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Anti-Reductionism Slaps Back[1]

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For nearly thirty years, there has been a consensus (at least in English-speaking countries) that reductionism is a mistake and that there are autonomous special sciences. This consensus has been based on an argument from multiple realizability. But Jaegwon Kim has argued persuasively that the multiple realizability argument is flawed.[2] I will sketch the recent history of the debate, arguing that much --but not all--of the anti-reductionist consensus survives Kim's critique. This paper was originally titled "Anti-Reductionism Strikes Back", but in the course of writing the paper, I came to think that the concepts used in the debate would not serve either position very well.

Multiple Realizability

Fodor and Putnam initiated the anti-reductionist consensus thirty years ago by noting the analogy between computational states and mental states (Fodor, 1965, 1974; Putnam, 1965, 1967). Any computational property can be "realized" or "implemented" in a variety of ways (electronic, mechanical, hydraulic), so it would be a mistake to identify any computational property with, say, an electronic property, since the same computational property can be implemented *without* the electronic property, for example mechanically. If thought is computational or functional, then for the same reason it would be a mistake to identify thought with any neural state; for thought can be implemented non-neurally, e.g. electronically. It would be wrong to identify thinking with a brain state if a device without a brain could think.

I have put these points in terms of identity. Computing square roots is not identical to any electronic property, pain is not a brain state, etc. But reduction is not

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[1] This is a slightly revised version of a paper, the unrevised version of which appeared in a volume of *Philosophical Perspectives* in part devoted to the work of Jaegwon Kim, *Philosophical Perspectives* 11, *Mind, Causation, and World*, J. Tomberlin (ed.). An earlier draft of this paper was presented at the Pacific APA meeting in March, 1995 in San Francisco at a symposium on the work of Jaegwon Kim. A version was also presented at the Centre de Recherche en Epistémologie Appliquée in Paris, at the meeting of the Società Italiana di Logica e Filosofia delle Scienze in Rome in January, 1996, at University College London, at the University of Maribor, Slovenia and at the CUNY Graduate Center.. I am grateful for comments to Alex Byrne, Noam Chomsky, Jerry Fodor, Ned Hall, Paul Horwich, Jaegwon Kim, Noa Latham, David Papineau and Daniel Stoljar. I discovered after writing this paper that elements of the points made by Kim and my reply were anticipated in a series of papers by David Papineau, notably Papineau 1985 and 1993; Papineau does not agree, however, with the line of thought expressed here in connection with the Disney Principle.

[2]The argument appears mainly in Kim 1992, but it is foreshadowed in Kim 1972, and various features of it are distributed in other parts of Kim's 1993b book, especially in Kim 1993a and in some unpublished papers. Other critiques of the multiple realizability argument have appeared in Richardson (1979), Enç (1983), Churchland (1986) and Bealer (1994). Pereboom and Kornblith (1991) argues against Kim, Kitcher (1980, 1982) argues against Richardson, and Blackburn (1993) argues against Enç and Churchland.

quite the same thing as identity. According to a variant of a commonly accepted analysis (Nagel, 1961), a theory U (for upper level) is reducible to a theory L (for lower level) if and only if the terms of U are *"definable"* in terms of L, and the laws of U are *explainable* (or approximations to them are explainable) by the laws of L plus definitions. The "definitions" can be seen as identities (temperature = mean molecular kinetic energy), but it is usually supposed that they can also be seen as nomic equivalences (by nomic necessity, the value of temperature is a known constant times the value of mean molecular kinetic energy). These definitions are often called bridge principles or bridge laws. The important point is that the multiple realizability observation applies to reduction, on either way of construing the definitions. If thinking is not even coextensive with any neurological property, then the term 'thinking' is not definable neurologically and so psychology is not reducible to neurophysiology. The difference between seeing the definitions in terms of identity as opposed to nomic equivalence will not loom large in this paper.

I keep speaking of realization. What is it? As Kim notes, we can think of realization this way. Suppose we have a family of interconnected macro-properties (e.g. mental properties or economic properties) of a given system (say a person). Suppose that corresponding to each of these macro properties there is a micro property in this system, and that the family of interconnected micro properties provides a mechanism for explaining the connections among members of the macro family. Then the micro properties realize the macro properties. (Of course, this talk of macro and micro is relative; properties that are micro relative to to one set of properties can be macro relative to another.)

