Three Levels of Modality in Scientific Representation

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Scientific Representation and Inferentialism

The Debate on Scientific Representation

Models are central in science. Models are representations.
What makes a vehicle a representation of its target?
Naturalistic accounts: a relation between model and target. Morphism[1]? Similarity[2]? No[3]!

- Not enough (asymmetry/non-reflexivity)
- Too much (possibility of misrepresenting)

The Inferentialist Account (Suárez)

Representation as a three-place relationship (vehicle, target, user)

Representational force (relevance): Something is a representation in virtue of

- its denotational function (by the user) – the vehicle *stands for* the (possibly abstract or fictional) target
- allowing the user to make inferences on the target (epistemic vs. symbolic representation)[4]

Accuracy: a representation is *accurate* if inferences are sound (but they need not be: possibility of misrepresentation)

Without relevance, no inference: a model is neither accurate or inaccurate (cf. "the king of France is bald"). Difference between being *confused* and *wrong*.

Deflationism, Minimalism

The inferentialist account gives general norms of representation. They are necessary but *not* sufficient (minimalism[5]).
A substantial account would *explain* how these norms are met by specifying a *constitution* of representation.
But for Suárez, no perfectly general account exists.

- There are norms specific to contexts or epistemic communities.
- Variety of means (isomorphism, similarity, etc. are means for making inferences, but not constitutive of representation).

Minimalist vs. Substantive Accounts

Can We Say More? Interpretation (Contessa)

Representing is interpreting[6]:

- mapping between properties/relations/functions of vehicle and target. Example: metro map.
- this is a constitutive account (sufficient for representation): explains how inferences are possible

Very liberal: Suárez' conditions are sufficient! One could use Rutherford's model of the atom to represent a hockey pluck sliding on ice. Misrepresentation, but still representation.
But saying more would run afoul of examples of misrepresentation.

Can We Say More? Informativeness (Bolinska)

A representation must be informative about the target, this requires *aiming* at faithful interpretation[7].
Using Rutherford's model to represent a hockey pluck, if arbitrary, is not aiming at faithfulness, hence being uninformative.
Is faithfulness a psychological factor? Don't we need *public norms*? (at least in science) Couldn't a faithful, but incompetent user fail at representing at all?

Can We Say More? Conceptual and Practical Norms

Denotation carries implicit assumptions. Ex. Galileo denoting time with a line.[8] Maybe not all interpretations are allowed (conceptual confusion).
There are norms of valid inferences within some representational practice. Inferences must be licensed by epistemic community.[9] Scientific representation is not an individual matter.
Example: using the right formalism, the right kind of dynamics for a kind of system…
But how strict?

- Too low cannot account for conceptual confusion
- Too high cannot account for conceptual developments outside of accepted knowledge

Resolving the Dispute: the Role of Context

Abstraction and Indexicality

Often overlooked: most models are abstract (ex. hydrogen atom).
The map analogy is misleading. No direct mapping, but indexicality: the reference is fixed only in concrete applications, with

specific operationalisations (low levels of abstraction). "Denotative function" is more appropriate in abstract contexts.
An abstract model only gives *potential* interpretations. But then conceptual resources (character) are required to fix legitimate concrete interpretations; not "anything goes".

The Role of Context

Context of use specifies a *target* and an *aim* (predicting, explaining, testing, presenting, theorising).
This fixes:

- The target, associated with suitable level of abstraction
- Relevant properties for the aim and required degrees of precision

Correct identification is required to make inferences. *Identity conditions* for the target and properties can assume a formalism, a theory, a family of models.
Ex.: if a target is identified as a pendulum, failing to use well-known characteristics of pendulum is *failing to represent.*
If the aim of the model is fixing the relativistic mass of a target, using a Newtonian model is *failing to represent.*

What I will Defend

I will defend that norms of representation depend on the level of abstraction associated with the aim of representation:

- Concrete representational uses inherit conceptual constraints from more abstract uses. Not anything goes.
- Abstract representational uses can relax identity conditions, so as to explore possibilites.

