Reduction revisited

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Abstract
This is a first tentative examination of the possibility of reinstating reduction as a valid candidate for presenting relations between mental and physical properties. Classical Nagelian reduction is undoubtedly contaminated in many ways, but here I investigate the possibility of adapting to problems concerning mental properties an alternative definition for theory reduction in philosophy of science. The definition I offer is formulated with the aid of non-monotonic logic, which I suspect might be a very interesting realm for testing notions concerning localized mental-physical reduction. The reason for this is that non-monotonic reasoning by definition is about appeals made not only to explicit observations, but also to an implicit selection of background knowledge containing heuristic information. The flexibility of this definition and the fact that it is not absolute, i.e. that the relation of reduction may be retracted or allowed to shift without fuss, add at least an interesting alternative factor to current materialist debates.

I Introduction

The dominant current paradigm in the philosophy of mind is non-reductive physicalism. This 'anti-reductionist consensus' (Block, 1997) has been in place since the mid 70's and is supported by anti-reductionist arguments developed by, for instance, Fodor (1974) and Teller (1983). Pro-reductionist arguments have been offered in various forms by Kim (1982, 1984, 1985), Hooker (1981) and Bickle (1998). I shall not go into any of these. I rather consider how recent changes in philosophy of science depictions of the processes of scientific knowledge and the interrelations among theories can be usefully considered in terms of a reductive portrayal of inter-theoretical relations in the philosophy of mind.

Classical Nagelian reduction is undoubtedly contaminated in many ways, but here I investigate the possibility of adapting an alternative definition of so-called 'defeasible' reduction (Ruttkamp & Heidema, 2005) to (possible) mind-body relations. The definition is formulated with the aid of non-monotonic logic, which is an interesting realm for testing notions concerning mental-physical reduction, because this kind of reduction may turn out to be possible only in some kind of 'localized' manner.

More specifically, non-monotonic logic seems applicable in the mind-body context, because non-monotonic reasoning by definition is about conclusions drawn from sets of premises or 'evidence' by methods that are not strictly speaking deductive – think of

Sherlock Holmes's methods of 'deduction' (see Makinson, 2005:1) – in the sense that they involve 'presumption and conjecture and the ever-present possibility of going wrong' (ibid.). Makinson (2005: 1) writes:

> ... in real life, the incidence of failure is very much greater than pleasant fiction allows. Nevertheless for all its fallibility, it is reasoning. ... Most important, conclusions may be withdrawn as more information comes to hand, and new ones may be advanced in their place. This does not necessarily mean that there was an error in the earlier reasoning. The previous inferences may still be recognized as the most reasonable ones to have been made with the information available.

Moreover, non-monotonic reasoning, by definition, is about appeals made

> ... not only to the observations explicitly mentioned, but also, implicitly, to a reservoir of background knowledge, a supply of rules of thumb, a range of heuristic guides (Makinson, 2005:1).

Preferential semantics – the semantics used in defeasible reasoning – allows the incorporation of factors 'outside the theory' – i.e. not part of the theory's syntax – such as inclination, emotion, limited access to knowledge, and so on, into a meta-analysis of the theoretical framework of the relevant science. A definition for reduction formulated in this context – such as 'defeasible reduction' – is not absolute, i.e. the relation of reduction may be retracted or be allowed to shift without fuss.

In the philosophy of science, 'defeasible' reduction is a practical device for studying the processes of science, since it is about highlighting different aspects of the same theory at different times of application, rather than about naive dreams concerning a metaphysical unity of science. My claim in terms of philosophy of mind is much more tentative. It is not so much about establishing a metaphysics of mind, and not at all about determining one-to-one relations between terms in psychological theories and terms in neurological theories. What is mostly important is that it seems as if the relations between the mental and the physical – if any – are always naturally tentative, complex, and at least one-to-many, if not perhaps many-to-many. In this context, it is interesting that defeasible reduction allows for different relations of reduction between the same two theories at different times, according to different rankings (in terms of some preference) of the models of the reducing theory. Also, the rules according to which rankings are done allow for tracing motivations behind certain reductions at certain times. More is said about this in the next two sections.

Defeasible reduction is based on preferential semantics and forms part of a semantic analysis of science. In the next section I sketch the background against which defeasible reasoning should be understood, and explain the basic mechanics of non-monotonic logic. In Section III, I set out the definition for defeasible reduction developed by me and Johannes Heidema (Ruttkamp & Heidema, 2005), the results of which appear in the July 2005 issue of *International Studies of Philosophy of Science*. Next, I consider some of the consequences of applying this kind of reduction to descriptions of mind-body relations. In the final section, I list the current shortcomings of this discussion, but also offer some hope for the future of reduction in the mind-body context.