Fodor and Putnam were reacting against the Unity of Science movement, a positivist ideology whose ultimate expression was Oppenheim and Putnam (1958), "Unity of Science as a Working Hypothesis". Oppenheim and Putnam divided all of science into levels, starting at the bottom with elementary particles and building up to molecules, cells, individuals, and societies. They argued that the science at each level was reducible to the next lower level, and thus that the laws of micro-physics are the basic laws of all sciences. By contrast, Putnam and Fodor advocated what might be called the Many Levels doctrine, the view that nature has joints at many different levels, so at each level there can be genuine sciences with their own conceptual apparatus, laws and explanations. Fodor's (1974) key article emphasizing the autonomy (which we can take to be just irreducibility) of the special sciences was subtitled "The Disunity of Science as a Working Hypothesis".

An illustration (see Block, 1995) of the Many Levels idea appeals to explanations of how a computer works at different levels. Suppose that a computer makes an error that is explainable in terms of a glitch in a program. The explanation in terms of the glitch is more general than a hardware account in that it holds of all computers that run this program no matter what the hardware. However, the hardware level will itself be more general in allowing explanations of computer errors due to vibration, a factor that is invisible at the program level. And the hardware level allows us to see similarities between different sorts of machines that use the same hardware but are very different at the program level. For example, a programmable computer may use much the same hardware as a dedicated word processor. Another influential analogy was Putnam's (1975) explanation of why a solid rigid round peg 1 inch in diameter won't fit through a

square hole in a solid rigid board with a 1 inch diagonal. We can contrast the "upper level" explanation in terms of solidity, rigidity and geometry with the "lower level" account in terms of the specific elementary particle constitutions of a specific metal peg and wooden board. The upper level account is more general in that it applies to any solid rigid peg and board with that geometry, including materials that are composed of glass (a supercooled liquid) instead of the lattice structure of metals or the organic cell structure of wood. But the lower level account is more powerful in that it explains the specific cases of solidity and rigidity themselves. Further, it is more general because it explains details of the interaction between the peg and the board, including cases where the peg crumbles or the board breaks or tears.[3]

Multiple realizability often applies within and between individual people. For example, the central nervous system is often supposed to be quite plastic, especially in the young. If the brain is injured, knocking out some capacities, the capacities often reappear with different neural realizations. Recently, Mriganka Sur (2003) and his colleagues at MIT rewired the visual system of one eye of neonatal ferretts to feed to the auditory cortex. They found that ocular dominance columns of the sort found in visual cortex formed in auditory cortex and the auditory cortex functioned much like the visual cortex normaly functions. Further, there are many states and capacities that are known to be implemented differently in different people, e.g. the capacity to read. The multiple realizations are often themselves multiply realized, a fact that I will sometimes ignore in this paper for simplicity, talking as if each special science has only one level of realization, the physico-chemical level.

Heterogeneous Disjunctions and Kim's Challenge

Fodor and Putnam deny that multiply realizable upper level properties can be identified with or defined in terms of lower level properties. Rigidity cannot be characterized in terms of a lattice structure of the sort that we find in many rigid materials, since an amorphous structure such as glass can also be rigid. Pain and thought may be similarly multiply realizable. Let us suppose so. But if that is so, can't pain be identified with or defined in terms of the *disjunction* of all of its nomically possible realizations? Putnam (1967) said that this possibility "does not have to be taken seriously". But Kim has raised questions that justify taking it seriously. The rest of this paper is concerned with this issue.

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[3]These examples have flaws. Rigidity is not the best example of an "upper level" property in the sense discussed here. Although rigidy applies to things that are made out of particles rather than to the particles themselves, it does not belong to any particular level of the hierarchy of levels that are supposed to be micro-reduced one to the other.

And there is another flaw common to both the computation and the peg/hole analogy: both are as much matters of mathematics as empirical science. Geometry carries the weight in the peg/hole case. And in the program case, once the program and the error are fully specified, explaining the error in terms of a glitch in the program is like explaining sleep in terms of dormitivity. Still, there is some explanatory force since alternative explanations are excluded. The thermodynamics/statistical mechanics example presented in Nagel (1961) is far better for the points I am making here but takes a lot of space to spell out.

Consider the disjunctive property whose disjuncts are every physico-chemical property that could, compatibly with the laws of nature, realize pain. Pain is *nomically equivalent* to that disjunction in that the two are coextensive in all possible worlds compatible with the laws of nature. So why isn't pain identical to that disjunction? Or at least, why can't we "define" 'pain' in terms of that disjunction for the purposes of reducing psychology to physics and chemistry? This is the challenge that Kim raises for the anti-reductionists.

