IS FUNCTIONAL REDUCTION LOGICAL REDUCTION ?

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ABSTRACT. The functionalist conception of mental properties, together with their multiple realizability, is often taken to entail their irreducibility. It might seem that the only way to revise that judgement is to weaken the requirements traditionally imposed on reduction. However, Jaegwon Kim has recently argued that we should, on the contrary, strengthen those requirements, and construe reduction as what I propose to call « logical reduction », a model of reduction inspired by emergentism. Moreover, Kim claims that what he calls « functional reduction » allows one to reduce (at least some) mental properties by these new standards. I argue against both theses. First, I present a counterexample to the emergentist model of reduction: The model judges irreducible certain properties which are clearly reducible. Second, I contest that functional reduction as construed by Kim satisfies the emergentist constraints. Functional reduction implies, over and above a functional definition of the reduced property, the indication of its realizers. But the latter information corresponding to the discovery of a (local) bridge law, is empirical and not purely logical.

1. Nagelian reduction and multiple realization

It is generally acknowledged that the functionalist conception of mental properties, together with the thesis of their multiple realizability, entails the impossibility of reducing such properties to properties of the brain. However, that argument commits functionalists to antireductionism only as long as an often unnoticed premise goes unchallenged. That premise is Nagel's (1961) thesis that the reduction of one theory to another proceeds by establishing links between the vocabulary of the reducing and reduced theories via universally quantified

conditionals[1], the so-called bridge principles or bridge laws. The multiple realizability of the (higher-level) properties described by a theory establishes the irreducibility of that theory to some theory describing the properties on the (lower) level of their realizers, but only on the Nagelian premise that reduction requires bridge laws: for there cannot, or so it is often argued, be any bridge laws linking a predicate of the higher-level theory designating a simple property to the open disjunction of the many predicates designating its lower-level realizers[2].

But Nagel's model of reduction has been challenged. The case of the concept of temperature has been used as a counterexample to this model, taking for granted that its reduction to the atomistic concept of mean molecular energy constitutes a paradigmatic case of a successful reduction which can be used as a test case for any plausible model of reduction. The observation[3] that temperature is multiply realizable, together with the above-mentioned argument that there is no bridge law linking a multiply realizable property to the open disjunction of its realizers, can be used in the following reductio of the Nagelian model of inter-theoretical reduction[4] :

1. (Nagel's thesis) Reduction of a theoretical predicate A requires the existence of a bridge

law linking A to a predicate belonging to the reducing theory[5].

2. Temperature is multiply realizable, with different realizers in gases, solids, plasmas, and empty space (i.e. portions of space containing no material objects but only radiation).

3. (Putnam's and Fodor's antireductionist thesis) There can be no bridge laws linking multiply realizable properties to the properties realizing them, because the predicates expressing these realizing properties form an open and heterogeneous disjunction.

4. Temperature is a paradigmatic case of successful reduction of a theoretical concept; it is therefore reducible if anything is.

1., 2. and 3. together entail that temperature is irreducible which contradicts 4.

Therefore, reduction does not always presuppose the existence of bridge laws, in other words 1. is false.

This argument does not only establish that the Nagelian model of reduction is inadequate as a general model of reduction, but it also suggests that its inadequacy stems from the overly restrictive conditions it imposes on reduction: it rules out the reducibility of a paradigmatic case of a successfully reduced concept because the requirement of the discovery of a bridge law is too strong[6]. It appears therefore that the correct strategy would be to look for weaker criteria of reduction than the existence of bridge laws[7].

In a series of recent works[8], Jaegwon Kim has defended two surprising and provocative theses which turn the preceding appreciation of the situation on its head. First, Kim proposes to take up the distinction between resultant and emergent properties due to the British emergentists[9], and to reformulate the criterion grounding this distinction so that it can be used in place of the distinction between reducible and irreducible properties. As Kim reconstructs the emergentist position, the emergentist thesis according to which conscious mental states are paradigmatic cases of emergent properties is compatible with the acceptance of the existence of nomic correlations between properties of the brain and such conscious mental states. The emergentists would insist that the existence of such bridge laws, and thus the Nagel-reducibility of conscious mental states, would still not make them resultant, or in other words would give us no reason to revise our judgement that they are emergent properties. The reason lies in the strong requirement emergentism imposes on resultant properties: for a higher-level property P to count as resultant, and thus as non-emergent, it must be possible to predict every occurrence of P on the mere basis of properties and laws on the base-level relative to the level of P. This means that if P is to count as resultant, it must not be necessary to use Nagelian bridge laws in the prediction of an occurrence of P. The reason is that such

bridge laws contain essential reference to both levels. Therefore, a Nagel-reduction of P is not sufficient to establish that P is a resultant property.