II Defeasible reasoning and preferential semantics

The idea of 'defeasible knowledge' is that knowledge is viewed as a fluid concept, because information may change, be amended, be expanded, be retracted, or acted upon

in general as a result of what is happening in the current context of application. The word 'defeasible' means that our preference for applications of our knowledge may change. Reiter (1980: 81) comments that:

> The need to make default assumptions is frequently encountered in reasoning about incompletely specified worlds. Inferences sanctioned by default are best viewed as beliefs which may well be modified or rejected by subsequent observations. It is this property that leads to the non-monotonicity of any logic of defaults.

Since the logic of defaults I apply in the current context is a non-monotonic one, consider the meaning of 'non-monotonicity'. The meaning of a formula in classical logic is the set of interpretations that satisfies it, or its set of models. In the context of a non-monotonic logic the focus is on a subset of those models, that is, those that are 'preferable' or 'most preferred' in a certain respect.

In classical logic $A \models C$ if C is true in *all* the models of A, however 'unwanted' or 'inapplicable'. Moreover, since all the models of $A \wedge B$ are also models of A, it follows that $A \wedge B \models C$, and hence that an increase in the knowledge represented by the antecedent of an entailment relation in classical logic does not invalidate the knowledge represented by the consequent of the relation, and so classical logic is 'monotonic'. In a non-monotonic framework, in line with the fact that defeasible conclusions may have to be retracted in the presence of additional information, 'A defeasibly entails C' is defined as meaning that C is true in all *preferred* models of A, which implies that only a subset of the models of A is chosen, according to some preference for them at a given time. Furthermore, $A \wedge B$ may have preferred models that are not preferred models of A, and so the consequents of A are not necessarily included among those of $A \wedge B$ in the non-monotonic context. Defeasible inferences are inherently non-monotonic, since enhancing our system of assumptions might change our conclusions.

In what follows, I use Shoham's (1988) model-theoretic non-monotonic logic, since it offers a simple way of ranking models, which is not as adequately possible in other versions of non-monotonic logic. Note that this kind of non-monotonic logic is a small part of a complex set of non-monotonic logics (see Delgrande, Schaub, Tompits, & Wang 2004, for a detailed discussion of the field).[1]

A non-monotonic logic consists (for our present expository purposes) of a propositional or predicate language together with a preferential semantics. The main idea is that an agent (a community of scientists working in some disciplinary matrix) may have two kinds of knowledge (Heidema & Labuschagne, 2001): sentential information about the aspects of the real system at issue, which may be expressed in the 'designer-built vocabulary' of the relevant formal language (ibid.); and meta-information depicted in terms of so-called 'default rules', motivating certain choices the agent/scientist makes at a given time.

Defeasible reasoning is the process of making informed 'choices' on the basis of the latter, i.e., a mixture of definite knowledge and heuristic considerations determining our processing of this knowledge, informally expressed as so-called default rules, and formally as relations called 'total pre-orders'. Intuitively, such relations are thought of

1 Non-monotonic logics with a preferential semantics originated with McCarthy's notion of circumscription (McCarthy, 1980, 1986). Shoham (1988) generalised McCarthy's work. His work was in its turn refined by Lehmann and Magidor (Kraus, Lehmann, & Magidor, 1990; Lehmann & Magidor, 1992; Lehmann, 2001).

as allocating models or states (of some real system) to levels of normality, or preference. Note however that a default rule is not an absolute guarantee. Our informed guess may turn out to be wrong. An example of a default rule could be: 'Normally if Tweety is a bird, then Tweety is able to fly'. But exceptional circumstances may defeat the default rule: Tweety may be a penguin or an ostrich, Tweety may be in Sylvester's tummy, and so on. Abnormal states or a change in the content of the body of knowledge concerning a certain situation can sometimes occur. This leads to changes of preference (changes of default rule), and so to new rankings of models. That is why, after all, in such cases we call our reasoning 'defeasible'.

