Deflationary Representation, Inference, and Practice

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Abstract: This paper defends the deflationary character of two recent views regarding scientific representation, namely RIG Hughes' DDI model and the inferential conception. It is first argued that these views' deflationism is akin to the homonymous position in discussions regarding the nature of truth. There, we are invited to consider the platitudes that the predicate "true" obeys at the level of practice, disregarding any deeper, or more substantive, account of its nature. More generally, for any concept X, a deflationary approach is then defined in opposition to a substantive approach, where a substantive approach to X is an analysis of X in terms of some property P, or relation R, accounting for and explaining the standard use of X. It then becomes possible to characterize a deflationary view of scientific representation in three distinct senses, namely: a "no-theory" view, a "minimalist" view, and a "use-based" view – in line with three standard deflationary responses in the philosophical literature on truth. It is then argued that both the DDI model and the inferential conception may be suitably understood in any of these three different senses. The application of these deflationary 'hermeneutics' moreover yields significant improvements on the DDI model, which bring it closer to the inferential conception. It is finally argued that what these approaches have in common – the key to any deflationary account of scientific representation – is the denial that scientific representation may be ultimately reduced to any substantive explanatory property of sources, or targets, or their relations.

Keywords: Deflationary Representation; models and idealization; deflationary accounts; theories of truth; inference.

1. Scientific Representation: The State of Play

'Science represents through its models - and this representational aim is characteristic, or defining, of its model-building activity'. As stated – in this minimal and restricted sense – this is as uncontroversial a claim as one may encounter in contemporary philosophy of science. But what is it that science represents, and how does it do it? These are much harder questions, and there is intense debate nowadays amongst philosophers regarding how best to address them. [i]

The various attempts to answer these questions can be distinguished in a number of different ways. In this paper I focus on one particular distinction between what I call 'substantive' and 'deflationary' accounts of representation. The former type claims that representation is some substantive or objective property or relation; the latter, by contrast, 'deflates' the notion of representation by claiming that there is no substantive property or relation at stake. These terms will be defined more fully below. Substantive accounts have traditionally been, implicitly if not explicitly, the norm in much of the discussion of scientific representation. Bas van Fraassen and Ronald Giere have often been thought to defend substantive analyses of representation (as isomorphism and similarity, respectively), although their views turn out to be in fact more subtle than has been supposed – and, in particular, their most recent and considered views are decisively deflationary (Giere, 2004; Van Fraassen, 2008). More recently, champions of substantive accounts include Pincock (2012), who defends structural isomorphism, and Weisberg (2013), who defends similarity; yet other attempts at substantive accounts include Bartels (2006), who defends homomorphism, French (2003) and his disciples, who defend partial isomorphism, and Contessa (2007), who defends a substantive version of the inferential conception. In all these cases the ostensive aim is to analyze away representation in virtue of some other relation or property, or set of relations and properties, that provide its reductive base.

In other words, these accounts are both *substantive* and *reductive*. It is worth noting that it is not the case that, for any concept X, a substantive account of it should be reductive. It is important in particular to distinguish 'primitivist' accounts from what

I will in the paper consider strictly 'deflationary' accounts: they are by no means the same. True, a 'primitivist' account about a concept X starts from the recognition that X may not be reduced or analysed away. But this is because, for a primitivist, X is substantive yet unanalysable. On such a view X is an explanatory primitive property or relation that bears no reduction to any other concept or set of concepts Y. For illustration it is instructive to consider the case of laws, causation, or time. A primitivist about these concepts claims them to be explanatory primitives. For instance, David Armstrong is widely held to defend primitivism about laws; and Tim Maudlin is a primitivist about (the passage of) time. Wesley Salmon may have been a primitivist about causal processes, etc. By contrast, a Humean considers all these concepts to have a problematic status calling for analysis in terms of other concepts that he or she considers to be unproblematic. The unproblematic concepts from the Humean point of view are empirically accessible – thus laws are to be reduced to regularities; causation is to be reduced to probability, typically understood as frequency; and time is to be reduced to open conjunctive forks, or oriented correlations. None of these views is deflationary in the sense that I will develop in this paper.

Another striking example of the distinction that I am appealing to here can be found in debates surrounding the nature of knowledge. Many philosophers have attempted to analyse 'knowledge' away in terms of notions they regard to be self-explanatory, or at least less obscure, such as justification, truth, and belief. Yet others have resisted any such analysis, claiming instead that knowledge is an explanatory primitive that requires no analysis (notably Williamson 2000). Along the same lines, a primitivist about representation claims that representation is an explanatory primitive which bears no further reduction. It should thus be clear that this view is a non-reductive kind of substantive account – certainly not an analysis –, and should be distinguished from both the deflationary and the reductive kind of substantive accounts that will be discussed here. [ii]

Deflationary views or accounts of scientific representation are inaugurated by Hughes (1997), include explicitly Suárez (2004) and Van Fraassen (2008) and – on the version of deflationism defended here – implicitly Giere (2004) and Elgin (2009). On such views, representation is not a substantive property or relation. Some of these deflationary views take it to be no property or relation at all; others take it to be a property or relation, but not a substantive one – in some precise sense to be specified. Deflationary accounts are not typically reductionist – indeed it would be strange to first claim that representation is not a substantive property, or no property at all, and then go on to attempt to analyse it away anyway. (But note that the difficulty here is not logical or conceptual, but a pragmatic difficulty concerning the possible use of a reductive deflationism – for if X already fails to be, or to correspond to, a substantive property or relation then what cognitive gain could there be in reducing it to further deflationary properties or relations?) All the deflationary accounts of representation reviewed here (including 'used-based' accounts) are non-reductive in the weaker sense that they either do not provide an analysis in terms of necessary and sufficient conditions, or if they do provide such conditions, they claim them to have no explanatory purchase. Hence, the deflationary accounts reviewed here give up on the aim to provide an explanatory reduction of representation in terms of properties or relations between sources and targets, and this is what distinguishes them from reductive substantive accounts.

A critical issue for the purposes of this paper concerns the relationship between representation and model-building practice. In a substantive account this relation is contingent: if modellers' practice is appropriate and effective it will latch on the relevant features of representation, but there is no logical or conceptual necessity for this to be so – the practice may in principle be fundamentally misguided. It is first the case that at the individual level, modellers can be better or worse at grasping the select set of features of a source that holds the representational relation R to the target. While collectively, there is nothing to guarantee that the practice is in any way geared towards a successful appraisal of the features and relations in question. In other words scientific practice may be more or less proficient in getting at genuine representational relations. At best, we can take scientific practice to provide some defeasible evidence for or against particular substantive accounts, and this only if we accept that our account of representation should aim to be descriptive, or explanatory, of the actual practice.[iii] In other words, if representation is a substantive relation, or property, then the practice of model-building provides at best an empirical benchmark to judge how appropriate the different accounts of this substantive relation are. But the practice and the account may in principle – i.e. logically or conceptually – differ markedly.

By contrast, I argue in this paper, one thing that all deflationary accounts have in common is that the agreement between representation and model-building practice is, if not a priori, at least conceptually much tighter– for it turns out that on these accounts representation cannot be contradicted by the norms that inform that practice, or be explicitly at variance with them. On some deflationary accounts this is because there is nothing that the concept of representation per se says about representational or model building practice; on other deflationary accounts, representation is itself constituted in the practice. Either way representational practice is not an 'empirical benchmark' against which to judge our theories of representation. Of course, individual modellers – even whole communities or groups of scientists – may, whether intentionally or not, misrepresent, in the sense that they may mistakenly ascribe the wrong sources, or the wrong features of such sources to the wrong targets, or mistaken features thereof. However, whenever they do, there must be some failure on their part to follow the constitutive norms of the practice that explains their mistake. [iv] For it is impossible, on a deflationary account, for the concept of representation in any area of science to be at variance with the norms that govern representational practice in that area. Rather, representation in that area, if it is anything at all, is *nothing but* that practice. [v]

Now, beginning with Hughes (1997) and culminating in Van Fraassen (2008), the deflationary tradition has shown increasing concern with reductive substantive accounts (i.e. attempts at explanatory definitions) of representation. Consequently, I argue, the role of practice has shifted from a potential arbiter in disputes between accounts of representation towards a constitutive element of representation itself. In a deflationary approach, as I argue in this paper, practice does not merely adjudicate competing accounts of the concept. Rather to the extent that there is any concept at all, practice fully informs the concept. As a consequence, the functions and roles of representation may not be defined a priori independently of representational practice – but can be fully articulated only against the background of practice. And although this bare and general deflationary thesis seems to be becoming popular, its mere statement still leaves open important details, and is open to several interpretations.