Kim considers, rightly in my view, first that this strong requirement is based on the legitimate intuition that there is a sense in which the mere existence of a nomological correlation between P and some base-level property leaves the existence of P fundamentally unexplained, and second that we should take over that requirement as a condition on reduction. If P is the state of feeling pain, we should not consider P to have been fully reduced to the brain state of the firing of C-fibres only because we have discovered a Nagelian bridge law linking these two properties. We would still not understand why someone is feeling pain when and only when her C-fibres are firing. But to accept the emergentist criterion of predictability solely on the grounds of base-level properties and laws as a criterion for reduction means to judge that, contrary to the conclusion of the argument sketched above, the Nagelian requirement for reduction is not too restrictive, but rather not restrictive enough. I shall call Kim's emergentist model of reduction the model of « logical reduction » because I take its central claim to be that a property is reducible - or non-emergent, or resultant - if its occurrences can be predicted on the mere basis of properties and laws of the base-level, in combination with logical and mathematical principles.

Second, arguing against the widespread conviction that the functionalist conception of mental states leads, given their multiple realizability, to their irreducibility, Kim elaborates a concept of « functional reduction » which permits one to show not only that functionalism is compatible with the reducibility of mental states, but that this kind of reduction is stronger than the Nagelian one: According to Kim, functional reduction turns out to be a form of logical reduction in the sense required by the emergentists.

In this paper I shall defend the diagnosis of the situation outlined at the beginning, by arguing against two of Kim's theses. The first concerns the legitimacy of the emergentist

model of reduction. I shall try to show, with the help of the example of the addition of masses, that using the concept of logical reduction makes certain properties which are in fact clearly reducible, emergent and thus irreducible. The second thesis I shall contest is that functional reduction fulfils the emergentist constraints on reduction.

2. Emergentism and « logical reduction »

According to Kim's reconstruction of the concept of reduction used by the emergentists, a successful Nagelian reduction does not yet constitute a genuine reduction, because its premises do not refer exclusively to the properties and laws of the reducing level. The key question which allows one to distinguish genuine reductions is this: « Can the occurrence of the [higher level] property be predicted solely on the basis of information concerning the basal level? » (Kim 2000, p. 17)[10]. In Kim's terminology[11], the occurrence of a reducible (resultant, or non-emergent) property can be "theoretically predicted", and not only "inductively predicted". The theoretical prediction that a complex object possesses the higher-level property E takes the form of a deductive argument the premises of which do not contain any reference at all to properties at the level of E. The premises of a theoretical prediction make reference only to properties and relations of objects belonging to the base level and to laws linking these properties; in particular; they do not refer to bridge laws linking base-level properties to higher-level ones. In this terminology, it can then be said that emergent properties are properties which cannot be theoretically predicted. However, emergentism recognises that they can nevertheless be inductively predicted. If it has been observed that occurrences of the higher-level property E are regularly correlated with occurrences of the lower-level property M, then one can predict (inductively) that E will be instantiated in every new situation in which M is. But emergentists insist, and rightly so according to Kim, that inductive predictability alone is not intuitively sufficient for explaining occurrences of the

higher-level property, for the premises of an inductive prediction contain reference to the correlation between E and M which is precisely what is in need of explanation. Instead of explaining « the emergence law "Whenever M is instantiated by a system, it instantiates E" », it takes it as « primitive, stating a brute correlation between M and E » (Kim 1997c, p. 48).

Using this terminology, we can say that a successful Nagelian reduction leads only to inductive, not theoretical predictability of the higher-level property. In this sense, Nagelian reduction does not satisfy the stronger requirement imposed on reduction by emergentism: that it should make possible the deductive (or, in Kim's words, theoretical) prediction and explanation of occurrences of the higher-level property solely on the basis of premises making reference exclusively to properties and laws of the base level. The reason why Nagelian reductions do not meet this requirement is that the bridge laws which are an essential component of its premises make reference to a link between base-level (reducing) and higher-level (reduced) properties. Insofar as the bridge laws make reference to the reduced properties - which are higher level properties - the prediction which is produced by a Nagelian reduction, in line with the deductive-nomological (or D-N) model of prediction, is not based only on information concerning the base level. Kim shows that this constraint expresses a widespread intuitive requirement for genuine reduction. Including it in the account of reduction allows, among other things, a justification of the intuition that « classic dualist mind-body theories as the Spinozistic double-aspect theory, Leibniz' doctrine of preestablished harmony, parallelism, and neutral monism » (Kim 2000, p. 17)[12] should not be judged forms of reductionism. However, the Nagelian model makes them compatible with reductionism because they allow for the existence of bridge laws[13].