III Preferential model-theoretic reduction

Nagel (1949, 1961, 1998) offered his derivational definition of theory reduction[2] as providing a method of explanation within the accepted positivist covering law model for scientific explanation. Critical analyses of Nagel's account of theory reduction have been presented by well-known philosophers such as Feyerabend (1998), Nickles (1998), Sklar (1967), Schaffner (1967), Kitcher (1998), and the defenders of the structuralist school led by Sneed (Balzer, Moulines & Sneed, 1987) and Stegmüller (1976). Among others, Feyerabend (1962, 1963), Suppes (1957, 1965), Hooker (1981), and Bickle (1998) have applied their discussions of reduction to mind-body relations. This article also offers a critical reconsideration of reduction resulting in a generalisation of the classical definition.[3]

'Defeasible reduction' of T' by T may be defined as follows[4]: The conjunction of the assumptions of a reducing theory T and the set D of linking assumptions of terms in T', supplementing the vocabulary of the language of T, *defeasibly entails* the assumptions of the reduced theory T'. Notice that here it is not simply the reducing theory T that defeasibly entails the reduced theory T', but the reducing theory T in the presence of some set D of linking assumptions. (Recall that 'A defeasibly entails B' means that the set of preferred models of A, written as PMod(A), is a subset of the set of models of B, written as Mod(B).)

It seems obvious that both the conjunction of T and D, and theory T' must be formulated in the same language. This 'merged' language will usually be the union of the languages of T and T'. This is the weakest part of any definition of reduction, but for now, it is perhaps best to acknowledge that this kind of union is logically possible, though it might be difficult in practice, because the relations between the theories we are dealing with and their linguistic expression are complex, and not yet stable. We assume that $T \wedge D \wedge T'$ (for simplicity taken as a sentence of the union of the languages of T and T') is consistent.

D consists of one or more sentences of the merged language, linking the two sets of vocabularies. Usually D will contain definitions of the T'-terms not occurring in the T-language in terms of the T-language. Occasionally D may contain definitions of new terms that help to smooth other definitions, for example: the notion of the average ki-

2 See Ruttkamp & Heidema (2005) for a thorough discussion and critique of this definition of reduction.

3 It is interesting to note here that Margaret Morrison (2000) has also recently offered an approach to theoretical reduction, and more explicitly, of 'unifying scientific theories' by making use of mathematical structures. Also, the highly complex analysis of the structure of theories offered by the structuralists (Stegmüller, 1976), Balzer, Moulines & Sneed, 1987) offers very refined arguments of theory reduction with the help of mathematical structures. Suppes (1956, 1965) also uses set-theoretic methods in his depictions of reduction, and Bickle (1998) has recently been considering its advantages as well.

4 Many parts of this section are from Ruttkamp & Heidema (2005).

netic energy of gas molecules may facilitate the definition of temperature (from T'= thermodynamics) in terms of mass, speed, etc. (from T = mechanics). In principle, D may sometimes even contain linking axioms that transgress the usual eliminability and non-creativity of genuine definitions. In these cases T is effectually strengthened logically.

To check whether defeasible reduction holds logically, the models of $T \wedge D$ (or, actually, all interpretations of the language of $T \wedge D$) must be ranked according to a particular default rule (determined by meta-information). This default rule is a preference order (reflexive, transitive, and a total relation) so that Pmod($T \wedge D$) can be defined as the set of (most) preferred models of $T \wedge D$. Important is the fact that the feasibility of the rankings presented by a default rule cannot be established in general, once and for all, because the motivations behind default rules are context specific, i.e. the preference order is bound to specific context.

It seems obvious from discussions leading to the establishment of non-reductive physicalism that the relations between the mental and the physical, if any, are complex, specific (usually at least domain-related somehow), not one-to-one, and not absolute. This seems compatible with the atmosphere created by defeasible reduction: The final result of the contextual nature of a default rule is that more than one relation of reduction is possible between the same two theories, because the formulation of a default rule is so closely linked to the context of application (especially, it seems to me, the application of T), and because a change of default rule causes a change of ranking of models (so a change in membership of the set of preferred models of the relevant theory). Note also that the ranking of models in terms of preference does not imply at any stage denying their status as true interpretations of the language of the theory; it simply means that some are at certain times preferred above others. Default rules may vary from McCarthy's (1980) unary predicate *Ab*, stating that it is preferable to have as few abnormal individuals as possible in a world, to information regarding precision or accuracy, to merged information or merged comparative orders, such as merging in belief revision (Alchourrón, Gärdenfors & Makinson, 1985), and many others.[5]

After the models of $T \wedge D$ have been ranked by a preferential order (represented formally by a total pre-order), the possibility of defeasible reduction between T and T' may be investigated. After the languages of T and T' have been merged as set out above, interpretations of the language must be formulated, specifying the domain of discourse, denotations of all individual constants, function symbols, and predicate symbols. The next step is to determine which of these interpretations are models of T', and which are models of $T \wedge D$. Next the ranking of models of $T \wedge D$ according to the chosen default rule is considered and PMod($T \wedge D$) is identified. Finally, if PMod ($T \wedge D$) $\subseteq$ Mod(T'), a relation of reduction according to the relevant (chosen) ordering of models may be confirmed. (There is also an empirical interpretation of this definition of reduction which is relevant in realist debates, see Rutkamp & Heidema, 2005.)

