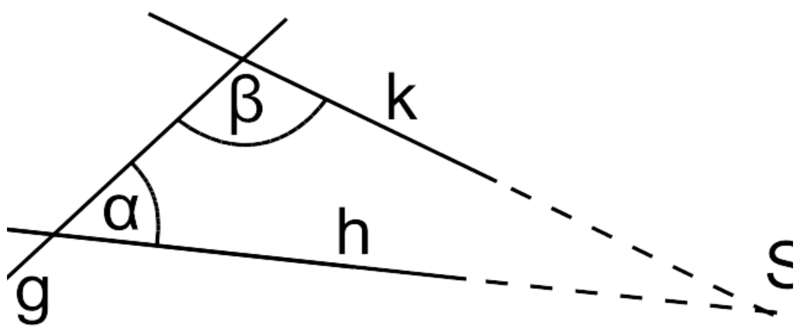
Here again, the commitment to joint-carving predicates would help.

Sider: "To constrain prior probability distributions, then, we need some way to pick out appropriate languages for evaluating simplicity, symmetry, and related notions. And—to finally get to the point—it seems reasonable to pick them out by using the notion of structure. Now, even given the notion of structure, there are nontrivial questions about how exactly to pick out the appropriate languages. For example, how well do the predicates in the appropriate languages need to carve at the joints? Again, the appeal to structure is the beginning of a solution, not the end of one."

4. Physical Space

Let's take things from the beginning.
Axioms of Euclidean Geometry

- "Η κατασκευή μιας <u>ευθείας γραμμής</u> από ένα σημείο σε οποιοδήποτε άλλο"
- "Μια πεπερασμένη ευθεία μπορεί να επεκταθεί απεριόριστα"
- "Ένας <u>κύκλος</u> ορίζεται από ένα κέντρο και μια απόσταση(<u>ακτίνα</u>)"
- "Όλες οι ορθές γωνίες είναι ίσες"
- Το αξίωμα παραλληλίας: "Αν μια ευθεία τέμνει δύο άλλες, τότε αυτές οι δύο αν επεκταθούν επ' αόριστον θα τμηθούν απ' την μεριά που οι εσωτερικές γωνίες που σχηματίζονται έχουν άθροισμα μικρότερο από δύο κάθετες



Είναι ισοδύναμο με το «Από σημείο εκτός ευθείας άγεται μόνον μια παράλληλη προς αυτήν».

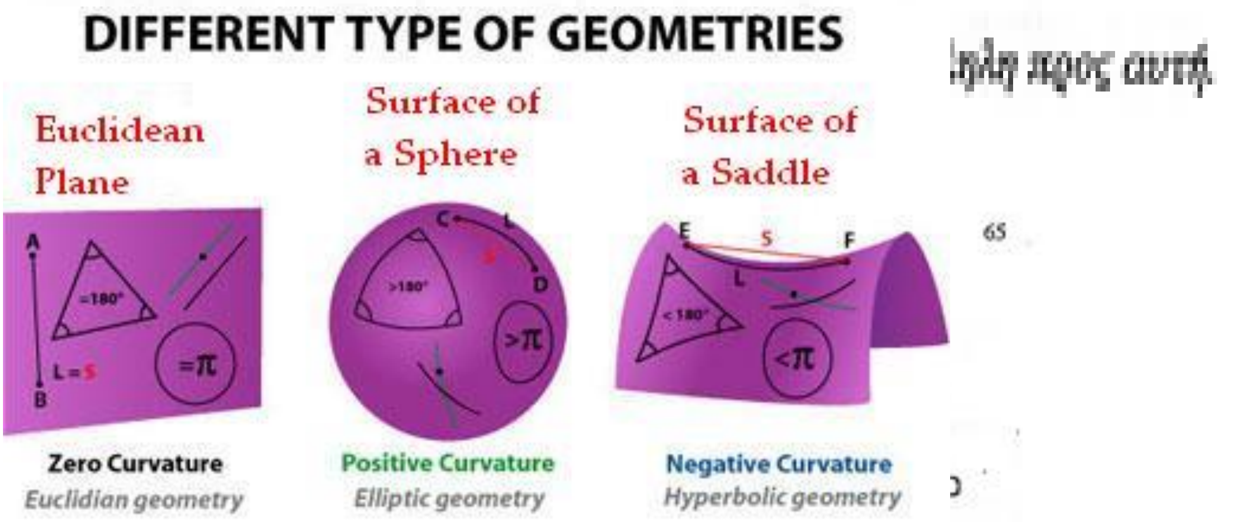
- Είναι το 5^{o} αίτημα ανεξάρτητο από τα υπόλοιπα ή αποτελεί εν τέλει θεώρημα;
- Τι θα πει ανεξάρτητο;
- $1\&2\&3\&4 \nvdash 5$
- $1\&2\&3\&4 \nvdash$ not-5