How this Settles the Debate

Contessa is right: in principle, one could use Rutherford's model for a hockey pluck *if the aim is develop new theory of hockey plucks in general.* But this is a peculiar aim…
Suárez is right, because this cannot be true in any context. Merely predicting the behaviour of a given pluck requires using licensed conceptual tools (a hockey pluck is a solid object, etc.).
Bolinska's faithfulness analysed in terms of conformity with conceptual norms, associated with levels of abstraction and aims.

Modalities and Levels of Abstraction

Hierarchy of Models

Theories are not mere collections of models, but topologies[10] organised in hierarchy[11] with various levels of abstraction.
Taking the case of physics:

- types of objects and degrees of freedom $\rightarrow$ state space
- a form for the dynamics (ex. $F = -kx$)
- specific dynamical parameters ($k = \ldots$)
- what is measured
- specific bound conditions ($x(t = 0) = \ldots$)

Relation to Modalities

An abstract model needs not specify everything. It can be compatible with various more concrete possibilities. A model has an *internal modal structure* (it represents possibilities).
Level of abstraction of a model = lowest level at which everything is specified. Presumably depends on the aim and kind of target. Ex. predicting particular experiment requires specifying bound conditions, explaining type of phenomena requires representing various possible bound conditions.
A set of models at any level themselves *constitute a modal structure* (model as possible state of affairs), the internal structure of a more abstract model.

The Different Kinds of Modalities

We have different levels of modalities. What kinds of modalities are at stake? Our options: what must/can be true given:

Conceptual: our concepts ("Red is a colour", "Electrons are negatively charged particles").
Epistemic: our state of knowledge ("The radius of the earth is about 6000 km")
Normative: our desires, practical aims, moral principles ("Killing is bad", "I need to drink")
Natural: natural constraints on phenomena ("No object goes faster than light")

Conceptual possibilities encompass the others.

Modalities and Scientific Representation

One can think of modalities (except natural) as constraints on our inferences. There is therefore a direct link with the inferential account of representation.

- Relevance = *conceptual constraints.*Required to make *valid* inferences (even if not *sound*)
- Accuracy = *epistemic constraints.*Set of models that could be accurate as state of knowledge. Moorean paradoxes[1] apply to modeling[12].
- Other virtues = *normative constraints.* (simplicity, fit with practical aims: the direction of fit is not always from the model to the world, cf. technology).
- The model is used for explanations and counterfactual reasoning. It represents *natural constraints* on the target.

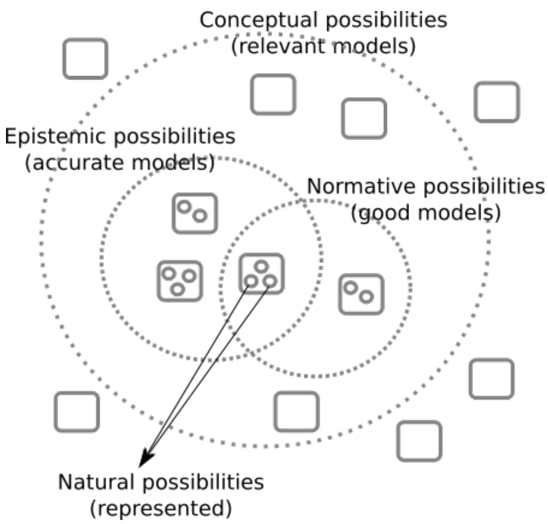
Relevance, Accuracy and Level of Abstraction

Given a specific target and level of abstraction,

- Conceptual norms fix a legitimate *family of models*, each at the appropriate level of abstraction
- Accuracy and other virtues are about evaluting *which model in this family* is good (different virtues can be in conflict).
- Each model represents possibilities at *lower levels of abstraction*, so as to allow for counterfactual reasoning.

[1]"I believe X and not X"

Higher levels must be fixed for lower levels to make sense. Ex.: reasoning on possible bound conditions (for the aim of explaining a phenomena) means having fixed the dynamics (otherwise no inference can be made on other properties).
Ideally, the conjonction of conceptual, epistemic and normative constraints should correspond to natural constraints



The Contextuality of Modalities

Is There a Fixed Conceptual Level?

The received view: there is a fixed set of conceptual truth, a fixed set of epistemic truth, etc.
This implies that there is a "right" level for modeling. But which? What level in the hierarchy must be correctly specified for the model to be relevant? To be accurate?
Can we distinguish conceptual and epistemic levels in the structure of theories? Ex. form of dynamics as conceptual, dynamical parameters as epistemic?