We can get a clearer idea of what it is for pain to be nomically equivalent to a heterogeneous physico-chemical disjunction by considering the objection that nothing could be nomically coextensive with a heterogeneous disjunction because heterogeneous disjunctions have no place in *laws*. This objection is a red herring. To see why, we must distinguish between two grades of nomic necessity. The strong grade is nomic necessity as a matter of law. For example, electrical and thermal conductivity are coextensive as a matter of law, the Wiedemann-Franz law. The weaker kind of nomic necessity attaches to anything that is true in all possible worlds that are compatible with laws of nature. (We don't have to answer the question whether there are more possible worlds compatible with the laws of physics than with all the laws of nature to understand nomic equivalence.) Consider certain consequences of laws. Suppose it is a law that all metals expand when heated. Then it is nomically necessary that all metals either have the property of expanding when heated or are made of green cheese. Because of the heterogeneous disjunction--expands when heated or is made of green cheese--this claim is perhaps not a law, but the heterogeneous disjunction does not preclude its being nomically necessary. However we decide to use the word 'law', the point is that there is a kind of nomic necessity that is not allergic to heterogeneous disjunction, so the attempt to appeal to intuitions about laws to rule out the nomic equivalence of pain with a heterogeneous disjunction won't fly.

It is worth noting that consequences of laws are often very unlike stereotypical laws, yet are nomic necessities in good standing. Another example is "apparatus necessities" (Block, 1994): consequences of laws keyed to descriptions of a specific apparatus. Thus consider a setup in which the insertion of some coins in a machine causes a box of candy to emerge. Suppose we could completely describe the machine, the insertion and the candy emergence in terms of the motions and masses of all the particles therein. Then the description of the input and the machine, together with the appropriate laws of physics, would entail the description of the output, revealing that what happened was a nomic necessity (idealizing away from quantum effects and external perturbations). Any object (machine plus inserted coins) with that elementary particle constitution *has* to evolve in that way, yielding the box of candy.

In terms of this distinction between laws and mere nomic necessities, or, if you like, between two grades of nomic necessities, then, all Kim requires is nomic equivalence in the weaker of the two senses, and that is the way that I will be using the term 'nomic necessity' (and 'nomic equivalence') here. (Incidentally, nomic necessities in the sense used here do not include by-products of the initial conditions of the universe. Nomic necessities are true in all possible worlds compatible with laws of nature whatever the initial conditions.)

Now back to Kim's challenge. There is a disjunction of physico-chemical properties that can, compatibly with the laws of nature, realize pain. The coextension of

pain with that disjunctive property is nomically necessary (in the weak sense). So can this nomic equivalence serve to reduce pain to the physico-chemical disjunction? Another lame answer is: no, because the disjunction is infinite. But why is an infinite disjunction incompatible with the aims of reduction? And even if infinite disjunctions are incompatible with the aims of reduction, how do we know that the disjunction is infinite? The universe is now thought to be Riemannian and if the curvature is constant and positive (unknown at present), it is finite in space-time, so for all we know the disjunction may be finite too. The anti-reductionist should not try to base his position on a speculative empirical claim. But the more important response is the question: why is a nomic necessity between pain and an infinite disjunction incompatible with the aims of reduction? Kim's challenge is not met by simply invoking infinity.

Fodor responds to the puzzle I am focusing on by, in effect, adding a condition to Nagel's conception of reduction, namely that the inter-level definitions or bridge principles connect *kinds* to *kinds*. And he assumes that a heterogeneous disjunction is not a kind. But he does not say *why* this nomic equivalence is no good for reduction.

Before I pursue these questions further, let me just say a word about heterogeneity. The disjunction of all nomologically possible realizations of, say, pain, is said by Kim to be a heterogeneous disjunction. But, one might object, it is not totally heterogeneous, since the disjuncts resemble one another at least in that they are all realizations of pain. I believe that Kim thinks of this resemblance as highly superficial, along the lines of saying dormitive substances resemble one another in that they cause sleep. I will return to this issue in the second half of the paper, but for now I will go along with thinking of these disjunctions as heterogeneous.[4]

Explanation

We might hope for some illumination on heterogeneous disjunctions by considering the *explanation* condition on reduction. Laws of the reducing theory together with "bridge" laws or definitions are supposed to explain the laws of the reduced theory. This condition is often ignored in the debate over multiple realizability because of the widespread positivist assumption that explanation is just deduction. If the terms of the upper level theory are all definable in lower level terms, explanation of the upper level laws is said to be trivial. The upper level laws can be deduced from the lower level theory plus definitions, and if the lower level theory isn't rich enough, the "images" of the upper level laws can simply be added to the lower level theory. As images of laws, they will be nomically necessary. Of course, if one has to do *psychology* to discover basic laws of *physics*, reductionism loses its epistemic bite even if it is not compromised as a metaphysical thesis.