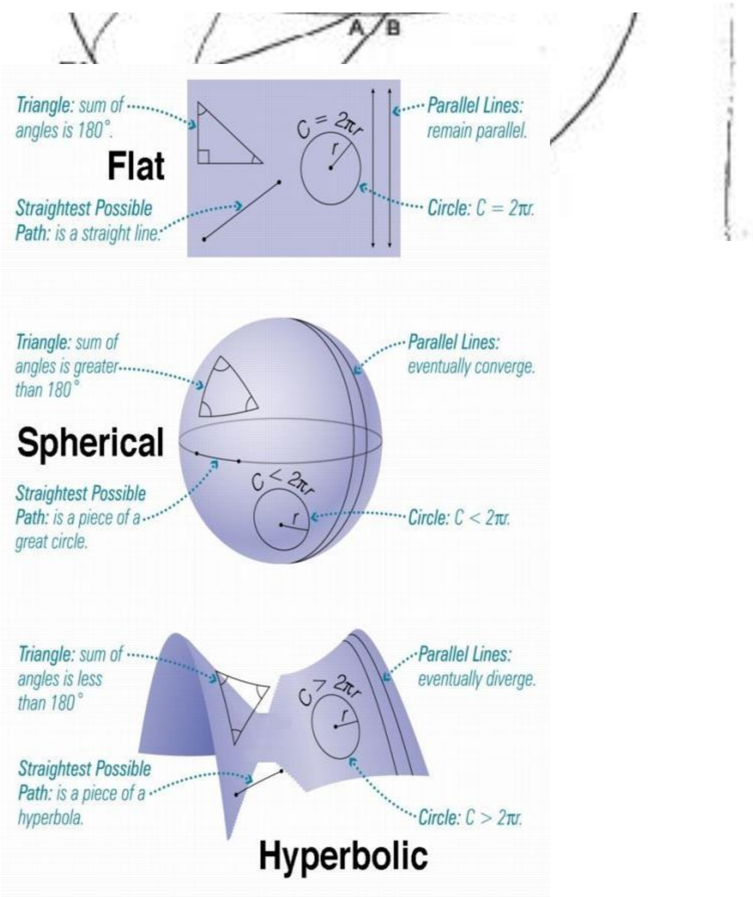
Αλλα αν το 5^{o} αξίωμα είναι ανεξάρτητο, τότε

- Ο συνδυασμός 1&2&3&4&not-5 είναι συνεπης
- Οπως είναι και ο
- 1&2&3&4&5
- Ο συνδυασμός 1&2&3&4&not-5 είναι η απαρχή των μη-Ευκλείδειων γεωμετριών
- Η ανακάλυψη μη Ευκλείδειας Γεωμετρίας έγινε σχεδόν ταυτόχρονα από τους Lobachevsky (1793 – 1856) και Bolyai (1775 – 1856).
- Ο Lobachevsky δημοσίευσε το 1830 την πραγματεία του *Αρχές της Γεωμετρίας*, ενώ Bolyai δημοσίευσε το 1831 την πραγματεία του *Απόλυτη επιστήμη του χώρου*.
- **Υπάρχουν άπειρες ευθείες γραμμές που περνούν από σημείο εκτός ευθείας και οι οποίες δεν την τέμνουν, δηλαδή είναι παράλληλες**
- Ο Γερμανός μαθηματικός Riemann, θεμελίωσε την ελλειπτική γεωμετρία, κατά την διάρκεια της διάλεξης που έδωσε το 1854 στο Πανεπιστήμιο του Gottingen, με τίτλο «***Επί των υποθέσεων επάνω στις οποίες θεμελιώνεται η γεωμετρία*».**

