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CHAPTER 4

REDUCTION OF CONCEPTS

4.1 Introduction

In the preceding chapter I have argued that all types of law or theory reduction (excepting instrumentalistic reductions) involve logical relations between statements or systems of statements and that, therefore, reduction is an epistemological issue, not an ontological one. Several authors have claimed, however, that some types of law or theory reduction also involve the reduction of concepts and that this would imply some form of ontological reduction (Schaffner 1967; Sklar 1967; Hempel 1969; Causey 1972, 1977; Gyrill 1976; Pluhar 1978; Moulines 1984; Kuipers 1990, 1997). This pertains to identificatory reductions, of course, because of the ontological identity relations being assumed in these reductions. Since ontological identity relations are relations between concepts (or terms designating these concepts), identificatory reductions involve the reduction of concepts, and because they are ontological identity relations, this is supposed to involve some form of ontological reduction. Some authors have even claimed (Causey 1972, 1977; Kuipers 1990) or suggested (Pluhar 1978) that it involves some form of micro-reduction. My chief purpose in this chapter is to show that these are grave misunderstandings.

It is extremely difficult, however, to detect the source or sources of these misunderstandings. This is due partly to terminological confusions and partly to the inherent complexity of the subject. The main problem in this respect seems to be that it is not at all clear what sort of relations are to count as ontological identity relations. As a result, we are provided with all sorts of examples of what are supposed to be ontological identity relation but which, on close inspection, turn out not to be. Therefore, before getting to the arguments against the view that concept reductions are ontological reductions and/or micro-reductions, I will first discuss 'the problem' of ontological identity relations. This involves the difference between ontological identity relations and correlations (causal relations); the difference between so-called thing-identities and attribute-identities; and, since analyses of concept reductions generally rely on the distinction between types ('kinds' of things or attributes) and tokens (individual instantiations), the difference between types and tokens and the associated difference between token-identities and type-identities. This chapter will be rather technical and may be skipped by readers who are not attracted by the subject itself. However, I think the conclusions should be read.

4.2 Ontological identity relations

4.2.1 Identities versus correlations

Concept reductions are generally supposed to involve ontological identity relations (from here on, OIRs for short). As mentioned in the former chapter, these are statements to the effect that a (term denoting a) concept which occurs in a law or theory to be reduced but not in the reducing theory, is identical to a (term denoting a) concept in the reducing theory. This may apply to thing-concepts (for instance, the concept 'gene' in Mendelian genetics is supposed to be identical to the concept 'piece of DNA' in molecular genetics) but also to attribute-concepts (for instance, the concept 'atomic number' in the periodic table (law) of elements is supposed to be identical to the concept 'number of protons or electrons' in Dalton's atomic theory). However, as the argument against the identity of mendelian genes and molecular genes (see 3.3.3.h) has already shown, what some consider to be OIRs, others don't. More

generally, it is very difficult to establish what sort of relations are to count as OIRs.

In the literature on concept reductions this problem is usually discussed by asking what is the difference between OIRs and correlations, where the latter are defined as causal relations. Two criteria have been proposed (Causey 1972, 1977; see also Kuipers 1990, 1997), to wit the 'causal explanation' criterion and the substitution criterion.

4.2.2 Criteria for ontological identity relations

According to Causey (1972), identities are biconditionals which, like correlations, require empirical justification (a demand which Nagel also made on his rules of correspondence) but which, unlike correlations, are not subject to causal explanation. I have already used this criterion in the former chapter: correlations are causal relations which themselves call for a deeper, causal, explanation, whereas identities cannot be causally explained.

The favourite example in this context is the identity of the evening star and the morning star. Formerly, one used to think that these were two names for two different objects but today we take them to be two different names for one and the same object. The identity is a triple identity, moreover, as we also believe the object to be the planet Venus. There is no use in asking for a deeper explanation of this identity: there is no causal relation between Venus, the morning star and the evening star. In the case of correlations, on the other hand, the call for further explanation seems always pressing. In chapter 3 I mentioned the example of the correlations being used in Mendelian genetics to explain phenotypical traits of organisms. Between these traits and the genes or alleles postulated in Mendelian genetics generally lie complex biosynthetic pathways which are all causal relations calling for deeper, causal explanations.

The identity of the morning star and the evening star is an individual identity, however, whereas the OIRs that are to figure in concept reductions (that are to figure in law or theory reductions) must be general identities. The problem with Causey's first criterion thereby is that though it seems manageable in practice, it is essentially circular. For the only justification for the claim that a given relation cannot be causally explained seems to be that it is an OIR (Kuipers 1990, 1997).