So let us ask: Will heterogeneous disjunctions at the lower level suffice for explaining upper level laws? Consider an upper level law, $U_1 \Rightarrow U_2$. (I leave out quantification for simplicity.) U_1 is realized by a heterogeneous disjunction, L_1 or L_1*--nothing else can realize U_1 (let's suppose). And U_2 is realized by another heterogeneous disjunction, L_2 or L_2*. Now suppose there are two sorts of cases in which the upper level law holds, the starred and unstarred cases, and we can explain *each case* of $U_1 \Rightarrow U_2$ via

[4] Kim tends to use pain as an example. In my view, thought is a much better candidate for multiple realization and for being a functional property.

appeal to the lower level. That is, there is a lower level law $L_1 \Rightarrow L_2$ and another lower level law $L_1^* \Rightarrow L_2^*$. Each case of $U_1 \Rightarrow U_2$ is explained by one of these laws.

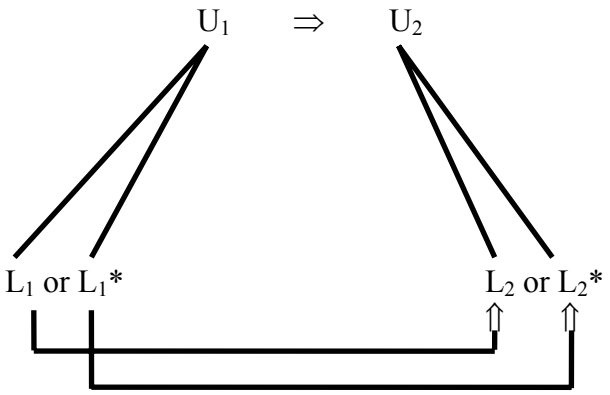

Figure 1

U_1 is realized by a heterogeneous disjunction, L_1 or L_1*; U_2 is realized by another heterogeneous disjunction, L_2 or L_2*. There is a lower level law $L_1 \Rightarrow L_2$ and another lower level law L_1* $\Rightarrow L_2$*. Each case of $U_1 \Rightarrow U_2$ is explained by one of these laws.

Are the properties U_1 and U_2 and the law $U_1 \Rightarrow U_2$ thereby reduced or not? Of course, there is all the difference in the world between a reduction to a heterogeneous disjunction and a reduction to a single property that gives a uniform explanation of all cases. But that doesn't show that there is no reduction to a heterogeneous disjunction. In one sense of 'reduction' yes, there is a reduction, and in another sense no, there is not. In one sense of 'reduction', if you have explained *each implementation* of the law, you have reduced the law. But if the question at hand is just a matter of how one decides to use the word 'reduction', it is of little interest. Philosophers sometimes analyze our ordinary concepts such as knowledge, belief, etc., and these analyses have a point because our everyday concepts are of interest to us. But there is much less interest in analyzing technical philosophical concepts. We should use whatever technical concepts do the jobs we want done. I mentioned that Fodor adds the condition to Nagel's characterization of reduction that bridge principles connect kinds to kinds. If we are to accept this revision, it will not be as a stipulation about the words 'reduction' and 'kind', but as a way of codifying the idea that bridge principles that link kinds to heterogeneous disjunctions are importantly defective. But we have yet to find a persuasive rationale for this idea. The upshot of the remarks of the last few paragraphs is that it is not obvious how to find an answer in the requirement of explanatory adequacy.