But could there be a reduction without bridge laws? If it turns out that the emergentist condition is too strong to be met, including it in the analysis of reduction means to stipulate a generalised antireductionism, not only with respect to mental properties, but with respect to

all properties belonging to levels above that of the properties of elementary particles. But the claim that all macroscopic properties are irreducible is unacceptable, for at least some cases of successful reduction are uncontroversial. This is in line with the emergentists' own intention, which was not to show that all macroscopic properties are emergent, but rather to oppose a particular class of emergent properties to another, more vast class of « resultant » properties. The crucial emergentist thesis is that it is possible in the case of the latter, but not in the case of the former, to predict their occurrences solely using information concerning the base level.

In fact, if such a reduction did not presuppose empirical information on the level which is to be reduced, it would nevertheless have to presuppose the principles of logic and mathematics. For this reason, I propose to call « logical reduction » the model of reduction which Kim ascribes to the emergentists. In Kim's words, resultant properties "are analytically determined by a simple logical or mathematical relationship vis-à-vis the underlying properties" (Kim 1992b, p. 127). A resultant property is reducible in this logical sense if its prediction is possible according to the D-N model, with the specification that the only laws to be mentioned in the "N" part of the premises are logical and mathematical principles. Prediction according to logical reduction is a particular type of D-N prediction, namely a « D-L » (for « deductive-logical ») prediction, where the empirical laws which are the nomological premises in a D-N prediction are inexistent, having been replaced by purely logical and mathematical principles. In this sense, a logical reduction would allow one to justify the claim that the reduced property « is nothing more » than its base of reduction, where « nothing » would be understood as meaning: « nothing empirical », but only logic and mathematics. A logical reduction would at the same time be an ontological reduction, insofar as the fact that a theory makes reference to properties which have been reduced in this way would not make it ontologically committed to any higher-level properties, for the sentences making such a reference can be logically deduced from sentences referring only to properties

of the base level. In this way, the model correctly makes the non-reductionist character of the above-mentioned dualist doctrines apparent: these conceptions are incompatible with logical reduction. Even if some dualist doctrines imply the existence of nomological links between the mental and the physical, these links are not merely logical or mathematical, and therefore do not allow the mental to be logically reduced to the physical[14].

In order to test the plausibility of the model of logical reduction, let us consider the mass of a complex object. This is a case Kim mentions[15] as a paradigmatic instance of a « resultant » property: the information on the mass of an object composed of parts o_1 and o_2 seems to depend only on information on the masses m_1 and m_2 of the parts o_1 and o_2. In this sense, the calculation of the mass of the complex object would be a D-L prediction[16] : nothing beyond the rules of addition seems to be required to deduce that the mass of the whole is m_1+m_2, given that the masses of the parts are m_1 and m_2. As Kim says in a note, nowadays we no longer consider the additivity of mass as an a priori principle but rather as « empirical and contingent » (Kim 2000, p. 18, note 11). This principle is indeed contingent, for it is false. Mass is only approximately but not strictly additive: whenever two objects make up a whole through a physico-chemical link, the mass of the whole is smaller than the sum of the masses of the parts, the difference corresponding to the energy which was given off when the link was established.

Now if the dependence of the mass of the whole on the masses of the parts is empirical (and known only a posteriori), Kim is wrong in claiming that « we can explain why [this] table has the mass it has on the basis of information about the masses of its two constituent parts » (Kim 2000, p. 18), where the context makes it clear that this is meant to be the claim that the explanation does not make use of any empirical law or empirical facts beyond the masses of the parts: « The mass of this table is logically/mathematically derivable from the masses of its parts, say the top and base » (ibid.). But if we accept the idea that the additivity

of masses is not known a priori, but obeys an empirical law which depends on the type of physico-chemical link existing between the parts since their assembly, we must conclude that the derivation of the mass of the whole is impossible without making use of that empirical law[17].