Therefore, Causey (1972) proposed another, second criterion, to wit the substitution criterion: if 'a' is identical to 'b', then in all statements about 'a', excepting statements in which personal (propositional) attitudes²⁸ occur, the term 'a' may be replaced by the term 'b', without loss of truth-value. This criterion is generally accepted for individual identities but, according to Causey, on the grounds of his conviction that identities are biconditionals, may be extrapolated to general identities. The problem with this second criterion is, however, that though non-circular, it is not manageable in practice, for the simple reason that we cannot check for every statement whether substitution is allowed or not (Kuipers 1990, 1997).

Thus, the distinction between OIRs and correlations, though intuitively clear, is philosophically hard to justify. For the moment, however, we could say that on the basis of our intuition and on the combination of Causey's criteria we can come a long way. Though there may be difficult cases where the distinction is not readily made, there are sufficient

²⁸Propositional attitudes are intensional mental states such as 'I think that ..' or 'I believe that ..'.

examples where the distinction seems clear, or at least useful. I will return to this later.

4.2.3 Thing-identities and attribute-identities

According to Causey (1972, 1977), it is not only possible to reduce thing-concepts but also to reduce attribute-concepts. In other words, there are not only thing-identities but also attribute-identities. His claim is supported by Kuipers (1990, 1997) who has given a formal reconstruction of both kinds of concept reduction. According to Kuipers, "Thing-identities are general identities in which types of objects, belonging at first sight to different domains, are identified: "light consists of electromagnetic waves", "water consists of H₂O-molecules", "genes consist of pieces of DNA-molecules", etc. Attribute-identities are general identities in which properties, relations or functions are identified. [For example:] "the macroscopic pressure [of a gas] is the same as the kinetic pressure [of the gas molecules]" and "equal thermal state is the same as equal mean kinetic energy" (Kuipers 1990, p. 257). The latter OIR (an identification of qualitative attribute concepts or relation concepts) is an alternative formulation of the more familiar OIR that the temperature of a gas is identical to the mean kinetic energy of its molecules (an identification of quantitative attribute concepts or function concepts).

Kuipers has shown, convincingly in my view, that the reduction of attribute concepts runs completely analogous to the reduction of thing concepts, the only difference being that in the former case a time parameter must be introduced to account for phase-transitions of things. Therefore, I will not question the possibility of reduction of attribute-concepts *per se*. It should be mentioned, however, that the *actual* possibility of reduction of attribute-concepts is questioned, especially in the literature on the mind-body problem (see below).

4.2.4 Types and tokens

Analyses of concept reductions generally rely on the distinction between types and tokens. Unfortunately, however, these terms are rarely if ever explicitly defined. Therefore, I will attempt to do so myself, or at least make clear what I consider them to be.

A *type* can best be compared with a natural *kind*. A type of thing is a kind of thing, and a type of attribute is a kind of attribute. A *token* is an individual *instantiation* of a certain type or kind. Thus, the relation between types and tokens is like the one between a species and its individuals: a (an individual) sparrow is a token of the type 'sparrow' and a particular human being is a token of the type 'human being'. But of course the type-token distinction is not restricted to biological species. For instance, anticipating the major example of an OIR to be discussed later ('water = H₂O'), an (individual) H₂O molecule is a token of the type 'H₂O molecule', and an (individual) amount of water is a token of the type 'water'. A particular chair is a token of the type 'chair', and the brown colour of my chair is a token of the type 'brown'.

It is often thought (Guichard, Kuipers, personal communications) that the relation between types and tokens coincides with the relation between a set and its elements, but in my view this is not true: the former is a subset of the latter. That is, all type-token relations are set-element relations but not all set-element relations are type-token relations. For example, a particular sparrow is a token of the type 'sparrow' and at the same time an element of the set of sparrows. A particular raven is a token of the type 'raven' and at the same an element of

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the set of ravens. All individual sparrows and ravens are also tokens of the type 'bird' and at the same time elements of the set of birds. However, there is a subset of the set of birds, viz. the set of sparrows and ravens, which can be described in terms of the set-element relation but not in terms of the type-token relation: the set of sparrows and ravens is not a type. All birds and mammals belong to the type 'animal' and they are elements of the set of animals, but there are all sorts of subsets of this set that do not form types, such as the set of robins and field mice, or the set of sparrow hawks and humans.

The cause of this asymmetry is, of course, that sets can be arbitrary whereas types generally are not. We can lump all sorts of things or attributes together into sets, but types are a sort of 'natural' categories, a sort of 'natural' kinds.