Ευθεία=μεγάλος κύκλος

Ολοι οι μεγάλοι κύκλοι τέμνουν τον κύκλο DD′.





The key question: Does Euclidean geometry describe the structure of physical space?

Non-Euclidian geometries—the status of the fifth postulate of Euclid's

These are consistent mathematical theories but can they describe physical space?

Το αξίωμα της ελεύθερης κινητικότητας (Helmholtz-Lie)

- Τα στερεά σώματα που χρησιμοποιούμε για να κάνουμε τις μετρήσεις είναι άκαμπτα, δηλαδή δεν αλλάζουν τις διαστάσεις τους και το σχήμα τους κατά την μετακίνηση τους.
- Αλλά αυτό είναι ένα εμπειρικό γεγονός.
- Γεωμετρίες σταθερής καμπυλότητας.
- Ή μήπως δεν είναι; Ποια εμπειρικά γεγονότα θα μπορούσαν να το τεκμηριώσουν;
- Poincare

réflexions non moins importantes.

Telle est par exemple celle de l'égalité de deux figures : deux figures sont égales quand on peut les superposer; pour les superposer il faut déplacer l'une d'elles jusqu'à ce qu'elle coïncide avec l'autre; mais comment faut-il la déplacer? Si nous le demandions, on nous répondrait sans doute qu'on doit le faire sans la déformer et à la façon d'un solide invariable. Le cercle vicieux serait alors évident.

En fait, cette définition ne définit rien : elle n'aurait aucun sens pour un être qui habiterait un monde où il n'y aurait [illegible] des fluides. Si elle nous semble claire, c'est que [illegible] sommes habitués aux propriétés des solides n[illegible]els qui ne diffèrent pas beaucoup de celles des [illegible]les idéaux dont toutes les dimensions sont inv[illegible]bles.

Cependant, toute i[illegible]ite qu'elle soit, cette définition implique un a[illegible]ome.

La possibilité du mouvement d'une figure invariable n'est pas une vérité évidente par elle-même; ou du moins elle ne l'est qu'à la façon du postulatum d'Euclide et non comme le serait un jugement analytique *a priori*.

D'ailleurs en étudiant les définitions et les démonstrations de la géométrie on voit qu'on est obligé d'admettre, sans les démontrer, non seulement la possibilité de ce mouvement, mais encore quelques-unes de ses propriétés.

figures are equal when they can be superposed. To superpose them, one of them must be displaced until it coincides with the other. But how must it be displaced? If we asked that question, no doubt we should be told that it ought to be done without deforming it, and as an invariable solid is displaced. The vicious circle would then be evident. As a matter of fact, this definition defines nothing. It has no meaning to a being living in a world in which there are only fluids. If it seems clear to us, it is because we are accustomed to the properties of natural solids which do not much differ from those of the ideal solids, all of whose dimensions are invariable. However, imperfect as it may be, this definition implies an axiom. The possibility of the motion of an invariable figure is not a self-evident truth. At least it is only so in the application to Euclid's postulate, and not as an analytical *à priori* intuition would be. Moreover, when we study the definitions and the proofs

Ποιος είναι ο φαύλος κύκλος;
Η ισότητα δύο σχημάτων προυποθέτει την επίθεσή τους.
Η επίθεση προυποθέτει την μετατόπιση χωρίς παραμόρφωση.
Αλλά ποια είναι η μετατόπιση χωρίς παραμόρφωση;
Αυτή που οδηγεί στην ισότητα των σχημάτων