2. What is Deflationism? Three Views.

My main claim in this paper is that both Hughes' DDI model and my own inferential conception are deflationary accounts of scientific representation in some relevant respects. In order to make the claim precise I need to first characterize what those relevant respects are. My strategy is to employ an analogy with the debates regarding the nature of truth within metaphysics and the philosophy of language. By means of reference to those debates, I shall attempt to distinguish three different senses of "deflationism", or more generally three distinct deflationary approaches to any concept: The 'no-theory', 'abstract minimalism' and 'use-based' approaches. The implications for scientific representation and, in particular, for the sort of philosophical work that is appropriately relevant to them, seem different in all three cases. However, in sections three and four, I go on to apply these three deflationary approaches to the DDI model and the inferential conception, and I will then claim that there is something that these three approaches have in common after all. They all emphasize the essential link to practice mentioned above that makes a substantial definitional approach helpless or impossible. An inquiry into the nature of scientific representation, on any of these views, is essentially an inquiry into a form of practice. [vi] Thus I shall end by urging philosophers of science to focus on the ways in which any deflationary approach may contribute to this common goal. [vii]

It will help us to understand deflationism if we first provide a sketch of its opponent – substantialism. A substantive analysis of some concept X is a set of necessary and sufficient conditions that defines the concept and moreover explains its use. The defining conditions of the concept are thus also conditions for its use, which stipulate under what conditions the concept applies. Let us, for instance, consider the truth concept. A substantive analysis establishes some conditions that define the nature of the 'truth' predicate. Whatever property truth is then taken to be, it is possible to explain any correct or legitimate application of the predicate by reference to these conditions. The conditions may stipulate a particular type of relation that must obtain between on the one hand propositions, or sentences, and facts on the other hand. Or it may stipulate some property that propositions, or sentences, need to have in order to legitimately be said to be true, or truth-apt. [viii]

In accordance with this terminology, three substantive theories of truth may be said to have essentially emerged in the literature so far, which we may refer to as the correspondence, coherence and pragmatist theories or accounts of the nature of truth. They all begin by accepting the equivalence or disquotational schema, which we may state as follows: [ix]

The Disquotational Schema (DS): 'P' is true if and only if P. [x]

Each of the theories reviewed then establishes a set of defining conditions for the predicate "true" that are supposedly necessary and sufficient for legitimate applications of the predicate in whatever context. These conditions certainly include the (DS) but will add something else substantial in addition – whether a relation or a property of sentences. Yet, what each theory adds differs dramatically. Thus, the correspondence theory adds the idea that truth is correspondence to the facts – and understands this as a substantive or metaphysical relation between sentences and facts (the relata of the correspondence relation). The coherence theory adds the idea that truth is coherence with the rest of (an agent's) beliefs, and again understands coherence as a logical relation amongst sentences. For the so-called 'pragmatist' theory, truth is supposed to consist in the property of cognitive utility in accordance to the maxim often ascribed to James: "to be true is to be useful to believe". [xi]

The distinguishing mark of a substantive theory of truth (and by extension, of any concept) is therefore the laying down of conditions that define the concept and that moreover explain its use. Deflationary accounts, by contrast, give up on at least one of these distinct aims – if not both the definitional and the explanatory aim. Thus these accounts have in common the rejection of a defining set of application conditions that explain the use of the concept. In particular, with respect to truth, these accounts take it that there is no substantive nature to truth (i.e. no explanatory nature with respect to the use of the corresponding predicate) to be captured by philosophical analysis. Naturally, there are two ways to deny that such an explanatory analysis is possible. In the first instance by denying that an analysis is possible full stop; in the second instance, by accepting that an analysis is possible while denying that it is the kind of analysis that will shed explanatory light on our use of the concept. Thus many deflationists accept that truth is nominally a property, but deny that it is a substantive one – i.e. one that can be employed for explanatory purposes.

I want to argue that we may helpfully distinguish in the literature on truth three different deflationary approaches. [xii] I shall refer to them as the 'no-theory', 'abstract minimalism', and 'use-based' approaches. I identify the first type of approach roughly with the so-called 'redundancy' theory of truth, in particular as espoused by Frank Ramsey. The second type of approach is best characterized by Crispin Wright's 'minimalism' about truth. The third and final type is roughly suggested by Paul Horwich's variety of deflationism. All of these views have some explicit or implicit debt to Wittgenstein's middle and late period thought, and indeed the core of what they share in common - when considered as generalized deflationary accounts of any concept - is perhaps some late Wittgenstenian attitude to conceptual analysis. Nevertheless, they do differ in the way they apply the central insight – and they correspondingly differ in some central claims they make regarding truth. I shall review them in turn with an eye on the central Wittgensteinian insight they share in common.

One of the first explicitly deflationary accounts of truth appears in Frank P. Ramsey's works, in particular in "Facts and Propositions" (1927). The relevant passages have been discussed extensively, and Ramsey is often credited on their account with the inauguration of so called redundancy theories of truth. The basic thought is that the (DS) exhausts what we may informatively say regarding the truth predicate. Accordingly, to assert of some proposition 'P' that it is true is to assert nothing over and above whatever 'P' itself asserts. Hence the redundancy theory of truth extracts from the (DS) the idea that 'true' denotes no substantial property. The predicate 'true' is instead redundant, in the sense that to predicate of any proposition that it is 'true' adds nothing to the content of that proposition. There is no substantial property that all true propositions share. The ascription of the predicate 'true' to a proposition is rather taken to possess only a kind of honorific value: it merely expresses the strength of someone's endorsement of a particular proposition. [xiii] Truth is, if it is a property at all, a *redundant* property. [xiv]

For our purposes here we may focus on the part of the redundancy theory that most closely approaches the view that the terms 'truth' and 'falsity' do not admit a theoretical elucidation or analysis, but that, since they may be eliminated in principle – if not in practice – by disquotation, they do not in fact require such an analysis. I will take this implicitly to mean that there are no non-trivial necessary and sufficient conditions for these concepts. [xv] The generalization of this 'no-theory theory' for any given putative concept X is the thought that X neither possesses nor requires necessary and sufficient conditions because it is not in fact a 'genuine', explanatory, or substantive concept. The most that we can aim for is a more or less accurate account of the norms that appear to govern the use of the corresponding term; but this account does not (and cannot) provide an explanation of that use – it merely summarizes it.

Let us now move on to the second type of deflationary account of truth that I shall discuss, namely the view defended by Crispin Wright in his book *Truth and Objectivity* (1992). Wright refers to his view as 'minimalism' and he acknowledges that this can create confusion with other extant deflationary views that also go under that name (Wright, 1992, p. X). For this reason, among others, I will sometimes refer to Wright's view more specifically as 'abstract minimalism'. Wright believes that truth is a genuine property ruled by an abstract norm, and that this norm is provably distinct from the norm of warranted assertability. The view is nonetheless broadly 'deflationary' because the account of truth thus provided does not explain any of the actual uses of the 'truth' predicate. What is more, there is no reason to suppose that such an explanatory account is forthcoming for the truth concept – for according to Wright there is a gap between the abstract property of truth and any concrete norm of use in any particular domain where it may be used. In order to explain a particular use we need to resort to further norms and properties that operate in the domain of the discourse where the predicate is employed – and there is no reason to believe that such norms will be unique or universal across domains.

The disquotational schema (DS) on this view just provides one of the platitudes of the truth predicate that can at best partially characterize the concept abstractly, but fails to explain any of the concrete uses of the concept in practice. There are, according to Wright, other platitudes of truth such as those "concerning negation and correspondence; and which we may wish to see augmented by considerations about stability and absoluteness". [xvi] Besides, the (DS) itself is a consequence, for Wright, of the more fundamental thesis that to assert is to present as true. But to state all these platitudes does not add anything substantially explanatory to the concept. So while truth is legitimately a property, which is abstractly characterized by the platitudes, it is a property that cannot explain anything, in particular it fails to explain the norms that govern its very use in practice. For that sort of explanation, Wright contends, we need to appeal to additional factors, which will be distinct for each different context of use, or domain of discourse. There is no general account of the use of truth across domains, and no comprehensive universal pattern to the application of the concept throughout. Hence 'abstract minimalism' ably combines a general description of the platitudes that characterize the abstract concept with a pluralistic understanding of its diverse means of application. As we will see this combination has a straightforward analogy in the case of scientific representation.