In my view, the type-token distinction corresponds to the relation between abstractions and concrete instantiations (or particulars), but this too is a source of confusion. There seems to be general agreement that types are always abstractions, but there are different ways of looking at tokens. One way is to say that tokens are always concrete instantiations, the other way is to say that though some tokens are concrete instantiations, others are abstractions. It may be argued, for instance, that though a particular sparrow is a token of the type 'sparrow', the type 'sparrow' is itself a token of the type 'bird', and that the type 'bird' is in turn a token of the type 'animal' (Guichard, Kuipers, personal communications). Similarly, in this view, the 'brownness' of my chair is a token of the type 'brown', but the type 'brown' is itself a token of the type 'colour'. Though on the one hand this is a mere matter of definition, on the other hand it seems more parsimonious to me to use the term 'token' only for concrete instantiations. Instead of viewing the type 'sparrow' as a token of the type 'bird', it seems more parsimonious to me to say that tokens of the type 'sparrow' are tokens also of the type 'bird', and also of the type 'animal'. And the 'brownness' of my chair is a token of the type 'brown' but it is a token also of the type 'colour'. At least, this view seems less ambiguous to me than to allow types to be also tokens. The latter is bound to create confusion.²⁹

Thus, in my view, tokens are always concrete instantiations and types are always abstractions. The fact that concrete things may be tokens of various different types merely indicates that it is possible to set up hierarchical classification schemes of things.

4.2.5 Type-identities and token-identities

Based upon the type-token distinction, two kinds of identities are being distinguished in the literature, to wit token-token-identities, or token-identities for short, and type-type-identities or type-identities for short. Naturally, one talks of type-identity when different types (of things or attributes) can be identified, and one talks of (mere) token-identity when only tokens of the one type can be identified with tokens of another type, but the types themselves are not co-extensive.

The main significance of the distinction is that, as noted above, concept reductions require general identities, that is, type-identities. This is particularly relevant in the context of the

²⁹There are two ways of formalizing the relations between a sparrow (s) and the types 'sparrow' (S), 'bird' (B) and 'animal' (A): (1) $s \in S \in B \in A$; and (2) $s \in S \subset B \subset A$. The point is not that either of these formalizations is more parsimonious than the other, for neither is. The point is that, in my view, S , B and A should never be allowed to be called tokens.

mind-body problem, where it is often argued that though tokens of mental types (in particular propositional attitudes) may be identical to tokens of physical (biological, neurophysiological) types, the types themselves are not coextensive. More specifically, it is argued that though tokens of a mental type may be identical to tokens of physical types, the latter tokens do not yield a single physical type coextensive with the mental type. It is said that, therefore, mental types are *multiple realizable* by physical types, or, alternately, that mental types *supervene* on physical types (Kim 1996). Since the mind-body problem falls outside the scope of this book, I will not discuss this view, but of course the possibility of similar problems occurring in other areas should not be excluded (see, for example, Rosenberg 1985, chapter 6, on the supervenience of the concept 'fitness' in evolutionary biology).

4.3 Ontological identities versus micro-reductions

4.3.1 Introduction

Having introduced the relevant terminology, I will now argue that concept reductions, if they are to involve OIRs, cannot be micro-reductions. Actually, the argument is very simple. For micro-reduction is, by definition, reduction with an aggregation step. This is incompatible with the claim that concept reductions involve OIRs (and only OIRs). Alternatively, to claim that concept reductions are micro-reductions is to claim that they involve two ontological levels, a macro-level and a micro-level. However, to claim that concept reductions involve (only) OIRs is to claim that they involve only one ontological level.³⁰ Clearly, the two claims are incompatible.

Though the argument doesn't depend on specific examples, it will be illuminating to discuss some examples. I will start with an example that is mentioned by Causey (1972, p. 410) and reconstructed by Kuipers (1990), viz. the reduction of the concept 'water'. Both Causey and Kuipers claim that this reduction involves an OIR *and* that it is a micro-reduction (though Kuipers 1997 has retreated from the latter claim).

4.3.2 An example: 'water = H₂O'

To claim that the reduction of the concept 'water' is a micro-reduction is to claim that this macro-concept can be reduced to the micro-concept 'H₂O' or 'H₂O molecule'. The macro-type in this case is 'water', tokens of this type being individual amounts of water (which may vary from a single raindrop to the amounts of water in a lake or ocean). The micro-type is 'H₂O molecule', tokens of this type being individual H₂O molecules. Clearly, however, individual amounts of water, whether they be raindrops or oceans, are not identical to individual H₂O molecules. For individual amounts of water have attributes, such as liquidity and transparency, which individual H₂O molecules don't have, and in order to arrive from the level of individual H₂O molecules at the level of individual amounts of water we need both an aggregation step and a correlation step. For there is a certain minimum number of H₂O molecules required to produce the first amount (drop) of water, and it is only when H₂O molecules interact with each other, and when they do so under certain well-defined temperature conditions, that they form the liquid substance water. Therefore, 'water' is not

³⁰For this seems to be implied by the very definition of an OIR.

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token-identical to 'H₂O molecule', nor can it be type-identical. It follows that 'water = H₂O' is not an OIR.