In conclusion of this section, I offer brief comments on two of the philosophical implications of defeasible reduction. First, the context-specific nature of the preference ordering or default rule seems to be clear now. This particular aspect of default rules points to their temporary or defeasible nature, which in turn points to the issue of the continuity of science. 'Continuity' here means that science is alive and changing; i.e. it

5 See Ruttkamp & Heidema (2005) for a discussion of six possible examples of default rules.

might sometimes be cumulative, and sometimes it might not, but at least it is never static. Progress in science should be interpreted as not necessarily in terms of development into a universally better or higher form of knowledge, but rather, development in the sense of adapting to circumstances or context. This may be reminiscent of eliminative materialism sentiments, but more about this later.

Secondly, in classical (Nagelian) reduction all models of $T \wedge D$ are some of the models of T', while in the case of defeasible reduction, some models (the preferred ones) of $T \wedge D$ are some of the models of T'. This implies that the conjunction of T and D is semantically stronger in the defeasible case, since it has fewer models than in the classical case. This in turn implies that T might be easier to falsify (more counter-examples exist), which is compatible with the Popperian attitude to theories. There are also interesting implications of this definition for meaning change and scientific realism, which will not be discussed here (see Ruttkamp & Heidema, 2005).

Defeasible reduction allows at least an approximate grip on the complex relations weaving the fabric of science. In other words, just as the links between theories and reality are extremely complex, non-unique or temporary at best, so may inter-theoretic relations be. Defeasible reduction can deal with such a situation, because this complexity can be *articulated* with the help of model-theoretic preferential semantics.

Note here that Hooker's (1981) definition of reduction in some senses seems to come close to at least some of the above implications of defeasible reduction. Hooker's depiction of reduction implies that reducibility of T' to T does not exist in the possibility of deducing T' from T (and bridge laws and boundary conditions), but rather in the possibility of deducing within T a (somehow) isomorphic (and equipotent) image of T' still expressed in the vocabulary of T.

> The older theory, therefore, is not itself deduced. Rather, it is mimicked by a restricted subset of T with which it is judged to be relevantly isomorphic (Rowlands, 1995:66).

Although the concept of isomorphism here is sometimes not very clearly stated, the fact that perhaps various such isomorphic relations might exist seems to warrant some investigation of possible comparisons between defeasible reduction and Hooker's model. This, however, cannot be done here.

IV Defeasible reduction in a mind-body context

So, where are we in terms of reduction in mind-body debates? Place (2000) and Smart (2000) argued, with variations, for 'topical-neutral' translations (or reports) of mental events as brain states or events. This kind of neutrality turned out to be too indeterminate and much too weak, among other things, to capture the kind of contingency that later token-token identity theories acknowledged. Kripke (1980) on the other hand, kept everything uninterestingly stable with his presentation of the identity relation in terms of 'rigid designators'. So-called 'type-type' identity (and the closely related notion of reduction), have been rejected on the 'dual grounds that it is implausibly strong, and that it is not necessary for materialism' (Haugeland in Cooney, 2000:157). 'Token-token' identity seemed a better option, because materialist metaphysics can still be satisfied by identity between individual psychological tokens (such as specific events, states, etc.) and individual physical tokens (ibid.). The notion of dealing with particulars rather than with universals is appealing to me, but token-token identity also seems still to be based on one-to-one mappings between individual cases, which is always a bit ambitious and often too rigid a context to be really useful (as we know).

In terms of eliminative materialism, defeasible reduction seems a suitable candidate for describing mind-body relations, because current linguistic practice may be one of the factors determining preference or ranking of models of the relevant neurological theory. Against Ryle (1949), Place (2000), Smart (2000), and Kripke (2000), Rorty's point is that

> ... [t]here simply is no such thing as a method of classifying linguistic expressions that has results guaranteed to remain intact despite the results of future empirical inquiry. ... there is no method which will have the sort of magisterial neutrality of which linguistic philosophers fondly dream (in Cooney, 2000: 112).

In the defeasible context however, previous rankings are not necessarily branded as incorrect, and so the eliminativist aspect might seem not to be dealt with adequately. Defeasible reasoning, nevertheless, allows for the fact that it is often more practical, even if views, models, or forms of reduction change over time, for certain purposes to continue using previous views, models, or forms of reduction; e.g. Newton's laws send people to the moon, not Einstein's, because Newton's are 'good enough' – under certain precise conditions – for this particular purpose. The point is whether or not Rorty's kind of elimination really occurs, ranking models according to preference seems like an effective mechanism to capture the fluidity Rorty, among others, seems to attribute to linguistic practices (and to measure progress made in terms of empirical research).