Let me finally consider what I will refer to as the 'use-based' account and which, although sometimes known as "minimalism", is very different from the kind of "abstract minimalism" that I just reviewed. On this account, which we may most closely associate to the work of Paul Horwich, truth is nominally a property, although not a substantive or explanatory one, which is essentially defined by the platitudes of its use of the predicate in practice. So the DS on this account fully defines truth – there is nothing else at all to say in addition. Truth is entirely captured by the schema and thus revealed to be a useful vehicle for semantic ascent (from the object language where P obtains to the meta-language where "'P' is true" obtains) and generalization (in sentences such as "whatever Peter says is always true" or "she will never lie"). There are on this account no purposes beyond these pragmatic ones that the predicate "true" plays in our language, and there are no further properties beyond these formal ones that it may possibly refer to.

Amongst all the deflationary views reviewed, Horwich's is arguably closer to a pure 'use-theory" of truth; it certainly comes closer to the slogan that "the meaning of the truth predicate is given by its use". The key differences with the other two accounts concern this close definitional connection with use. Thus the 'no-theory theory' flatly rejects that truth may be analysed – either by connecting it to use, or any other means. This is a crucial difference because according to the 'no-theory theory' truth is simply not a property and has no analysis, while the 'use-based' view accepts that it is a property and moreover one susceptible of philosophical analysis, but locates this property entirely in some features of the proper use of the corresponding predicate in a linguistic practice. In other words, the use-based minimal approach is reductive in a way the no-theory theory patently is not. Both views are deflationary in that they deny that philosophical accounts of 'truth' can explain our ordinary uses of 'truth' – but they do so for different reasons. The 'no-theory' view denies that any analysis is possible, while use-based minimalism only denies that any *explanatory* analysis is possible.

Abstract minimalism too accepts that truth is a property but denies that it is an explanatory one. But there is again one major difference with the use-based view. The reason why the property of 'truth' is not explanatory of the use of the 'true' predicate is different in both cases. According to use-based minimalism 'truth' cannot explain its use precisely because it is defined in terms of this use. And nothing that is X can explain X itself – in a genuine explanation the explanans and explanandum must be distinct. By contrast, abstract minimalism contends that the property of truth is not explanatory of its use because the use does not follow from the property in the way the explanandum follows from the explanans in a genuine explanation. The property is abstract, and does not suffice, on its own, to explain any actual concrete use of the predicates. Rather, as was already saw, according to abstract minimalism the platitudes of truth – which include the DS – define the concept in the abstract, and do not determine or define the use of the corresponding predicate in practice. Any legitimate uses of the predicate must of course be in agreement with these 'abstract' platitudes; however, these platitudes do not suffice to prescribe or fix any of these uses – other norms must be invoked in order to explain the different application conditions of the corresponding predicate in different domains.[xvii]

I have now provided an outline of the main elements of three distinct deflationary approaches to truth: the 'no-theory', 'abstract minimalism', and 'use based' approaches. I claim that these three distinct deflationary strategies may be generalised and applied to other suitable concepts. [xviii] In particular, I aim to show that each of these 'hermeneutical' strategies provides a legitimate strategy to deflate scientific representation. Each of them, in their own characteristic fashion, determines a possible deflationary account of representation. These accounts are distinct – along the lines just rehearsed above in relation to truth – but they share in common their refusal to provide a substantive reductive account of the practice of scientific representation. [xix]

3. Deflationary Representation: Two Accounts

In this section I review the elements of two accounts of scientific representation that have been claimed to be deflationary, namely RIG Hughes' (1997) DDI model and my own inferential conception (2004). I shall defend their deflationary character in due course, but first some neutral terminology is needed. We shall say that, in model-building science, a model source A typically represents a target B. This terminology implies no constraints on what types of objects A and B may be: These may be concrete or abstract, physical or mathematical, real or imaginary. Neither is it precluding the standard view according to which any scientific model must have a target in the real world and represent it via relations that hold between the properties of both source and target. Indeed, as discussed below, the standard view is constitutive of representation on most substantive accounts, which take representation to be a relation – and hence take both relata to be real. Yet, the terminology also leaves room for other views that do not require sources or targets (or both) to be real, and hence do not require representation to be a relation.

Thus, the types of objects that are sources can vary greatly – from concrete physical objects and diagrams to abstract mathematical structures or laws. Besides, different sources may represent one and only one target. Thus the solar system may be represented both by a concrete array of small balls strung together by means of wires, or by Kepler's three mathematical laws. Targets may also vary: Some models represent concrete physical systems and their dynamical evolution, such as the solar system; other models represent more general phenomena, or effects, such as the Ising model for phase transitions; yet other models represent abstract properties, such as the second law of thermodynamics, which, in asserting that entropy increases in a closed system, also represents entropy.

Why are all these instances of 'scientific representation' - what do they have in common? In line with the distinctions introduced in the first section, we may classify responses to this question into two types: substantive and deflationary. Substantive approaches aim to provide answers to the question in terms of the properties of sources and targets – or, rather, their relation – that constitutes representation. In this paper I shall be concerned mainly with the other set of approaches, which we may refer to as 'deflationary' – according to which there is in fact no substantive property or relation that constitutes representation. On these deflationary views what is in common between the different cases of representation is rather related to the function that sources play with respect to targets, i.e. the uses that they are put to by agents towards their specific goals in their particular contexts of inquiry.

According to Hughes' Denotation-Demonstration-Interpretation (DDI) account, scientific modelling is a three-part relation cum activity (more on the distinction between relations and activities later). According to this account a source A represents a target B when the following three conditions are met: i) The source stands for the target in the sense that it denotes it; ii) Some demonstration is carried out by an agent on the model; and iii) The results of this demonstration are then interpreted, so as to apply them to the target.

As an illustration, Hughes (1997) deploys the model that Galileo introduces in the Third Day of his *Discourses Concerning Two New Sciences*. Galileo there describes a kinematical problem in exclusively geometrical terms. He goes on to solve the problem in geometry, only then to apply the solution to the original kinematical problem. Thus he deduces that the space *s* traversed by a body in uniform motion with constant velocity in a given interval *t* is equal to that traversed by a uniformly accelerated body initially at rest, provided that the final speed of the accelerating body is twice that of the body in uniform constant motion.

The DDI model can be applied in a straightforward manner to the example, as follows. First, the kinematical situation must be described by means of a geometrical diagram that therefore denotes it (Figure 1). Thus Galileo denotes the time *t* that the body takes to traverse the space *s* by means of the segment AB of a line, and the speed of the body at any instant of the interval t by another segment of a line perpendicular to the first line. Thus AC denotes the speed of the body at A and BD the speed of the body at B. Second, a demonstration must be carried out on the diagram. Galileo demonstrates that the area of a rectangular shape ABCD is identical to the area of a triangle ABD' where D' is twice the value of D. Finally, we need to interpret this result back in the terms of the original kinematical problem. By interpreting the overall area covered as the space traversed by the body in its motion over the *t* interval, Galileo infers that the time *t* that a body in uniform motion takes to traverse *s* is identical to the time taken by a body uniformly accelerated. Whatever the merits of the model, the combination of denotation, demonstration, and interpretation constitutes an act of representation, according to the DDI account.

The account is ostensibly deflationary in not providing necessary and sufficient conditions for representation; and in the claim that representation is a set of 'speech acts' (Hughes, 1997, p. 329). However, the overt appeal to denotation turns a substantive relation into a necessary condition on representation, thus compromising the strength of its deflationism. I discuss this in greater detail in section 4, where I endeavour to show that it is possible nonetheless to extend the DDI account in such a way as to render it genuinely deflationary.