This is not to say, of course, that the concept 'water' (or rather, lawlike statements about water) cannot be reduced to the concept 'H₂O molecule' (lawlike statements about H₂O molecules), only that it cannot be done by means of an OIR. Nor is it to say that there is no OIR involved in the reduction of the concept 'water', only that it cannot be an OIR between 'water' and 'H₂O molecule'.

The question is, of course, what then is the OIR if it cannot be 'water = H₂O'. There are two possibilities, namely to formulate the OIR either on the macro-level (water) or on the micro-level (H₂O molecule). Interestingly, this is exactly what Causey and Kuipers actually do, where Causey takes the latter option and Kuipers takes the former. The OIR is variously formulated by Kuipers as 'water consists of H₂O molecules', 'water is a set (or a collection) of H₂O molecules', or 'water is an aggregate of H₂O molecules'. According to Causey, however, we should read: 'the smallest possible sample of water is an H₂O molecule' (Causey 1972, p. 410). Thus, whereas Kuipers situates 'the' OIR on the macro-level, Causey situates 'it' on the micro-level (that is, we are actually dealing here with two quite different 'OIRs'). As Kuipers notes, "aggregates [such as aggregates of H₂O molecules, RL] do not constitute a separate ontological level, but just belong to the macro-level" (Kuipers 1997, p. 133). Thus, 'water' and 'aggregate of H₂O molecules' are different concepts of one and the same thing on the macro-level. Put differently, they are two epistemological sides of the same ontological coin on the macro-level. In Causey's case, on the other hand, 'smallest possible sample of water' and 'H₂O molecule' are two different concepts (epistemological sides) of one and the same thing (ontological coin) on the micro-level.

Notice that both formulations are consistent with the argument that the reduction of the concept 'water' is not a micro-reduction (and hence inconsistent with the authors' own claim that it is). Notice also, however, that, by consequence, in Causey's case it is not the concept 'water' that is being reduced (to the concept 'H₂O molecule'), but the concept 'smallest possible sample of water', while in Kuipers's case it is not the concept 'H₂O molecule' to which the concept 'water' is being reduced, but the concept 'aggregate of H₂O molecules'. Thus, both Causey and Kuipers face the problem of how to explicate the relation between 'water' (= 'aggregate of H₂O molecules') and 'H₂O molecule' (= 'smallest possible sample of water'), that is, between the macro-level and the micro-level. Neither of them does, at least not adequately.

According to Causey (1972), all bridge laws in micro-reductions should be OIRs (which he calls Thing Identity Bridge Laws, or 'TIBLs' for short, and Attribute Identity Bridge Laws, or 'AIBLs' for short). This is impossible. Causey completely ignores the fact that micro-reductions are, by definition, reductions with an aggregation step (though he himself did not define micro-reductions as such). He also ignores the fact that we need correlation hypotheses (about interactions between H₂O molecules) to link the level of individual H₂O molecules with the level of water.

According to Kuipers, water is an aggregate of H₂O molecules. This strongly suggests that, in his view, the only relation between the micro- and the macro-level is an aggregation relation (in addition to the OIR on the macro-level). It is interesting, in this respect, that Kuipers notes that "the example has in the present context not yet anything to do with the aggregation phase of the substance water. That is, [a certain isolated amount of the substance] x₀ may well be water in solid form (ice) or in gaseous form (vapour)" (Kuipers 1997, footnote

on p. 122). This leads to the question, however, how one and the same set of H₂O molecules can sometimes lead to a liquid substance and at other times to a solid or gaseous substance. The answer is, of course, that this depends on the temperature conditions, and that lower or higher temperatures give rise to more or less strong interactions between the molecules, leading to, respectively, ice, water and water vapour. Thus, in order to explain each of the aggregation phases we need correlation hypotheses linking these phases to interactions between the H₂O molecules and to temperature conditions.

Kuipers states that "Reduction of substance terms means of course that we relate them to a suitable representation of macro-objects in terms of micro-objects [sic!] *and (some of) their properties, relations and functions*" (Kuipers 1997, p. 123; emphasis added). That is, he acknowledges that properties, relations and functions (attributes) of H₂O molecules, and hence, possibly, interactions between them, play a role in the reduction of the concept 'water'. However, these properties, relations and functions do not reappear in his formal reconstruction of the example, nor in the remaining informal part of his analysis. For the basic set, M_p, in terms of which he defines his base-classes of structures (that is, aggregates of molecules of certain chemical kinds) and base-types of aggregates, is simply the set of all molecules, partitioned into subsets of molecules of different kinds, among them the subset of H₂O molecules. That is, in Kuipers's terminology, the macro-type 'water' is ontologically identical to the base-type 'aggregate of H₂O molecules' generated by the base-class of 'aggregates of H₂O molecules'. However, nowhere are the properties, relations and functions of these molecules included in the aggregates. Thus, apparently, in Kuipers's view, the only relation between 'water' and 'H₂O molecule' is an aggregation relation.