Must we generalise this result to conclude that all macroscopic properties are « emergent » in the sense that they are « logically irreducible », i.e. that it is impossible to predict the least property of the whole solely on the basis of information on the properties of the parts, together with logic and mathematics? To stay with the example of mass, it may well seem possible at least to predict, on the basis of mere logic, that the whole has a mass, even if one does not a priori know which. But in fact even this modest prediction is based on empirical laws. The interaction of certain massive particles leads to a transformation of part of their mass into radiation. We can know only a posteriori in which circumstances this happens and in which not, and we can also know only a posteriori that, if such a transformation of mass into energy takes place, it concerns only part of the mass, and thus that the whole resulting from the interaction of two parts of a given type still has a mass at all rather than having been transformed entirely into radiation.

Fortunately it is not necessary to pursue any further the question of whether there are any resultant macroscopic properties, to show that the emergentist account of reduction is inappropriate. For it is difficult to find a property whose reducibility is less doubtful than that of the mass of a complex object with respect to the masses of its parts. Therefore if logical reduction makes this property irreducible - according to the above-mentioned criterion of derivability on the mere basis of a priori logical and mathematical knowledge plus information on the parts - it cannot serve as an analysis of our intuitive concept of reduction.

If even such a clearly reducible property as the mass of a complex object with respect to the masses of its parts proves to be non-resultant or emergent, and thus irreducible on the

emergentist account of reduction, then "emergentism may [...] be an empty doctrine" (Kim, 1997c, p. 56). But the reason for the emptiness is exactly the opposite of that given by Kim: not the possibility that "there may not be any emergent properties" (ibid.), but rather the possibility that there may be no resultant ones, or that all properties may prove to be emergent (and thus irreducible) on this account.

The argument from the reducibility of some multiply realizable properties shows that Nagel was wrong in thinking that it is necessary for the reduction of a property, and of the laws in which it takes part, that there exist bridge laws. The emergentist account of reduction makes the opposite mistake. As the case of the addition of masses shows, even in the case of clearly reducible properties, it is not in general true that their reduction can be carried through without any reference to empirical laws, i.e. solely on the basis of logic and mathematics.

3. Kim's model of functional reduction

With the concept of « functional reduction »[18], Kim claims to have constructed an account of reduction which is superior to Nagel's and which is - in my terminology - a kind of « logical reduction » in the sense that it conforms to the emergentists' requirement for reduction: logical derivability solely from the properties and laws of the base level. However, as I shall try to show now, functional reduction does not obey this requirement of logical reduction.

Functional reduction requires three steps: first, the « macroscopic » property M receives a functional definition in terms of the causal role it plays. This definition takes the form of an existential quantification over the properties P of the base level which occupy that role thanks to their causal/nomic links to other properties of the base level: $(\forall x)\ (Mx \leftrightarrow (\exists P)(Px \wedge D(P))$, where D is a causal/nomic condition on the properties P of the base level[19]. The second step which is crucial to our argument is the discovery of the property P which realises the

functional property M in the individuals of species S, where P is a microscopic property relatively to M. Once « a functional reduction [...] has been carried out [...], we know the realizer, say P, of property M in systems like S, and P is a base-level property or mechanism » (Kim 2000, p. 21). The third step consists in elaborating a theory that clarifies how the realizing property P manages to play the causal role D indicated in the first step[20].

True, it is possible, once the three steps have been accomplished, to predict occurrences of the property M on the basis of information bearing on the base level. If P is a neurological property, it will be possible to predict an occurrence of a mental property M on the basis of the observation of a neurophysiological process which is of a type regularly giving rise to occurrences of P. But the crucial question is whether this prediction is possible on this basis only. This is what Kim claims when he says that when an explanation or prediction of an occurrence of M is given on the basis of a successful functional reduction, « the explanatory/predictive resources marshalled are exclusively from the lower reductive-base level » (Kim 2000, p. 21) - and it is only the truth of this claim that could justify the thesis that functional reduction is a kind of logical reduction. But the claim is wrong. Let us examine the crucial second step of the functional reduction, where the link between the levels of M and P comes in. Kim acknowledges that the link between the realising property and the realised property is not a logical one: « The fact that a given neural property realizes, say, pain is empirical and contingent » (Kim 2000, p. 24). Let us abstract in the present context from the thesis of contingency[21]. To say that the fact that M is realised by P in the species S is an empirical fact, means that the link of realisation can only be known a posteriori.