At this point I wish to consider an alternative deflationary account of representation, the inferential conception, which I have defended in Suárez (2004). On this account, representation is characterised as a two-part activity involving the exercise of the inferential capacities of the model source (with respect to the target), and the setting of what I call representational force of the source towards the target. Both components are elements of practice and ensue in relations only in those contexts in which the practice's outputs include the establishment of a particular match or comparison between source and target. But even in those cases, the inferential conception reveals that representation is properly speaking constituted by the practice and not the relation. [xx] "Capacity" and "force" are proper nouns and may thus be taken to implicitly refer to a property. However, when appropriately placed in their context, they are best understood to appropriately refer to properties of particular activities within a normative practice. Neither predicate picks up a property or relation in the objects themselves that play the role of representational targets or sources. (See Knuuttila (2009) for a similar claim).

Let me try to make the claim in full – for both "inferential capacity" and "representational force" – by means of a particular example, which I have already employed to a similar effect in the past, namely the Forth Rail Bridge. The case for the Forth Rail Bridge as a representational target has been thoroughly made by the distinguished British art historian Michael Baxandall in his classic book *Patterns of Intention* (1985). What is peculiar about architecture or engineering cases, such as this one, is that the representational sources (the different diagrams and plans for the execution and construction of the bridge) precede the actual representational target. They are not merely representations of the bridge, but templates for, and instructions towards, its construction. It is thus worth reviewing the history of the bridge in some detail, since it sheds light on a number of the bridge's roles as a representational target. [xxi]

The background to the development of the Forth Rail Bridge is the intense competition between rail companies in Northern England and Scotland in the last decades of the 19th century. It was government policy to encourage competition, and a number of regional firms fiercely invested from 1850's onwards in developing tracks along the east and west coasts of Britain. The main direction of both passenger and cargo traffic was south- north of the border and back and - beyond that - between the populated conurbations of Edinburgh, Dundee and Aberdeen. Two companies in particular competed for traffic northwards from Edinburgh towards Dundee and beyond. The Caledonian Railway operated the western tracks, while the North British Railway Company owned and run the eastern routes. The western route from Edinburgh to Dundee involved a long detour around the main estuaries of the Firth and the Tay, but it was at least a continuous train journey. By contrast, the North British Railway Company could only bring passengers by track as far as the estuaries, where ferry boats would cross the passengers to awaiting trains at the other end. It was a long, complicated, and exhausting 3-hour journey to cover the merely 46 straight-line miles from Edinburgh to Dundee – and the North British Railway Company and its associated companies south and north of the border were quickly losing business to their competitors in the western routes.

The North British Railway Company effectively bridged the Tay in the period between 1871 and 1878. But bridging the Forth was a considerably more challenging task, given the depth of the berth, the stronger side winds, and the Admiralty's stipulations for navigation under the bridge (to allow navy vessels to reach the dockyards at Queensberry). Thus in 1873, the North British Railway Company joined forces with another three associated companies with interest in running trains on the eastern coast (Great Northern, North Eastern, and Midland) to found the Forth Bridge Company, with the sole remit to bridge the Forth for train traffic. The Company commissioned the design and construction to Sir Thomas Bouch – who had just been knighted for his work as lead engineer of the just completed iron wrought structure over the Tay. Works on the middle pier of the Forth Bridge at Inchgarvie Island had already started when disaster struck on the older bridge over the Tay on 28 December 1879. The Tay Bridge collapsed bringing down a train with 79 passengers with it – an event that, according to Petroski (1995, p. 70) "immediately affected the character of bridge design and construction endeavors throughout the world".

The history is relevant to both the representational force and inferential capacities of all subsequent designs plans and graphs for the Forth Bridge, since it reveals the intent of later attempts to bridge the Forth (Figure 2). In particular the subsequent engineers, John Fowles and Benjamin Baker, worked under an absolute requirement to make sure the design would guarantee bridge stability under the strongest side winds imaginable – the board Trade stipulated an equivalence of at least 56 pounds to the square foot (Baxandall, 1985, p. 19). This led Benjamin Baker – the younger partner and chief engineer in charge of the design – to discard both a girder bridge of the sort that had been employed at the Tay, and also a suspension bridge – the sort that had been originally planned by Bouch for the Forth. Baker instead chose a cantilever design – which was a rather novel approach for bridges as large as the one planned. [xxii]

The main principle in cantilever bridge design is tension-compression. In a cantilever bridge the lower arm of each lever is compressed while the upper arm is correspondingly in tension. In the central pier by contrast the lower girder is compressed while the upper one is in tension. This led Baker to choose different kinds of design for the different arms of the levers – those in tension would be built as lattices, while those in compression were tubular. These designs were made possible by the very recent availability of industrial steel. As ever the driving thought in this design concerned resistance to wind strength – Baker judiciously calculated that wind strength on the upper arms in tension would be maximal, while the lower arms had to be robust to resist greater compression shears. Lattices minimise resistance to wind pressure, while tubes maximise resistance to compression shears.

The point of reviewing all these details concerning the bridge design is hopefully now clear. Baker and Fowler's design was driven by a fundamental requirement – namely to overcome considerable side shear and torsion. All kinds of critical aspects of the design are conducive to the same goal to guarantee that the bridge would withstand the strongest side winds. The representational force of the graphs is not just towards 'a bridge across the Forth', but a very particular bridge capable of sustaining such strengths – and one moreover under no circumstances subject to the structural defects that led to the Tay bridge debacle. The inferential capacity of the graphic designs is thus geared towards showing clearly how – on the basis of the principles applied – a bridge built as designed would indeed withstand such shears and stresses. Baker and his colleagues thus fixed both the representational force and the inferential capacities of their designs, and it is only under a careful understanding of the normative practice of civil engineering at the time and other features of the historical context – of the sort provided by Baxandall (1985) – that the extent and sense of both features may be appreciated.

This shows that the twofold requirements of representational force and inferential capacities capture some of the essential surface features of representation in science. The force of a representation (such as the graph reproduced in figure 2) is essentially linked to a practice of interpreting features of the graph as standing for features of a (possible, but not actual at that time) bridge. The rubric on the graph makes the referent explicit, but more than that is required to appreciate the full force of the model – including an understanding of the principles of cantilever bridge building, and the recognizable shape of the diverse parts (such as tubes, girders, piers, and lattices). These principles are also required for an understanding of the design's inferential capacities, but here more must be added, including principles of torsion, compression, tension and stress, all of them required for a precise calculation of the strength of the side winds that a bridge built in accordance to the specifications would be able to withstand.

Thus there is a close connection, according to the inferential conception, between representation and modelling practice. This intimate link between representation and the norms of application and inference within model-building science is also at the heart of the claim that the inferential conception is a deflationary view. As I argue in section 4, even though the inferential conception may be understood in slightly different terms, each different construal issues – through the vital connection to practice just mentioned – a deflationary account of scientific representation in general.

4. Deflationary Views and Representational Practice.

Let us quickly take stock of what has been achieved so far. In section 2 I reviewed, in connection to truth, three different strategies for 'deflating' – or rather more simply, displaying the deflationary nature of – any concept: 'no-theory', 'abstract minimalism', 'use-based' strategies. In the last section I reviewed in outline the elements of two accounts of scientific representation that have been claimed to be 'deflationary': Hughes' DDI account and the inferential conception. In this section I apply these three strategies to the two deflationary accounts of representation. I argue that each strategy is in principle applicable, and reveals some of the reasons why scientific representation is indeed a deflationary notion on these accounts.

I will also argue that the DDI account and the inferential account prima facie differ in the degree to which they lend themselves to the deflationary strategies; in fact the DDI account as originally presented by Hughes turns out to be deflationary in only one possible sense, namely the 'no-theory' sense. There is, however, a possible development of the DDI account that brings it closer to practice in such a way as to fulfil the conditions of at least the use-based approach. [xxiii]The development of this refined account already shows the deflationary strategies have some heuristic power of their own – in the sense that applying them to a particular philosophical approach to any concept may lead to improvements on the approach.