4.3.3 Constitutive reductionism and relations between wholes and parts

The problem with this view becomes more pronounced when it is extended to similar examples at higher levels of organization. Indeed, Kuipers claims not only that water is an aggregate of H₂O molecules, but also that every macro-object can be conceived of as an aggregate of micro-objects: "macro-types of macro-objects are ontologically identical to base-types of aggregates generated by the base-classes of structures" (Kuipers 1997, p. 124), where 'structures' are tokens of aggregates of micro-objects and the 'base-types of aggregates' are the corresponding types. A macro-molecule, then, is an aggregate of molecules, a cell is an aggregate of macro-molecules, an organism is an aggregate of cells, a population is an aggregate of organisms, etcetera. However, by implication, then, all macro-objects are aggregates of, say, atoms or molecules (or quantum particles or whatever). Indeed, then, the entire biosphere or the entire universe is an aggregate of quantum particles, a most uninformative statement. That is, carving up the world in this way by means of ontological identities is actually not carving it up at all.³¹

The problem with Kuipers's view (when taken at face value) is that it is actually nothing other than constitutive reductionism (see chapter 2), or the view that higher-level entities are composed (exclusively) of lower-level entities. As we have seen, however, constitutive reductionism is compatible with both atomism ('ontological' reductionism) and emergentism

³¹I thank an anonymous reviewer for supporting me by stating that it wouldn't allow us to distinguish a human being from a dinosaur or a stone.

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(or other forms of holism or pluralism). For present purposes, we may take these doctrines to be, respectively, the view that 'the whole is equal (ontologically identical) to the sum of its parts' and the view that 'the whole is more than the sum of its parts'. That is, if not properly relativized (a relativation which depends more or less on the meaning of the term 'aggregate'), Kuipers's view may easily be taken for die-hard reductionism (though I know for a fact that Kuipers doesn't take this position): an organism in nothing but a collection of atoms and molecules. Though I have already pointed out the inadequacy of this view (the need for correlation hypotheses to connect micro- and macro-levels), I will not decide upon it here, since it is the subject of the next chapter.

It should be stressed that the point is not that water cannot be considered an aggregate of H₂O molecules, or that the statement 'water is an aggregate of H₂O molecules' cannot be considered an OIR (see below). The point is that between this OIR (the macro-level of water) and the micro-level of individual H₂O molecules (the level of Causey's OIR) there is more than just an aggregation relation.

4.3.4 Causal explanation and substitution

It is interesting, of course, to check whether Causey's and Kuipers's formulations of 'the' OIR satisfy Causey's criteria for OIRs (4.2.2).

Starting with Causey's own formulation, there seems to be no doubt that 'the smallest possible sample of water is an H₂O molecule' is an OIR. There seems to be no causal relation between 'smallest possible sample of water' and 'H₂O molecule', nor does the relation seem to be subject to causal explanation. Also, there seems to be no harm (loss of truth-value) in substituting the term 'H₂O molecule' for the term 'smallest possible sample of water' in statements in which the term 'smallest possible sample of water' occurs (though the problem with this criterion remains that it cannot be checked for all possible statements). On the other hand, what is to count as 'the smallest possible sample of water'? Those who have the right chemical equipment may be able to isolate a smallest possible sample of water that is identical to an H₂O molecule. But those who haven't, or those who never even learned about H₂O molecules, may take a single drop of water to be the smallest possible sample of water. However, in that case, replacing the term 'smallest possible sample of water' by the term 'H₂O molecule' in the statement 'the smallest possible sample of water is a drop of water' would radically change the truth-value of the statement. Or why not take the chemical analysis one step further and end up with hydrogen atoms and oxygen atoms? Or, taking it still further, why not establish that the smallest possible sample of water is a particular number (10) of protons, neutrons and electrons?

I don't mean to say that the relation as formulated by Causey cannot be considered an OIR, nor that, once it is accepted as an OIR, substitution is not allowed. The argument does show, however, that whether it is an OIR, and hence whether substitution is allowed or not, depends on whatever theory we adopt to specify what we mean by 'the smallest possible sample of water'. The relation may be considered an OIR all right, but only relative to the theory that water consists of H₂O molecules. However, on the simple 'folk' theory that the smallest possible sample of water is a drop of water, it isn't.

In addition, the entire analysis of the water example rests on the assumption that by 'water' we mean 'distilled water'. That is, it doesn't really apply to 'ordinary' amounts of water in raindrops, cups of tea, lakes or oceans. It is only on the theory that ordinary amounts of water

contain some 'basic stuff', some 'pure' substance called 'H₂O', that statements like 'water consists of H₂O molecules', 'water is an aggregate of H₂O molecules' and 'the smallest possible sample of water is an H₂O molecule' make any sense at all. This issue will be proceeded in the next section on ontological reduction.