In order for the link of realisation between P and M in S to be able to play a role in explanation and prediction, that link must be nomological and not merely factual. It is necessary that the individuals of species S possess the property P each time they possess property M, not only by accident but in virtue of a law of nature. Without this condition, it

would neither be possible to explain nor to predict that a given individual of species S possesses M, on the basis of the neurophysiological prediction that it possesses P. The prediction/explanation that the individual has M, presupposes the nomological premise that P realises M in species S; in other words, it presupposes a local bridge law. Elsewhere, Kim has explicitly presented the reduction which is accomplished by the discovery of the realising property of a property which had initially been characterised functionally, as a « local reduction » which is carried through with the help of « an array of S-restricted bridge laws of the form, $S \rightarrow (M_i \leftrightarrow P_i)$, for each mental kind M_i » (Kim 1992a, p. 19)[22]. In a local reduction, which is thus weaker than Nagelian global reduction, a higher level property is not Nagel-reduced to a lower level property simply, but rather relatively to each of a number of disjoint domains (e.g., species) S. It may be true that, as Kim says, in his « functional conception of reduction [...] there is no talk of "bridge laws" » (Kim 1999, p. 12; 1997c, p. 51, my italics), in the sense that it does not mention them explicitly. However, the existence of local bridge laws is objectively a necessary condition for accomplishing the functional reduction of a higher-level property (more precisely, the discovery of a local bridge law is necessary to carry through step 2 of the functional reduction).

Once one has noticed the essential intervention of local bridge laws in functional reduction, one can no longer consider it a form of logical reduction[23]. If functional reductions presuppose local bridge laws it is no longer true that they « are reductive in that the explanatory/predictive resources marshalled are exclusively from the lower reductive-base level » (Kim 2000, p. 21). Kim justifies the claim of « exclusiveness » by saying: « What provides the deductive linkages from the base level to the target property M is a definition, namely a functional characterization of M in terms of causal relations involving items at the base level. » (Kim 2000, p. 21). But the functional definition of M provides only an existential quantification over the properties of the base level which satisfy a certain

causal/nomic specification[24]. Such an existential quantification does not provide a deductive link from the base level to the level of M in the sense which would be necessary for the prediction of an occurrence of M solely from information at the base level. The following argument (A) is not deductively valid :

(A) (1) Fa, where a is an organism capable of instantiating mental properties by instantiating a realising property of the (neurophysiological) base level, and F is a base level property.

(2) : $(\forall x)\ (Mx \leftrightarrow (\exists P)(Px \wedge D(P))$, where D is a causal/nomic condition on the properties P of the base level[25].

Therefore, Ma.

It is true that (2), the functional definition of M, provides a link between the two levels of properties, and even a « deductive link », but in the absence of knowledge that property F of the base level is one of the realising properties P of M it is impossible to deduce the occurrence of M, solely from information on the occurrence of F. It is equally true that it is not necessary, for predicting the occurrence of M exemplified by a, to know the particular property which realises M in organisms of the type a. It suffices to complete premises (1) and (2) either by a specification of the set of realising properties of M (one of which is F), or by the specification of a subset of these realising properties including F. But in any case, the mere existential quantification figuring in the functional definition (2) will not suffice.

Our thesis that the second step in a functional reduction must include reference to a nomological realisation relation (a local bridge law)[26] is stronger than necessary for the present argument, which is intended to show that functional reduction is not a kind of logical reduction: to show this, it suffices to point out that the link of realisation between M and P in S is empirical (and thus known only a posteriori). As we have already noted above, this is explicitly acknowledged by Kim[27].

Kim denies the importance of the second step in a functional reduction, which is crucial according to our analysis, and which consists in finding the realising property P of a property M for a system of type S. For Kim « the crucial issue » is whether the property is « functionalisable », which presupposes that it can be given an implicit functional definition and that its functional role is fulfilled by some realising property or other[28]. « If a mental property has been functionalized, the rest is up to science; from a metaphysical point of view, it is as good as having been reduced » (Kim 2000, p. 25). Now, if our analysis is correct, functionalisation is not in itself sufficient for the explanation/prediction of an occurrence of M: it is necessary in addition to know the local bridge law $S \rightarrow (M \leftrightarrow P)$[29]. In Kim's own words, one can express this conclusion thus: « The possibility of functionalization [...] is a necessary condition of microreduction », but it is not, contrary to what Kim claims in some places[30], sufficient, for « whether the reduction will actually be executed is an empirical [...] question of science » (Kim 1997b, p. 202-3). Functional reduction, i.e. the indication of a functional definition, leads only to reducibility[31] and not to reduction, and in particular not to logical reduction.