The DDI account is a deflationary approach to representation because, as presented by Hughes, it refrains from postulating necessary conditions in terms of robust relations between sources and targets. As Hughes (1997, p. 329) writes "Let me forestall possible misunderstandings. I am not arguing that denotation, demonstration, and interpretation constitute a set of speech acts individually necessary and jointly sufficient for an act of theoretical representation to take place". Hughes is implicitly denying that scientific representation is a substantive explanatory property – or that it possesses necessary and sufficient conditions. Nevertheless, there are a few features of the DDI account that may lead us to question the strength of its commitment to deflationism, and at any rate suggest that the DDI account does not rank very high on any 'deflationary' scale. These features all follow from the surprising appeal to denotation – surprising since denotation is commonly understood as a substantive relation between the denoting sign and the denoted object. [xxiv]

Indeed the most striking feature in Hughes' account is its hybrid nature. Denotation is a relation between source and target; while demonstration and interpretation are best understood as activities on the part of an interpreter / user. There is, of course, an activity of denoting – but this is commonly understood to either establish a relation, or ride upon an already established one. In other words, we may not use A to denote B without ipso facto establishing a relation of denotation between A and B or otherwise employing an already established one. This relation substantially informs the notion of representation at play, as revealed by the fact that we speak of the geometrical diagram as in itself denoting the kinematical problem, independently of any activity carried out by Galileo.

By contrast, a demonstration is a piece of reasoning carried out by someone entirely within the 'space of reasons' or framework provided by the model source – there is no obvious way to interpret this as a relation of any sort between source and target, since at this stage of the modelling process, the target is not taken into consideration at all. So, on the DDI account, in order for the geometrical model to represent (for us) the kinematical situation, we must carry out Galileo's demonstration ourselves. Here, by contrast with the denotation part, it is the activity itself that is constitutive of representation, and there is no relation that may stand in its place.

Finally, 'interpretation', at least as the concept appears in model theory, may be understood as a relation. [xxv] In model theory an interpretation is a function mapping the elements of the language into a domain of independent entities endowed with their own properties. Hence, take a set of sentences in some particular language; the 'interpretative mapping' is what, on this account, provides them with a 'semantics' under which they may be said to be true or false. However, this is not the kind of ‘interpretation’ that figures in the DDI account, since to the extent that the model source contains sentences at all, they already come fully interpreted in terms of the model itself. The third step in the DDI account rather corresponds to something that we may refer to as the ‘application’ of the model source to the target in order to derive results of interest regarding the target itself. And although any application of the model is constrained by the relation of denotation established in the first step, it also comes with a large degree of freedom in two respects at least, as follows.

Firstly, the denotation relation stipulates what is the appropriate target for the representational source at hand, but it does not stipulate which parts of the target object correspond to what parts of the source object. There is plenty of leeway here. For instance, in Hughes’ Galileo example, the mere statement that the geometrical diagram denote the kinematical situation, does not settle which parts of the diagram stand for which parts of the kinematics. Secondly, the denotation relation does not stipulate how the source is to be partitioned in the first place, i.e. how it is to be structured into its constituent parts in order to be so related to the target. The application of the source to the target, however, does require a partition of the source into relevant parts and properties (a “structure”), and the relating of such “structure” to a similar “structure” of parts and properties in the target. Thus in Galileo’s modelling example, the geometrical diagram must clearly distinguish vertical and horizontal lines at every point, and the area therein comprised. Similarly the kinematical problem must clearly identify time intervals, speed of motion at every instant, and constant or accelerated motion across the interval. These distinctions are all products of the activities whereby the users of models apply representational sources to their targets – and they are in no way fixed by the mere statement that the source denotes the target.

So, although ‘interpretation’ is constrained by the relation of denotation, it goes further, in ways that were not made entirely explicit by Hughes. It requires at least two types of activity on the part of the modellers. First of all, it requires the ascribing of some structure to the source and target objects, by judiciously partitioning them into an appropriate set of parts and their properties. Then it also calls for a mapping of the elements of the source structure onto some corresponding parts and properties of the target, again under some suitable partition. [xxvi] Both steps (‘ascribing’ – or more strictly ‘partitioning’ –, and ‘mapping’) are activities within the modelling practice without which interpretation is rendered impossible. However, only mapping issues in a sort of relation akin to denotation between (elements of) the source and (elements of) the target.

Hughes' account is therefore a hybrid of a relation (denotation, mapping), and a number of activities (demonstrating, ascribing, partitioning). It is deflationary only in one sense (no-theory theory), and we may wonder if some extension of the account may be fully deflationary in all the relevant senses. Now, the activities are typically regulated within a modelling practice that imposes particular norms of correctness. The relations by contrast seem to some extent independent of that practice. At the very least, they are conceptually distinct, if not pragmatically, since they can be in principle distinguished without appeal to the practice itself. We could perhaps say that they are end products of the practice, but it would not be right to include them as part of the practice itself. A deflationary strategy would recommend replacing both denotation and mapping with functional activities or features of the representational practice as well.

I believe that there are credible functional replacements for both denotation and mapping, which I shall refer to as *denotative* and *inferential function*, respectively. The resulting account may thus be named the Denotative Function-Demonstration–Inferential Function (or DFDIF) account. It is an extension or version of the DDI account that is more faithful to modelling practice in so far as it relates all its various components directly to a number of salient features of the practice of model building.

The first replacement involves substituting "denotative function" (DF) in place of denotation. The best way to motivate this replacement is by reference to the recent literature concerning the role and nature of fictional representation in scientific practice. This literature emphasises the importance and centrality of scientific models that represent fictional or imaginary entities, processes, or phenomena. There is no need to rehearse here any of the many case studies developed;[xxvii] it is enough to note that the upshot is that any adequate account of scientific representation must accommodate representations with fictional or imaginary targets. To give just one illustrious example, Maxwell's famous 1861 vortex model of the ether is a representation whatever ontological status its various components, including both vortexes and idle wheels – and for that matter the ether itself –, is taken to possess.[xxviii]

The requirement of denotation would rule out such representations, but as Elgin (2009, pp. 77-78) has emphasised, this requirement can be weakened: "A picture that depicts a unicorn, a map that maps Atlantis, and a graph that charts the increase in phlogiston over time are all representations, although they do not represent anything. To be a representation, a symbol need not itself denote, but it needs to be the sort of symbol that denotes".   The paragraph above expresses a residual commitment to the idea that a representation only represents something to the extent that it denotes it, [xxix] but it nonetheless rightly emphasises that for a source to function 'as a representation' it does not need to actually denote its target. The only condition that must obtain is what we may refer to as the 'denotative function' of the source, and this function can be carried out without eventuating in actual denotation. In other words, one crucial difference between denotation and denotative function is that the former is a success term (for it is impossible for it to be true that 'x denotes y' unless y is real) but the latter is not (since 'x has denotative function and its purported denotation is y" may be true even though y is not real but imaginary or fictional). And while the former (denotation) requires the latter (denotative function) the converse is not true – not even in the long term or in a hypothetical future.

A comparison with portrait painting is enlightening at this point. A portrait always has denotative function but does not always denote. Velázquez's portrait of Pope Innocent VI both denotes and has denotative function; but it would seem to be a mistake to say of any of the series of canvasses that it inspired Francis Bacon to produce that it also denotes in spite of the obvious facts that they too are portraits. Or, consider the case of Leonardo's Mona Lisa, which notoriously raises historical questions concerning whom exactly it denotes, and how. This question is logically and historically independent of the uncontroversial fact that the portrait has denotative function – precisely because it is a portrait. Similarly, Maxwell's models of the ether may not denote anything. We nowadays take them to have no referent, and even though Maxwell, like any other 19th century physicist – at least at the time that he introduced the vortex model of the ether – was certainly committed to a carrier of electromagnetic waves, his attitude to both vortexes and particularly idle wheels was more nuanced. He thought of both as useful analogies but not as literal descriptions of the mechanisms underlying electromagnetic phenomena. The models seem clearly to function representationally nevertheless – there seems to be no substantial difference between the methodology we employ for both demonstration and application in such 'fictional' models and that methodology described by Hughes in the – purportedly – non-fictional models employed by Galileo. Any representational work that denotation can perform within the DDI account, denotative function seems to perform just as well. Since denotative function allows us to account for a much larger family of bona fide scientific representations it seems reasonable to substitute denotative function in an appropriately extended version of the DDI account.

A similar move may be made for the 'mapping' part of interpretation. The crucial function of the 'mapping' relation is to transfer over the results of the demonstrations carried out on the source onto the target. Thus in Hughes' example of Galileo's model, the overall area of the triangle is interpreted as the space traversed by the body in its motion over the *t* interval. This is a sort of mapping that thus connects an element in the source system (area in the geometrical figure) with an element in the target system (space traversed by the body in motion in the kinematical system). The point of this mapping in practice is to allow Galileo to carry through some inferences with respect to the target, namely to allow him to infer that the time *t* that a body in uniform motion takes to traverse *s* is identical to the time taken by a body uniformly accelerated (from a lesser to greater speed). Hence the functional role of the 'mapping' relation is to constrain the set of inferences about the target that we may perform on the basis of a consideration of the source about the target – i.e. what is technically known as the set of legitimate surrogative inferences.