Let us now briefly consider multiple realization. Why in mind-body terms should it matter that the same psychological state – or two 'indistinguishable' ones – are instantiated by different physiological means? Why do we need a one-to-one mapping? – Only to save materialism, reduction does not need it. Consider the following: Formulate interpretations of a psychological theory T', and of a physiological theory T both in some merged language (the union) of the two theories. To 'trace' a reduction of T' to T (in conjunction with the relevant set D), formulate an applicable default rule according to preferences in the relevant situation of application, rank the models of $T \wedge D$ accordingly, and then check if the set of preferred models of the conjunction of T and D is a subset of the set of models of T'. It might be that, under a different choice of default rule, and a subsequent different ranking of models of $T \wedge D$, the – new – set of preferred models of $T \wedge D$ is still a subset of the set of models of T', implying another reduction of T' by $T \wedge D$, and so at least a form of multiple realization. This kind of multiplicity can be dealt with because defeasible reduction is not absolute, and non-monotonic logic has methods of tracing different reductions (and so different inter-theoretic relations) between the same two theories. Although defeasible reduction cannot necessarily save materialism, it can be a useful mechanism to depict mind and whatever-embodiment-is-chosen relations, so that, indeed, to quote Fodor (in Cooney 2000: 154), '... scientific theories can fit together in more than one way, perhaps in many ways. ...' .

V Conclusion

Mind-body relations have in recent discussions been depicted by one of three ideas:

> ... the idea that the mental is 'realised' by the physical, the idea that the mental 'supervenes' on the physical, and the idea that the mental is 'emergent' from the physical (Kim in Cooney, 2000:170).

This article is not intended to replace any of these ideas, rather it is intended as an ex-

ploration of whether defeasible reduction might not reinstate reduction as a fourth idea about mind-body relations. Defeasible reduction does not make the same promises as supervenience concerning maintaining the primacy of the physical domain and its laws, and it cannot necessarily protect any physicalist commitments. It can, however, discuss inter-theoretic relations that are fluid and one-to-many, and it can allow for scientific progress. Also, the idea of a multi-layered world with a hierarchy of levels of entities where macro entities are composed of micro entities, might at present be best represented and dealt with by supervenience, although deeper investigation of the properties of non-classical logics might produce interesting new insights in representations of multi-layeredness.

The point here is to show that there are forms of reduction that can incorporate forms of multiple realization, and that defeasible reduction may be considered as another option to discuss mind-body relations. The fact that defeasible reduction is not necessarily tied to any specific metaphysics might not be a weakness, but rather enough reason to keep it in mind as science progresses. What is of note for now is that defeasible reduction is done within a (non-monotonic) context of reasoning where conclusions may be withdrawn as additional data is collected, and new ones may be proposed instead, while still preserving previous inferences as the most reasonable ones made with the data available at the time. Given that the philosophy of mind is probably one of the most notable of very few fields where philosophers still 'contribute' to science at least in their role as conceptual clarifiers, this non-monotonic feature of defeasible reduction might make it a very handy mechanism to have around in mind-body considerations of most kinds. Moreover, non-monotonic logic allows a meta-analysis of empirical research because it accommodates heuristic factors that are not part of the language of relevant theories in depictions of scientific processes.

Hooker's (1981:201ff.) arguments that the concept of reduction should be viewed in terms of a continuum between retention and elimination also seem interesting here. For instance, the relation between equilibrium dynamics and statistical mechanics is often cited as a typical example of theory retention, while it really is not (Hooker 1918: 47-48) – and really perhaps there are no 'perfect' or 'typical examples' of either theory retention or elimination (see Ruttkamp & Heidema, 2005) for related remarks regarding domain-preserving or homogeneous reduction). Defeasible reduction allows for this, because relations of defeasible reduction are temporary and context-specific to a certain degree, in the sense of being dependent on the particular ordering of the models of the reducing theory which is determined by a particular default rule defined by heuristic and other extra-theoretical factors at issue in the relevant science at a given time. To reiterate, in classical (Nagelian) reduction, all the models of $T \wedge D$ are some of the models of T', while in the case of defeasible reduction, some models (the preferred ones) of $T \wedge D$ are some of the models of T'. This is (at least in general) compatible with the implication of Hooker's (1981) argument that reduction becomes very much a matter of degree.

In general, non-classical logics have quite a lot to offer the philosophy of mind. At the very least, given their context-specific perspective, they may help throw new light on old problems in unthought-of ways.

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