Therefore, the argument Kim uses to show that Nagelian reduction is not logical reduction applies mutatis mutandis to functional reduction which is also Nagelian, although only locally. Instead of the Nagelian prediction

« System S will instantiate T at t

$M \leftrightarrow T$

Hence, S will instantiate M at t » where «$M \leftrightarrow T$» (Kim 2000, p. 22) is a global bridge law, functional reduction says:

« System S will instantiate T at t

$S \rightarrow (M \leftrightarrow T)$

Hence, S will instantiate M at t » where «S → (M ↔ T)» is a local bridge law to the effect that in systems of type S, M is realised by T.

It follows that one can turn Kim's criticism of Nagelian reduction against his own model of functional reduction. The following quote from Kim applies equally well to predictions based on functional and on Nagelian reduction: « Predictions of this form, therefore, are not predictions of the occurrences of M solely on the basis of information concerning the phenomena and laws at the base level, and hence do[es] not meet the desideratum on reduction » (Kim 2000, p. 22, Kim's italics) i.e., we should add, logical reduction.

One can also turn against Kim his criticism of the theory[32] according to which mental properties are identical to brain properties in the way of Kripke's necessary yet a posteriori identities, along the model of the identity of water and H_2O, namely: « Since these identities [...] are only empirically knowable and [since] they must be involved in any prediction of, say, pain on the basis of neural information, it will not be possible to predict occurrences of pain solely on the basis of information concerning the neurobiology or behavior of organisms » (Kim 2000, p. 24). Given that the factual (and nomological) link between the functional property M and its realising property in an individual of species S can also be known only empirically, and given that the knowledge of this link is indispensable for the prediction of an occurrence of M on the basis of information bearing on the base level, this prediction does not meet the requirements of logical reduction either.

Jackson (1994) and Chalmers (1996) have argued that “high-level facts and laws are entailed by all the microphysical facts (perhaps along with microphysical laws)” (Chalmers 1996, p. 71). In particular, “if materialism is true, then the psychological story about our world is entailed by the physical story about our world” (Jackson 1994, p. 105). I do not put into doubt the importance or correctness of Chalmers and Jackson’s thesis that higher-level facts supervene or are in a metaphysical sense entailed by all microphysical facts. However,

contrary to what they sometimes suggest, such metaphysical entailment does not suffice for the existence of an explicit deduction of those higher-level facts, on the mere basis of lower-level facts and a functional analysis of the higher-level concepts. According to the two-dimensional semantics of statements containing higher-level predicates that can be functionally analysed[33], the crucial a posteriori information about which property realises a given higher-order property in the actual world, is provided by the context of the utterance. Nevertheless, in the above argument (A), the construction of an explicit deduction of Ma, given Fa and the functional analysis of M, presupposes the explicit representation in the premises of the contextual information about the role-filler by "the right context-giving sentences" (Jackson 1994, p. 111). The mere knowledge of the base level-fact Fa and the conceptual analysis of the functional role of M, do not on their own allow to deduce Ma.

4. Conclusion

Emergentism tries to do justice to the intuition that the satisfaction of the Nagelian requirements on reduction, far from being sufficient for a successful reduction, allows one at best to ask clearly the following question to which the full reduction would then give an answer: why is the property M, in individuals of species S, nomologically linked to the realising property P? As long as no answer to this question has been found and as long as this link remains a brute unexplained fact, to consider M as an emergent property is a way of expressing the intuition that the existence of M has not been completely reduced to a physical condition, in a purely conceptual and therefore perfectly intelligible way. Kim proposes functional reduction as a model of reduction which allows one both to ask the question and to answer it. To give a functional definition of property M is to characterise it in terms of causal/nomic relations in which the objects possessing M enter by way of their possession of one or the other of the realising properties of M. As the realising property is mentioned in M's

very definition, the gap between the realising and the realised levels seems to have been bridged by a conceptual and therefore a priori intelligible link. Therefore, Kim claims to have found in functional reduction a form of reduction which fulfils the emergentist requirement of making the link between the property M and its realising property intelligible, rather than leaving it as the mysterious brute fact it remains after a successful Nagelian reduction.