The deflationary thought is then that this constraint can be stipulated independently of any actual relation between the source and the target. In other words, "taking area to stand for space traversed" sets up a rule of inference that provides us with an equivalent statement to "accepting the conjunction of all the surrogative inferences licenced by the rules", amongst which prominently is the claim that equal areas correspond to equal times travelled. There is a sense of mapping or correspondence that is preserved here, since certain claims about the source get transferred over to claims about the target, but note that this mapping is achieved without any need to invoke an independently existing actual 'relation' between the source and target. What the mapping rather relates, on this view, is a set of *claims* about the source with a set of *claims* about the target. And a mapping between claims of some sort and claims of some other sort need not require the establishment of any relation between the objects of those claims. In particular, such a mapping does not require that B, or A for that matter, be real entities.

This deflationary thought then sees the 'mapping' between source and target as merely an inference generation rule that determines the legitimate move from claims about the source to claims about the target. Talk about 'mapping' then is only genuinely responsive to talk about such inferential rules, and a 'mapping' is acceptable (or not) if the rule that it enacts is correspondingly acceptable (or not). It is in particular not possible to assess the propriety of the mapping independently, as it were – by merely looking into the source and target properties and assessing their similarity or resemblance. For the critical aspect of the 'mapping' does not lie in any relation between their properties but rather in the generation rule for inferences that it enacts. Of course, it is possible that the inference generating rules laid down also coincide with a genuine mapping between aspects of a real source and a real target. But this mapping is of a piece with the set of generating rules and not independent or prior to it. In particular it need not coincide with any recognizable antecedent similarity or resemblance. Thus in Hughes's example of Galileo's model, we would be at a loss to find any similarities or resemblances between the area of the geometrical figure and space traversed in a certain interval in the kinematical system – until the correspondence between area and space is set, and the set of legitimate surrogative inferences is naturally revealed.

These replacement moves accommodate fictional representation within the spirit of Hughes' original account. But the moves have the additional virtue to turn the account deflationary in the third relevant sense. For as was noted what stands in the way of a 'use-based' deflationary reading of Hughes' original DDI account is the appeal to mapping and denotation. More generally, the 'use-based' account of any concept eschews any reference to any substantive relation between that concept and anything else other than the use of the concept, or the norms that inform such use. There is no explicit or covert appeal to a relation between the concept and the world – beyond the aspects of the world that constitute or inform use. In particular, 'truth' is not to be understood as a relation between sentences and facts, states of affairs or any other aspect or parcel of reality. Similarly 'representation' is not to be understood as a relation between representational models, on the one hand, and facts, states, effects, phenomena, etc, on the other hand. It must be essentially related to features of the use of representations instead.

This is where the other crucial difference between denotation and mapping, on the one hand, and denotative and inferential function, on the other, has bite. While the former are relations between symbols in a language system and their putative referents, the latter are merely features of use. Consequently, the DFDIF account is use-based also in the relevant sense of connecting all the essential features of representation to features of use within representational practice.

Let me now turn to the inferential conception. I want to argue that this is straightforwardly deflationary in any of the deflationary senses described here – 'no-theory', 'abstract minimal' and 'use-based'. And although these provide no 'deflationary strategies' to develop the inferential conception further, the application of each of the three strategies so far discussed does bring into relief different features of the inferential conception. Let us consider them in turn.

From the point of view of 'no-theory' deflationism, the inferential conception is deflationary in the straightforward sense that it refuses to lay down necessary *and* sufficient conditions on any instances of representation. Representational force and inferential capacity are taken to be only general features (and therefore at best necessary conditions) on representation, but they are neither jointly nor individually sufficient for representation. Normally some other conditions – such as isomorphism or similarity – would need to obtain in each concrete case of representation. The underlying thought is of course the deflationary one that 'representation' is not a genuine, explanatory, or substantive concept – and that it therefore does not call for philosophical *analysis*. However, just as philosophers in the deflationary tradition have found a number of illuminating things one can say about the workings of the truth predicate in agreement with the DS schema, so may we find a number of useful things to say about the workings of representation in agreement with the two 'platitudes' that appear in the inferential conception.

In particular, inferential capacity is minimally informative about the features of representation that are responsible for surrogate reasoning. For any representation to possess inferential power towards some target it is required that there be some rules of inference that connect source and target – yet note that on a deflationary account representation is not constituted by those connections in themselves, but by the rules that provide the source with the capacity to generate the inferences. Such rules are complex features of the practice that involve carrying out demonstrations or modifications of the source in order to guide our beliefs regarding the behaviour of the target. So there must be two types of inference rules involved. First of all there must be rules to the demonstration steps within the model which are consequently internal to the workings of the source. These are the rules that govern the process of demonstration in Hughes' account and we may refer to them as vertical rules since demonstration appears as a vertical movement in his original diagram (Figure 3). For representation there must in addition be rules that cut across this process and connect source and target. These rules are set up, or constituted, by what Hughes refers to as the interpretation stage, and which we have found more accurately to refer to as application. We may call these the 'horizontal' rules for the similar reasons to those above. The inferential capacity of a source is a product of vertical and horizontal rules. The idea that scientific representation minimally involves the inferential capacity of sources relative to targets is therefore tantamount to the requirement that in some representational practice that employs such sources there are established vertical and horizontal rules of inference.

Now, this is all relevant to the third sense of deflationism considered, namely 'use-based' deflationism; for remember that, on this account, an account of a concept X is deflationary if it links it essentially – by definition or otherwise – to features of the use of this concept in practice. There is some ambiguity at this point regarding whether those features are normative, or merely descriptive. If the latter, there could be exceptional patterns of use, but given the widespread diversity of uses of any concept, it cannot be ruled out that the resulting account be incoherent. This problem is likely to be particularly acute with a concept as widely used as representation. Thus I will here opt for the normative option, and assume the mentioned features to be characteristics of the norms of use, rather than descriptive of the use itself. This allows for anomalous divergence from the norms, and for deviant uses of concepts, but it has the virtue that it renders the account internally consistent regardless of such divergence or deviance. On this third deflationary approach, representational force and inferential capacities are general features that model sources must have in practice if they are to play a representational role at all. In other words, no object (model, graph, equation) may play a genuine representational role unless it is normatively ascribed both components within a representational practice. If and when particular uses of some sources deviate from these two basic norms we are, on this account, to judge them non-representational, at least with respect to the practice at hand.

But as a matter of fact very little will be ruled out by such minimal constraints on use. For as we saw in section 2, both representational force and inferential capacity are features of activities within a normative practice, and do not stand for relations between sources and targets. And the bare satisfaction of these two conditions does not impose stringent constraints upon use; on the contrary, there will a vast range of uses that satisfy them. Representational force only fails to obtain when a source stands for itself only, and allows no surrogate reasoning towards any (fictional or real) target. As for inferential capacity, it was noted that it essentially requires normative constraints on two types of inference – referred to as vertical and horizontal inferences – but these are constraints on the validity of inferences and not the truth of their conclusions. Many types of hypothetical reasoning – and any reasoning grounded on idealized assumptions – will ensue in conclusions that are false or incorrect. One important task of modelling is precisely to pull apart, amongst all those inferences permitted by the constraints, those that issue in conclusions that we may assume to be truthful or correct. The leeway is therefore as large as desired in order to accommodate instances of distortion, idealized or fictional models. [xxx]

Finally, let me quickly consider the second deflationary strategy that I have discussed in this essay, namely 'abstract minimalism'. The inferential conception also lends itself naturally to this deflationary strategy. [xxxi] For, let us suppose that we close the definition of representation in terms of the two conditions (representational force and inferential capacity) that we have so far taken to be merely necessary, but that we do so by turning the concept abstract in the way abstract minimalism requires. We then obtain a definition proper of the abstract notion, as follows: "A represents B if and only if i) the representational force of A points towards B and ii) A allows competent and informed agents to draw specific inferences regarding B" (Suárez and Solé, 2006, p.