Turning next to Kuipers's formulation, things are a bit more complicated. On the one hand, there seems to be no causal relation between 'water' and 'aggregate of H₂O molecules', and it doesn't seem to make much sense to ask 'why is water an aggregate of H₂O molecules?' On the other hand, given that water has attributes which H₂O molecules don't have, the question 'how come that water is an aggregate of H₂O molecules?' does seem to be pressing. However, as noted above (4.3.3), the question whether the statement 'water is an aggregate of H₂O molecules' is an OIR is a different issue from the question of how to explicate the relation between water and individual H₂O molecules. That is to say, the question 'why is water an aggregate of H₂O molecules?' is a different issue from the question 'how come that water is an aggregate of H₂O molecules?' The former question pertains to the relation between water and aggregates of H₂O molecules, whereas the latter pertains to the relation between water and individual H₂O molecules. The former relation may not be subject to causal explanation, the latter certainly is. Notice also that the causal explanation of the attributes of (the liquid substance) water is much the same as the causal explanation of each of the aggregation phases of (the 'basic stuff' we also call) water. That is, the causal explanation of the attributes of water is as much a causal explanation of the attributes of 'aggregates of H₂O molecules' (which it must be if the former is to be ontologically identical to the latter). In this respect, therefore, there seems to be no reason to question whether the statement 'water is an aggregate of H₂O molecules' is an OIR.

The substitution criterion poses a serious problem, however. For it may be argued that if water is an aggregate of H₂O molecules, then so is ice (and so is water vapour). However, substituting both the term 'water' and the term 'ice' by the term 'an aggregate of H₂O molecules' in the statement 'water is not the same as ice' radically changes the truth-value of the statement. Or, if one finds this too radical, consider the statement 'when ice melts, it turns into water' and substitute only the term 'water' by the term 'an aggregate of H₂O molecules'. On the other hand, the argument seems to rest on the ambiguity of the term 'water': it is sometimes used for only the liquid substance 'water' and sometimes for all three aggregation phases of the 'basic substance' water. When the ambiguity is resolved, the argument fails. It merely indicates that we are somewhat sloppy in our usage of terms: the statement 'when ice melts, it turns into water' should be read as 'when water in a solid state melts, it turns into water in a liquid state'. This shows once again that whether some relation between concepts is an OIR is a function of whatever theories we adopt to specify the natures of these concepts.

4.3.5 Other examples

It is easy to see that the above argument against concept reductions as micro-reductions holds also for other examples of OIRs. Another example of a thing-identity mentioned by Causey is 'gold is a collection of gold [Au, RL]³² atoms'. This example has the same structure as

³²I think the example should rather be formulated as 'gold is a collection of Au atoms'.

the water example. Therefore, the same arguments hold. Firstly, gold has attributes, such as a certain solidness (under particular temperature conditions), brilliance and electrical conductivity, which Au atoms don't have. Therefore, the macro-thing gold is neither type-identical nor token-identical to the micro-thing 'Au atom', and the reduction of the concept 'gold' cannot be a micro-reduction. Secondly, it is only when many Au atoms interact with each to form a crystal lattice that they produce the macro-substance gold. Therefore, in order to micro-reduce (lawlike statements about) the concept 'gold' we need, in addition to an OIR, both a correlation hypothesis and an aggregation hypothesis. Thirdly, the required OIR in this case is 'gold is an aggregate of Au atoms', but it is also possible to formulate an OIR on the micro-level (as Causey does): 'the smallest possible sample of gold is a Au atom'.

It will be clear that the same holds for all examples having the structure 'X consists of y's' (that is, macro-object X consists of micro-objects y). The argument may be summarized, therefore, by concluding that 'to consist of' is not the same as 'to be identical to'.

Turning next to attribute-identities, examples are 'the macroscopic pressure of a gas is identical to the kinetic pressure of its molecules', 'the temperature of a gas is identical to the mean kinetic energy of its molecules', and 'the atomic weight of an element is identical to the number of protons or electrons of the element'. However, the kinetic pressure of gas molecules is not an attribute of individual molecules (which are assigned only mass and velocity), but of aggregates of molecules. Similarly, the mean kinetic energy of gas molecules is not an attribute of individual molecules, but of aggregates of molecules. And the atomic weight (number) of an element and the number of protons or electrons of an element are two attributes of one and the same thing. Therefore, none of these examples make for cases of micro-reduction (though, like the examples of thing-OIRs, they are involved in micro-reductions). I will leave aside whether they satisfy Causey's criteria for OIRs.