What is Conceptually Fixed?

Conceptual norms (or identity conditions) could apply at any level of abstraction:

- The objects/degrees of freedom that must minimally be involved (but not necessarily all)
- Sometimes, a minimal form for the dynamics (but adding perturbations is allowed)
- Sometimes, some dynamical parameters (but not necessarily all)
- Perhaps some bound conditions (but not all)

Depends on the kind of target we are interesting in: type of object, specific object, specific experiment on an object…
Dubious that what counts as conceptual norm or epistemic constraint is fixed a-contextually.

There is No Fixed Conceptual Level

Picking the wrong form for the dynamics of a system:

- Conceptual confusion if aim=fix dynamical parameters
- Epistemic uncertainty if aim=develop new model
- No point if aim=illustrate the theory (all dynamical forms are natural possibilities)

Picking the wrong energy state for a hydrogen atom:

- Conceptual confusion if aim=experiment on low energy state
- Epistemic uncertainty if aim=represent a concrete atom
- No point if aim=abstract model of hydrogen (all are natural possibilities)

→ There is no "right" level for modeling.

Consequences

The distinction between conceptual/epistemic/natural possibilities is *contextual*. The status of a constraint changes when navigating levels of abstraction. Does it make sense?

Problem solving: epistemic/practical constraints for abstract type of object (which model is right?) become entranched in the community. They are upgraded to conceptual constraints for concrete applications.

Paradigm shift: conceptual constraints on concrete applications become questioned in front of anomalies. They are downgraded to epistemic/practical possibilites.

Abstraction: epistemic/practical possibilities for instance are abstracted away: they become natural possibilites for a type of object.

Application: natural possibilities for the type become epistemic / practical possibilities in concrete applications (which one is/should be realised?)

Type	Instance
Conceptual constraint	Conceptual constraint
Epistemic/Practical constraint	Conceptual constraint
Natural possibility	Epistemic/Practical possibility
Natural possibility	Natural possibility

Conclusion

I think it makes sense.
Elaborates on Suárez' account (contextual norms) and solves the debate on minimalist vs. substantial accounts.
Provides a rather faithful picture of scientific reasoning, that can be associated with Kuhn's philosophy (problem solving vs. paradigm shift).
Possibly linked to contextualism about knowledge (epistemic modality).
In line with Quine: everything is revisable, but not at the same level of abstraction.

Notes

[1]Otavio Bueno and Steven French. "How Theories Represent". In: *British Journal for the Philosophy of Science* 62.4 (2011), pp. 857–894.

[2]Ronald N. Giere. *Science without laws.* Science and its conceptual foundations. Chicago: University of Chicago Press, 1999. 285 pp.

[3]Mauricio Suárez. "Scientific representation: Against similarity and isomorphism". In: *International Studies in the Philosophy of Science* 17.3 (2003), pp. 225–244.

[4]Mauricio Suárez. "An inferential conception of scientific representation". In: *Philosophy of Science* 71.5 (2004), pp. 767–779.

[5]Mauricio Suárez. "Deflationary representation, inference, and practice". In: *Studies in History and Philosophy of Science Part A* 49 (Feb. 2015), pp. 36–47.

[6]Gabriele Contessa. "Scientific representation, interpretation, and surrogative reasoning". In: *Philosophy of Science* 74.1 (2007), pp. 48–68.

[7]Agnes Bolinska. "Epistemic representation, informativeness and the aim of faithful representation". In: *Synthese* 190.2 (Jan. 2013), pp. 219–234.

[8]Anguel Stefanov. "Theoretical Models as Representations". In: *Journal for General Philosophy of Science* 43.1 (July 2012), pp. 67–76.

[9]Mauricio Suárez. *Representation in Science.* Ed. by Paul Humphreys. Vol. 1. Oxford University Press, July 9, 2015.

[10]Hans Halvorson. "What Scientific Theories Could Not Be". In: *Philosophy of Science* 79.2 (2012), pp. 183–206.

[11]Giere, *Science without laws.*

[12]Bas van Fraassen. *Scientific Representation: Paradoxes of Perspective.* Vol. 70. Oxford University Press, 2008.