29). Yet, on the abstract minimalism proposed here considered, to apply this notion to any given concrete case of representation requires that some additional relation obtains between A and B, or a property of A or B, or some other application condition. Without such an additional specification the notion above will remain empty – in the sense of lacking any precise application conditions.

Thus this 'abstract minimalism' regarding representation is perhaps best understood in terms of the distinction between the means and constituents of representation. [xxxii] The constituents are the necessary and sufficient conditions that define the concept. The means are whatever relations or properties of the sources and targets are employed by representation users – in the particular context of their representational practice – in order to draw conclusions regarding aspects of the target by means of some reasoning grounded on aspects or features of the source (what is known as 'surrogate' or 'surrogative' reasoning). On any of the two deflationary views first reviewed (the 'no-theory' and 'use based' version of the inferential conception) representation has no constituents, only means (in the case of the 'use based' version it even makes sense to say that 'the constituents of representation are its means'). By contrast, on the 'abstract minimalism' version of the inferential conception, representation is constituted abstractly by the platitudes of representational force and inferential capacities. And, of course, there are also means of representation – those concrete relations and properties of sources and targets that are in fact employed by users in their particular context. Yet, this is not a substantive account of representation since on this account the constituents explicitly fail to explain the means. That is, it is impossible to determine on account of the abstract definition of the concept what would be its conditions of application in any context, since the conditions of application are, on this account, underdetermined by its constituents. Thus on this view representation is a well-defined property, and moreover one that is not to be identified with any use or practice, but it is a property that cannot in any way explain any use or any practice.

The main insight of abstract minimalism is precisely the thought that there can be an abstract definition of the concept so minimal as to lay down virtually no constraints on the application of the concept. This does not render the concept empty if there are in addition concrete conditions of application – but abstract minimalism denies that the concrete constraints must be correspondingly minimal or thin. In other words one can impose very stringent constraints on the application of the concept in every domain, without requiring an explanation in terms of the general abstract definition. In the case of representation this amounts to the view that the context of use may impose highly constrained conditions on the appropriate means of application in that context, while remaining virtually silent – e.g. minimal – on the constituents. The view is certainly compatible with the inferential conception and aptly reflects the extant pluralism and contextualism regarding the various means available in practice.

5. Conclusions

In this largely theoretical paper I have aimed at an improved understanding of what is meant by the claim that an account of representation is "deflationary". I have distinguished three different meanings of the term "deflationary" and applied them to two accounts of representation that have been claimed to be deflationary. In so doing I hope to have illustrated the concept of representation, as much as the relevant kinds of deflationism. If the analysis provided of the different options is sound, it certainly carries consequences for "philosophy of science in practice" (whether the "philosophy-of-science in practice" or "philosophy of science-in-practice" varieties). The most important consequence is that – whatever sense of "deflationary" applied – the analysis of the concept of representation, even where feasible, cannot determine its conditions of application, and therefore cannot explain its use. These conditions concern the means of representation – and these are essentially plural and context-dependent. This strikes me as a novel consequence concerning 'philosophy-of-science in practice' which has not been fully explored yet, and deserves further discussion.

The second relevant consequence is related to 'philosophy of science-in-practice' and is by now better known and established, namely that a study of the uses of a representation is indispensible in order to determine its content. In particular as regards scientific models it is a widely accepted view by now that we are not able to understand what and how they aim to represent unless we have an understanding of the function that these models play in the particular context in which they are employed. The discussion in this paper does not perhaps lend further support to this view, except to the extent that it provides some theoretical grounds for why it should be true. If the concept of representation is deflationary, regardless of how we understand the term, then any understanding that we may possibly acquire of its nature is tied essentially to its use. This may be because the concept has no other nature of its own ('no-theory' theories), because it is too abstract to yield any explanation of its application (abstract minimalism), or because its nature is essentially given by its use ('use-based' theories). No matter what deflationary account, representation only acquires its functional role through a particular representational practice. All deflationary accounts have this much in common, and it follows that the study of scientific representation must always be carried out in explicit or implicit reference to a particular scientific practice.