The conclusion we can draw is that macro-concepts cannot be reduced to micro-concepts by means of OIRs, or, in other words, that concept reductions by means of OIRs cannot be micro-reductions. The misunderstanding about concept reductions as micro-reductions seems to be that, somehow, they are supposed to involve two ontological levels and that, therefore, either macro-objects are to be identified with micro-objects or attributes of macro-objects are to be identified with attributes of micro-objects. This is incompatible with the very idea of OIRs. That is, for some relation to be an OIR it must be a relation between two different concepts, of a thing or of an attribute, on one and the same ontological level.

4.4 Ontological identities versus ontological reduction

4.4.1 Introduction

Having shown that concept reductions cannot be micro-reductions if they are to involve OIRs, I will now argue that they cannot be ontological reductions either. In this case, the misunderstanding seems to be that, because concept reductions involve *ontological* identity relations, they are ontological reductions. However, the very fact that we are talking of the reduction of concepts indicates that it is concepts that are being reduced, not the ontologies (things or attributes, or, on an event ontology, events) to which they refer. Since the argument depends, however, on how we perceive of concepts, ontologies and the relation between them, and since this depends on how we perceive of the relation between ontology and epistemology, it may be illuminating to extend a bit on this relation.

4.4.2 Epistemological verificationism

'Ontology' is a very complicated and problematical subject, not so much because of its relationship to metaphysics (so cursed a term since Logical Positivism entered philosophy) but rather because of its relationship to epistemology. After the so-called linguistic turn in philosophy (initiated by Wittgenstein, but actually dating back to Kant, and proceeded by later philosophers such as Quine and Davidson) it has become difficult to state something in the field of ontology without at the same time stating something in the field of epistemology. With a nice term, coined by Lex Guichard (see Guichard and Looijen 1991), it is said that epistemology has become *verificationist with respect to ontology*. This means, roughly, that there is no ontological 'fact-of-the-matter' without there being at the same time an epistemological 'fact-of-the-matter'.³³ In simpler terms, epistemological verificationism³⁴ boils down to the following.

When we make a statement about reality (an ontological statement), when we state that reality is such or so, we do so implicitly or explicitly on the grounds of some theory about reality (theory being used here in the broad sense and including hypothesis, idea, model, etcetera). Kant already realized that reality in itself (the "Dingen an sich") is not directly accessible to our abilities of acquiring knowledge but, stated in modern terms, is always mediated by our conceptions of it. In other words, there is no way of knowing reality other than through theories.

Thus, when we make an ontological statement, we actually make a theoretical statement, a statement on the grounds of some theory. This leads us directly into the realm of epistemology. Though the terms 'experimental' and 'empirical' may suggest otherwise, experimental laws or empirical laws too are 'theoretical' laws in the sense of being 'laws in the light of some theory' or of being 'laws laden with some (deeper) theory' (Kuipers & Zandvoort 1985).

I have already argued that the reduction of laws and theories is an epistemological issue: it pertains to the logical relations between statements or systems of statements (theories). The question is now whether this applies also to the reduction of concepts.

4.4.3 Things, concepts, and terms

A concept may be defined as a certain representation which we have or make of some aspect

³³The issue is related to the very complicated subject of whether we should take a realistic or relativistic stance towards (scientific) theories. This subject is beyond the scope of this book. See Guichard and Looijen (1991) for a defense of realism in spite of epistemological verificationism.

³⁴'Epistemological verificationism' is shorthand for 'epistemological verificationism with respect to ontology'.

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of reality.³⁵ This shows immediately that concepts have a theoretical nature. Concepts are not directly related (equivalent or identical) to reality but representations of it. To be more precise, they are representations 'on the grounds of some theory': a conceptual theory.

In order to designate concepts, and to make them communicative, we use terms. (Communication failures often result from different meanings given to the same term: the same term denotes different concepts.) However, when a certain concept has become 'stable', that is, current or generally accepted (in other words, when the relevant term has become unambiguous), it gets a dual character: on the one hand it remains the representation of the aspect of reality it is, but on the other hand it becomes more and more associated with that aspect itself.³⁶ For instance, 'water' is the *term* we use for our *concept* of, among other things, a liquid substance, which is not-land, which we can drink, in which we can swim, etcetera, but 'it' (that is, 'water') is also that *substance itself*. (When I tell you about water, you don't think of the term 'water' nor of the concept 'water'; you think of the substance 'water'.)

Thus, the question what is being reduced when 'water' is being reduced has no straightforward answer. The reduction may pertain to (1) the term 'water'; (2) the (our) concept 'water'; or (3) the substance 'water'.