Έχετε σκεφτεί πως μετράμε αποστάσεις ή διαστήματα με ένα μέτρο ή ένα χάρακα;

In "L'espace et la géométrie", (1895), Henri Poincare told the story of a possible world in which the underlying geometry is Euclidean but, due to the existence of a strange physics, all attempts to find out empirically the geometry of this world would lead its inhabitants to assume that the geometry was non-Euclidean. This world is the interior of a sphere *S*. Viewing this world from 'the outside', we can easily infer that its geometry is Euclidean. Things are not so simple for the locals, however. For, unbeknownst to them, there is a medium permeating *S* such that the temperature at each point is variable, being a function of the distance of each point from the centre of the sphere. In particular, the temperature at each point is R^2-r^2, where *R* is the radius of the sphere and *r* is the distance of the point from the centre. The freely-moving inhabitants of this world cannot notice any difference because the laws of physics ensure that, wherever they move, thermal equilibrium is immediately restored. But the laws of physics also ensure that all bodies, including measuring rods, contract uniformly as they move away from the centre of *S* and towards the periphery.

Imagine that the inhabitants of *S* try to determine the geometry of their world. They will soon find out that they live in a Lobachevskian world of infinite extent. One of their relevant empirical findings will be that they can draw an infinite number of 'parallel' lines from a point outside any given line. The only operational procedure at their disposal will be enough to persuade them of this: they extend the lines indefinitely and they never meet. So, they will find irresistible the conclusion that their world is Lobachevskian. Yet, an eccentric mathematician of *S* suggests to his fellow scientists that the geometry of *S* is really Euclidean but that, due to a universal force (the temperature field) which makes everything contract as they move, the geometry appears to be non-Euclidean. Now, the inhabitants of *S* are faced with two empirically equivalent alternatives. How are they to choose between them? Poincaré says that whatever their choice be, it is not dictated by their empirical findings. The latter can be 'written into' any of the two geometrical languages, with suitable adjustments in the relevant physics.

Poincaré used this case to illustrate the ultimate role of conventions in science and in theoretical knowledge. But for our purposes, what matters is his claim that when we envisage an empirical test, we envisage a situation which tests the conjunction G&P (where G is some geometry and P is some physical theory); hence, when we find recalcitrant evidence, we are always free to stick to the preferred geometry and change the physical theory.

Reichenbach showed that we may choose a model of Euclidean geometry as the physical geometry of the universe. Then we can create all and only the empirical consequences of the General Theory of Relativity provided that we postulate universal forces which make moving bodies (e.g. moving rods) to contract accordingly. So roughly, the theories, T_1=(Rigid Rods + Non-Euclidean Geometry) and T_2=(Contracting Rods + Euclidean Geometry) are observationally indistinguishable (cf. Reichenbach, 1958, pp.33 & 66).

We always test Geometry plus Physics and we can always hold on **Geometry by changing physics accordingly**.
"Euclidean geometry has nothing to fear from fresh experiments"

GTR implies that **space is non-Euclidean**—actually Riemannian with variable curvature which depends on the distribution of mass in the universe.

But grounding this required an important philosophical shift. The principles of geometry are *not* conventions.

In Geometry and Experience (1921) Einstein argued that though geometry is always tested in **conjunction** with a physical theory, this conjunction (Geometry & Physics) is wholistically testable.

Hence, **if there is conflict between Geometry & Physics with experience,**

it is geometry that may be abandoned or modified.

What the Poincare case suggests is that it is entirely possible that there is a systematic mismatch between appearances and reality. The inhabitants' world (*their* world; the world empirically accessible to *them*) does not match the structure of the real world they live in. The uknowability of the structure of the world does not compromise its existence; nor its independence. By the same token, realism leaves open the possibility that the world might not be knowable.