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Figures

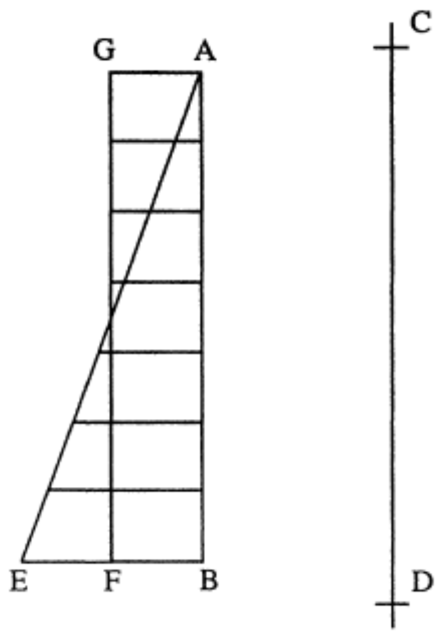

Figure 1: Galileo’s geometrical model

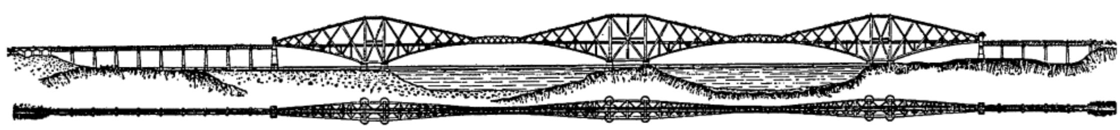

Figure 2: B. Baker’s representation of the Forth Rail Bridge

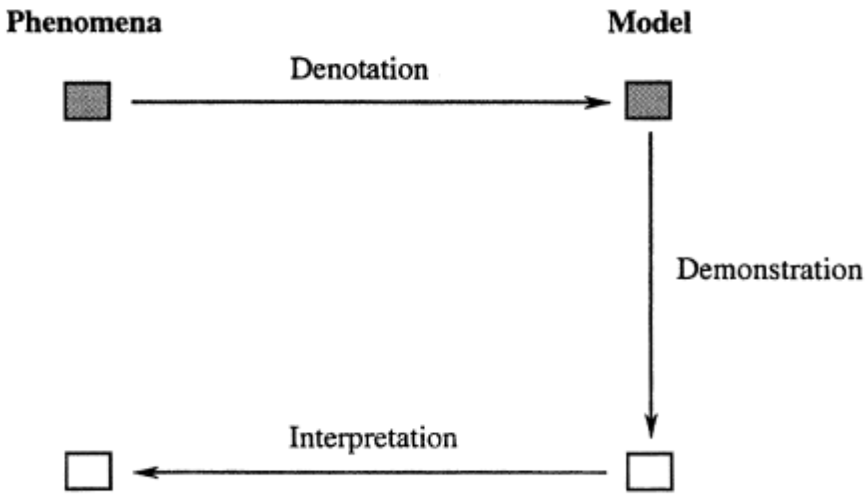

Figure 3: The DDI model

[i] There have also been claims to the effect that these questions are themselves irrelevant and / or ill posed. For instance, Callender and Cohen (2006) argue that the notion of representation that plays a role in the sciences is essentially the Gricean one discussed in philosophy of mind, and there are no particular issues to be broached in the scientific context. There is no space to deal with this view here - although it is an interesting question whether the view genuinely bypasses the present debate, or rather reduces to some form of deflatonism (in analogy with redundancy theories of truth, as discussed later on in the text). At any rate the term "representation" and its cognates such as "model" do appear prominently in the scientific literature, so there is prima facie a legitimate philosophical question to address regarding its nature and / or function in science.
[ii] I will therefore ignore the 'primitivism' option in the rest of the paper, reserving the term "substantive" for those accounts that are both substantive and reductive in the ways described.
[iii] Both Pincock and Weisberg accept this descriptive requirement, and there is no doubt that it may be best for a substantive account of representation to dovetail with representational practice; my point is that there is nothing in substantialism per se that *conceptually* or *logically* requires any degree of fit.
[iv] The norms involved here exclude those pertaining to the accuracy or faithfulness of the model, and can be seen to be restricted only to those norms that prescribe the selection of appropriate targets and sources and their inferential connections (what I will later refer to as representational force and inferential capacities). At any rate, the basic point is that while individual modellers may fail on occasion to follow the appropriate norms of their representational practice, the concept of representation that they employ cannot – on a deflationary view – fail to conform to the norms of their representational practice.
[v] The careful formulation above attempts to make it clear that while there can be, in a particular context, a relation between model sources and targets which, in that context, may be said to instantiate representation or to constitute its end product, it would be a mistake, even in that context, to identify representation with that or any other relation. Representation is rather an activity.
[vi] Hence, on any deflationary account, a *practical inquiry* into representation is primary, while any *analytical inquiry* is secondary. (For more on these terms, see Suárez, 2010). That is, a full description of the means of representation used in some practice enables an inquiry into its nature. Substantive accounts will typically order things the other way round – they will assume that an analytical inquiry is prior to any practical inquiry.
[vii] In this paper I only address representation, but I believe that a similar distinction between practical and analytical inquiries may be applied to discussions over the nature of 'scientific theory'. At any rate one of the interesting consequences of the contemporary deflationary *zeitgeist* is that discussions of representation no longer hinge on any particular account of the nature of scientific theory. More colloquially, we could say that 'deflationism has emancipated representation (from theory)'.
[viii] I will throughout gloss over the distinction between sentences and propositions since it does not matter to any of my purposes here. There are deflationary theories such as Quine's, and arguably Ayer's, where truth is predicated of sentences; other deflationary theories such as Horwich's, and arguably Ramsey's, appeal to propositions instead.
[ix] It is in fact an issue to what extent the (DS) is compatible with the different theories here reviewed, but many of their champions claim them to be so compatible, and for the sake of argument I shall assume that this is generally the case. See Blackburn and Simmons (1999) for extended discussion.
[x] Since theories of truth differ greatly as to what they consider to be the fundamental conditions of truth, it may be more appropriate to refer to a more general principle such as: 'P' is T if and only if P. It then remains open whether T is ascribed the right features for truth. I gloss over the issue, since it goes well beyond what is needed for our present purposes, but see Wright (2001, pp. 13-14) for discussion.
[xi] It bears mentioning that this crude theory was not actually defended by any of the traditional pragmatists, save the possible exception of James in one of his most radical moments, and thus hardly deserves the name. (For discussions of Peirce's rejection of such a crude 'pragmatist' theory see Hookway, 2000. For an equivalent discussion regarding Dewey, see Burke, 1994).
[xii] I claim this is a legitimate way to partition broadly 'deflationary' approaches to truth, but I do not insist this is the only way to classify such approaches. The distinctions I draw are certainly driven in part by the uses I want to put them to in the discussion regarding scientific representation. Of

course, even if the distinctions were illegitimate regarding deflationary approaches to truth, their application to scientific representation may still be legitimate, and enlightening. However, the analogy seems to me to add strength to deflationary approaches to representation to the extent that the same classification obtains in the case of truth – hence the extended discussion of deflationary theories of truth in this section.

[xiii] The use of the predicate may have other functions – for instance it helps in generalization and quotation – as in "everything Ed says is true" – but even then it does not express any substantive property – it does not establish that everything Ed says is true in virtue of any substantial property that all the propositions that he utters share.

[xiv] The distinction between redundant and substantial properties is subtle but it does not need detain us here – it is enough for our purposes to mark the difference as one between a nominal and a real property. A nominal property relies entirely on features of the symbol system employed to describe or denote it, while a real property depends on the constitutive nature of those objects that share it – independently of how we choose to describe them. Thus 'weighting less than 70 kg.' expresses a characteristically real property, while 'having a name that begins with M' is nominal. The distinction only becomes blurry for those properties of the symbol systems we employ (e.g. properties of sentences or any other entities in our natural languages – such as 'being seven letters long'), but these properties do not play a role in the analogy presented here (and their analogues for scientific models are in fact expressively ruled out by the inferential conception to be later reviewed).

[xv] In other words, we focus on those aspects of Ramsey's redundancy account that led Ayer to what is sometimes known as the 'no-theory theory' of truth (Ayer, 1936, p.117). On this account the redundancy view claims that 'truth' is a tool – for disquotation, generalization, etc –, which does not deserve any analysis beyond whatever concerns its use in practice as a 'vehicle of semantic descent'. There is no point looking for necessary and sufficient conditions for 'truth' since 'truth' is not a genuine concept and requires no such conditions.

[xvi] The full list is as follows (Wright, 1992, pp. 34 and 72): i) to assert is to present as true; ii) any truth-apt content has a significant negation which is likewise truth-apt; iii) to be true is to correspond to the facts; iv) a statement may be justified without being true, and vice-versa; v) truth is absolute (there is, strictly, no being more or less true) and vi) it is stable (if a content is ever true, it always is). Wright makes it clear (ibid, pp. 72-74) that all these *platitudes* of truth must be understood in a suitable deflationary spirit, and in particular iii) does not entail the metaphysical relation between propositions and facts characteristic of correspondence theories of truth.

[xvii] This crucially does not amount to the view that 'truth' has no sufficient conditions, or that its necessary and sufficient conditions are given by an extremely long, perhaps infinite, or indeterminate, list of conjunctive properties, each corresponding to a particular domain. Any of these alternatives would be entail a radical relativism according to which there is no unique or unified truth concept. The whole point of abstract minimalism is precisely to argue that there is one unique truth concept, it just so happens to be an abstract one.

[xviii] I am not claiming that every concept necessarily is susceptible to one of these strategies for deflation. There are successful substantial accounts of a range of different concepts, both across the sciences (formal and empirical) and in ordinary life, and philosophers have often excelled at bringing out their details. I merely claim that some concepts are deflationary in that they resist any substantial or explanatory analysis, and for those concepts any of these strategies for deflation is available. They each provides a hermeneutics: A complex interpretative framework which allows a better understanding of the concept. Other deflationary strategies or hermeneutics may be appropriate for some of these concepts; and often more than one strategy will suit. For instance, in the case of truth, each of the three strategies has something going for it, and illuminates – at least in part – the nature of truth's resistance to substantial analysis. Similarly, I argue, for scientific representation: Each of the three deflationary strategies has something going for it there too, and each sheds some light on why scientific representation resists a substantial analysis.

[xix] I am therefore assuming that any account on which representation can be understood as denoting a substantive property or relation of sources and targets, will thereby be able to provide a reductive analysis in terms of the application conditions of this property or relation.

[xx] A standard way to put this would be to say that the truth conditions of statements involving representation are in the practice itself, and in no way depend essentially on the obtaining of any relation between source and target. There is to my mind nothing in this standard expression that is

objectionable, but I avoid the expression 'truth-conditions' in order to avoid any appearance of conflation or collision with the analogy I develop with theories of truth in section 3.

[xxi] In what follows I am indebted to Baxandall (1985), as well as further documents on the Forth Rail Bridge from a more straightforward engineering point of view, such as Petroski (1995, particularly Ch. III), and Shipway (1990).

[xxii] At the point at which it had been decided to bridge it, the Forth required two bridge spans each 500 m. long, with a central pier at Inchgarvie Island, which happened to conveniently lie in the middle. Still this was an unprecedented length over which to build a cantilever. Petroski (1995, p. 87) points out that cantilever bridges had been built in North America already, but Baxandall documents Baker's inspiration in oriental bridge designs which, applying the same principles, were able to respect symmetry. This observation is not entirely inconsequential for the inferential capacities of Baker's representations of the bridge, but we may leave it aside for now.

[xxiii] I believe the DDI model may also be extended in order to comply with abstract minimalism, but for reasons of space I leave that strategy for another occasion.

[xxiv] Goodman (1976); see also Elgin (1996, 2009).

[xxv] For instance see Chang and Kleiser (1990, p. 20) which informs my discussion.

[xxvi] Hence the source and the target are both regarded as 'structures' under some abstract description suitable on pragmatic grounds – and there is no direct application to the target conceived as a bare system. See e.g. Van Fraassen (2008, p. X) and Suárez (1999) for discussion.

[xxvii] See the various essays contained in Suárez (2009) and Woods (2011).

[xxviii] Maxwell (1861); for discussion see e.g. Nersessian (2008).

[xxix] A commitment that I wish to move away from, as will hopefully become clearer in the discussion of the inferential conception.

[xxx] If anything, the inferential conception has been criticized for affording too much leeway at this point – see e.g. Bolinska (2013).

[xxxi] As has been argued more extensively in Suárez and Solé (2006) of which the text above is a development and summary.

[xxxii] These notions were first introduced in Suárez (2003, pp. 229-230).