The safest choice seems to be the term 'water'. The choice is favoured by the Nagelian consideration that heterogenous (for example identificatory) reductions are so-called because the reduced law or theory employs *terms* which do not occur in the reducing theory and that they require bridge principles (for example OIRs) to connect these terms with terms that do occur in the reducing theory. However, if reduction would merely involve terms, it would be a purely analytical issue (a matter of defining the one term into the other) and empirical research would be superfluous (which is why Nagel, among others, required that bridge principles be empirically supported). The only reason, of course, why the reduction of 'water' is interesting is that it teaches us something about the substance water.

It is tempting, therefore, to choose next for the substance water. However, the idea that in concept reductions substances are being reduced is seriously misleading because, as we have seen, there is no way of knowing substances other than through theories. The same applies, of course, to properties or other attributes of things. As noted by Nagel (1979, pp. 364-365), whether things or properties of things can be reduced is a function of whatever theories are adopted to specify the natures of these things. As I have argued in section 4.3.4, whether the statements 'water is an aggregate of H₂O molecules' and 'the smallest possible sample is an H₂O molecule' can be considered OIRs depends on how we perceive of the concepts 'water', 'smallest possible sample of water' and 'H₂O molecule', that is, on the theory or theories by which we specify the natures of these things.

³⁵Of course, there are also concepts that do not represent reality (non-referring concepts, and perhaps logical concepts), and there are also representations of reality that are not concepts (statements, theories), but I would not know of any other way to define a concept than as a representation.

³⁶Compare this with the so-called splitting and inversion model of Latour and Woolgar (1979).

4.4.4 Epistemological reduction

Thus, we are left with the concept 'water'. Once we have eliminated the other possibilities, it is easy to see why the reduction of 'water' cannot but pertain to the concept 'water'. Of course, the concept 'water' refers to the substance 'water', but the reduction of the concept 'water' pertains, exactly as is stated, to the concept 'water'. This is, after all, why we speak of the reduction of concepts.

The reduction of 'water' pertains to the concept 'water', to a certain representation of (the substance) water. This agrees with Kuipers's account in so far as Kuipers claims that reduction of the concept 'water' means that we derive a macro-*representation* of the substance water from a representation of its micro-structure, the micro-structure-*representation*.

As noted before, according to Kuipers, aggregates do not constitute an ontological level of their own, but belong to the macro-level. Thus, the macro-*representation* and its micro-structure-*representation* in terms of aggregates of micro-objects are different representations (concepts) of one and the same thing on the macro-level. 'Water' and 'aggregate of H₂O molecules' are two different concepts of one and the same thing on the macro-level. Similarly, 'smallest possible sample of water' and 'H₂O molecule' are two different concepts of one and the same thing on the micro-level. The same applies, of course, to reductions of attribute-concepts: 'atomic number' and 'number of protons or electrons' are two different representations of one and the same attribute.

Thus, concept reductions are relations (OIRs) between two different concepts or representations of one and the same thing or of one and the same attribute. The two concepts are different epistemological sides of the same ontological coin. But then, it follows that concept reduction is, like law or theory reduction, an epistemological issue, not an ontological one: it pertains to logical relations between statements (laws, theories) about things, or representations of things (concepts), not to the things themselves. The claim that concept reductions are ontological reductions, because they involve OIRs, rests on a misunderstanding of what it is for something to be an OIR.

4.5 Conclusions

The upshot of the above discussion is that there may well be ontological identity relations, both of thing-concepts and of attribute-concepts, but that the concept reductions in which they figure can neither be considered micro-reductions nor ontological reductions. The claim that concept reductions are micro-reductions is incompatible with the fact that micro-reductions pertain to part-whole relationships and involve, by definition, an aggregation step. The claim that concept reductions are ontological reductions is incompatible with epistemological verificationism, and with the very fact that they are concept reductions.

Both claims seem to rest on misunderstandings of the nature of ontological identity relations. The basic misunderstanding seems to be that ontological identity relations involve relations between different kinds of things or of different kinds of attributes. Because of the context of heterogeneous micro-reduction in which they figure, this easily leads to the idea that they involve relations between macro-objects and micro-objects or relations between attributes of macro-objects and attributes of micro-objects. This in turn leads to the idea that concept reductions, involving such relations, are themselves micro-reductions. In addition, because of the term 'ontological identity relation', the idea seems to be that concept reductions are

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ontological reductions. However, ontological identity relations are relations between different concepts of one and the same (type of) thing or of one the same (type of) attribute. They express different epistemological sides of the same ontological coin.

Therefore, the conclusion can be drawn that concept reduction is, like law or theory reduction, an epistemological issue, or, more generally, that *reduction* is an epistemological issue. The expression 'ontological identity relation', then, is seriously misleading (and had better be replaced by the term 'identification hypothesis'), and the expression 'ontological reduction' may (in the context of concept, law or theory reduction) even be considered a contradiction of terms.