However, I have tried to show that functional reduction permits one to explain/predict an occurrence of M only by introducing a new brute fact which is just as mysterious from the emergentist point of view as a Nagelian bridge law. This brute fact is nomological just as a bridge law, and it goes beyond a mere functional definition: it is the empirical fact that M possesses the realising properties P_1, P_2, ... P_n. The question is no longer: why is M linked to P by a bridge law?, but rather: why is M realised by P_1 or P_2 or ... P_n ? However, neither of these questions has a purely logical or mathematical answer, and in this sense M would, according to the emergentist criterion, still remain an emergent property, even after a functional reduction.

There is no reason to deny the intuition supporting the emergentist criterion of logical reduction. It seems perfectly legitimate to feel that there is a sense in which even the discovery of the realising property P of pain in humans does still not allow us to fully understand where the pain comes from, on the basis of information on P and the processes which lead to occurrences of P. After all, the mere knowledge of the base level does not suffice to deduce logically that the subject possessing P feels pain. But the consideration of the case of the mass of complex objects pleads against the emergentist interpretation of reduction adopted by Kim, i.e. against the idea of identifying emergent with irreducible properties on the one hand and resultant with reducible properties on the other. The mass of a complex object is no resultant property because it cannot logically or mathematically be deduced solely from information about its parts and their masses, without any information

about the bridge law specifying the mass of the whole as a function of the masses of the parts and the nature of their link. The emergentist concept of « logical reduction » considers the mass of the whole as a property which is irreducible (because emergent) with respect to the masses of its parts. But a concept of reduction which considers irreducible a property so clearly reducible is too strong to be adequate[34].

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[1] Nagel's model of reduction is often presented with biconditionals as bridge laws, but this strengthening is neither necessary nor contained in Nagel's original proposal.

[2] See Putnam (1967), Fodor (1974), Kim (1992a).

[3] See, e.g., Churchland (1988, p. 41).

[4] See ***.

[5] Nagel's thesis was originally formulated in the spirit of the tradition of logical empiricism, in terms of predicates. I shall however occasionally allow myself to speak, in the realist mode, of concepts or properties being reduced. I think that the difference does not influence the issue of the present discussion.

[6]Kim (1993) criticises Davidson for presupposing that reduction requires strict bridge laws, an idea which characterises, according to Kim, "a tendency, among some current anti-reductionists, to base their arguments on an unrealistically stringent and idealized model of reduction, thereby weakening their conclusions" (Kim 1993, p. 26).

[7] See Hooker (1981).

[8] Kim (1992b; 1997b; 1997c; 1998; 1999; 2000).

[9] In particular, Alexander (1920) and Lloyd Morgan (1926).

[10] Page references to Kim (2000) are to the published French translation but the quotes are taken, with kind permission of J. Kim, from the original English manuscript; similarly Kim (1999, p. 14; 1997c, p. 52/53).

[11] Kim introduces this distinction in Kim (1997c, p. 47), and Kim (1999, p. 8).

[12] Similarly Kim (1999, p. 12).

[13] As Kim (1997c, p. 51; 1999, p. 12; 2000, p. 17) notes, some of these dualistic theories even entail the existence of bridge laws whereas Descartes' version of interactionist dualism would not allow such bridge laws.

[14] Jackson (1994) and Chalmers (1996) have also argued that all facts except those concerning conscious experience “logically supervene” on the set of all microphysical facts. As I shall explain below, this does not imply that all macroscopic facts, in particular biological and psychological, can explicitly be deduced a priori from the microphysical facts.

[15] Kim (1992b, pp. 127/8; 2000, p. 18).

[16] Similarly, only logic and mathematics are required to explain the mass of the whole, given the masses of its parts: "When you know that the right and left halves of this table have each a weight of 50 pounds you understand why the whole table weighs 100 pounds." (Kim 1992b, p. 127).

[17] The mass M of a complex objet is certainly a "micro-based property" in the sense that the fact of having M « is the property of having proper parts a_1, a_2, ...,an, such that $P_1(a_1)$, $P_2(a_2)$,...,$P_n(a_n)$, and $R(a_1, ..., a_n)$ » (Kim, 1997a, p. 292), where P_1 is the property of having the mass of part a_1 etc. Nothing (with the possible exception of elementary particles) can have a mass M without having parts which have mass. But one cannot calculate M only from the masses of its parts. It is necessary also to take into account the nomic effect of the relation R on the result of this « physical addition » of masses which is not in general a simple mathematical addition. As Kim says elsewhere, « determination as such implies neither predictability nor explainability » (Kim, 1997a, p. 296). One can interpret this by noting that

the determination may be partial: The masses of the parts determine partially but not totally the mass of the whole. But the mass of the whole would only be predictable from the mass of the parts if the determination were complete.

[18] Kim (1997b) introduces the idea of the « functionalization » of a property as a decisive step towards its reduction. The suggestion that "explanatory reduction is [...] a two-stage process" (Levine 1993, p. 132), the first step of which is an a priori analysis aiming at identifying the causal role played by the property to be reduced, the second step being the empirical discovery of the "underlying mechanisms" (ibid.) playing that role, goes back to the functionalist version of the identity theory first formulated by Lewis (1966) and Armstrong (1968).

[19] See Kim (1997b, p. 195; 1998, p. 98; 1997c, p. 50; 1999, p. 10).

[20] This way to present things shows that functional reduction is an iterative process: one can conceive of the property P in turn as characterised in a functional way within the nomological network in which it takes part. This allows it to be considered in turn as a macroscopic property, relatively to a level of properties which are possessed by objects still inferior in size and complexity, and to which that property could possibly be reduced in turn, as soon as its realising property (or properties) has (or have) been found. See Lycan (1987, chap. 4; 1990).

[21] In order to show that functional reduction is not a type of logical reduction, it is sufficient to recognise that the link is not logical and thus not a priori but empirical and thus a posteriori. Beyond that, it is not a contingent fact but rather a nomological link. I disagree with Kim (1998, p. 99; 1997c, p. 53; 2000, p. 24) on the interpretation of the modal status of laws - contingent or necessary. But here is not the place to enter into this debate. The important and uncontroversial point is that the lawful link between realizing and realized property is known only a posteriori.

[22] In the same sense, Kim says that « from the definition of realization, it follows that P is sufficient for M - in fact, given the nomological constancy [...] of the realization relation, it follows that P is nomologically sufficient for M. » (Kim, 1997b, p. 197; 1998, p. 23).

[23] Kim notes explicitly that the supervenience entailed by the realisation relation which is in itself nomological and not logical, « has only the force of nomological necessity, not that of full metaphysical or logical/conceptual necessity » (Kim 1998, p. 24; similarly Kim 1997b, p. 197).

[24] See above, and the references in note 19.

[25] This equivalence corresponds to the first step of Kim's « functional reduction ». The thesis that mental properties can be functionally reduced in this way presupposes a functionalist conception of mental properties as second order properties, more precisely as « functional properties » which are the « second-order properties over B [a class of non-mental base level properties including physico-chemical, biological and behavioral properties] whose specification D involves the causal/nomic relation » (Kim, 1997b, p. 195; 1998, p. 20).

[26] This thesis is supported by some of Kim's suggestions, in particular Kim (1992a, p. 19), Kim (1997b, p. 197) and Kim (1998, p. 23); see above.

[27] See Kim (2000, p. 24).

[28] See Kim (2000, p. 24/5).

[29] What functionalisation establishes on its own is that the functionalised property is causally efficacious, by inheriting the causal powers of its realising properties; see Kim (1997a, p. 295). This is explained by the fact that functionalising M means to define M in terms of the causal relations in which the objects possessing M enter by virtue of the causal powers of one of their realising properties.

[30] Kim says that "functionalization of a property is both necessary and sufficient for reduction" (1999, p. 18; 1997c, p. 56), but takes the claim of sufficiency back immediately afterwards where he notes in a parenthesis : "sufficient at least as a first conceptual step, the rest being scientific research" (ibid.). This statement seems self-contradictory: To say that functionalization is only a first step toward reduction implies that functionalization alone is not sufficient for reduction, for something else, namely "scientific research" is required to accomplish it. Kim should say that the functionalization of a property is necessary and sufficient for its reducibility, not for its reduction. See the quote in the following note.

[31] « The functionalist conception of mental properties is [...] necessary and sufficient for reducibility » (Kim 1997b, p. 203; 1998, p. 101).

[32] See Block and Stalnaker (1999).

[33] See Stalnaker (1978).

[34] This paper elaborates on ***. I am obliged to ***.