Fodor (1974) hints at a proposal: what's wrong with bridge principles that connect kinds to heterogeneous disjunctions is that the disjunctions do not have their kind-hood *independently certified*. We should not accept the nomic equivalence of upper level kind U_1 with a lower level disjunction L_1 or L_1* as a bridge principle unless the disjunction appears in laws at its own level. But this condition has *no teeth*. If $U_1 \Rightarrow U_2$ is a law, and if U_1 is nomically equivalent to L_1 or L_1* and U_2 is nomically equivalent to L_2 or L_2*, then [L_1 or L_1*] $\Rightarrow$ [L_2 or L_2*] is just as nomically necessary as is $U_1 \Rightarrow U_2$. If

the lower level theory does not contain this nomic necessity, it can just be added, as just noted, and the upper level law is reducible to the lower level science, so supplemented, in one sense of 'reduction'. Of course, Fodor's condition rules out the reduction if [L_1 or L_1*] $\Rightarrow$ [L_2 or L_2*] is not a *law*. But the question of whether this nomic necessity is a law amounts to the question as to whether the disjunctions ([L_1 or L_1*], [L_2 or L_2*]) are *kinds*, and that is the very question to which we do not yet have an answer. And even if we accept that the disjunctions are not kinds and the nomic necessity involving them is not a law, we still lack an answer to the question of why that ought to block reduction.

Kim's Proposal

The place we are at in the dialectic is this: Fodor blocks the use of a bridge definition connecting pain to the physico-chemical disjunction with which it is nomically equivalent by laying down two conditions on reductions: First, bridge definitions connect kinds to kinds and second, heterogeneous disjunctions are not kinds. But we have yet to see a justification of these ideas.

Kim now enters the fray with a proposal: kinds are projectible properties. He shows that this proposal has a very important merit in light of Fodor's suggestion about kinds, namely that heterogeneous disjunctions are not projectible and therefor they are not kinds. (A and B are projectible if finding of an A that it is a B gives one some--even if very small--justification for believing that the next A is a B.)

Consider the putative law that people who have (rheumatoid) arthritis are helped by (that is, their symptoms are meliorated by) Ibuprofen. Suppose that this is a well confirmed law. We have 50,000 recorded cases of people who have the disease and who are helped by the drug, and no contrary cases. Now pick another disease at random, say lupus, and consider the putative law that people who have either arthritis or lupus are helped by Ibuprofen. This putative law has a heterogeneous disjunctive property (arthritis or lupus) in its antecedent. Does that prevent it from being well confirmed by the same data that confirmed the original law? Each person who has arthritis also has either arthritis or lupus. So *if* the disjunction is projectible, then each datum that confirms the original law also confirms the disjunctive law. Now we have the principle that if P is "well" confirmed and P entails Q, then the evidence that "well" confirms P also confirms (though perhaps not well) Q. (The need for the 'well' is discussed in the footnote at the end of this paragraph.) But the claim that people who have arthritis or lupus are helped by Ibuprofen is equivalent to the conjunction of the following two laws:

People who have arthritis are helped by Ibuprofen

People who have lupus are helped by Ibuprofen

And if the the law with the disjunctive antecedent is well confirmed by the data that confirms the first of these laws, then, it might be said, the second conjunct of the conjunction is confirmed by the same data. But we have no information about lupus in this data base at all, so the assumption that the disjunction is projectible leads to a ridiculous result. Conclusion: the heterogeneous disjunction is unprojectible. [5]

[5] The "tacking paradox" derives an absurdity from 2 principles: (1) If P entails Q, then evidence that confirms P also confirms Q, and (2) If T entails a that a certain datum will be observed, then that datum confirms T. The absurdity is much like the one in the text. If theory T entails datum-sentence D, then by (2) D confirms T. Conjoin T with anything at all, arbitrary claim A. T&A also

One question one might have about Kim's proposal is what notion of projectibility he might have in mind. The usual notion of projectibility may be too epistemic to bear the metaphysical weight that the notion of a kind is supposed to bear. This idea is bolstered by attention to Kim's argument, to which we now turn.

Kim's Argument I

Here is the first part of Kim's argument. Pain is nomically coextensive with a heterogeneous physico-chemical disjunction. Therefor either *both* pain and the disjunction are kinds, or *neither* pain nor the disjunction are kinds. Why? Because the kinds are the projectible properties, and one of two nomically equivalent properties is projectible if and only if the other is.

But wait! Why is it that nomically equivalent properties must be both projectible or both not? Here we see again that the usual notion of projectibility is not what Kim needs, for on the usual notion having to do with justified belief, we could be justified in supposing that something will have one of two nomically equivalent properties without being justified in supposing it will have the other. For one might not know about the nomic equivalence. The notion of projectibility that Kim needs is what one might call objective projectibility, which hinges on a notion of *objective* evidential support, whether or not anyone knows about it. The idea would be that if there is a certain degree of evidential support for the obtaining of one property, the same degree of objective support obtains for any nomically equivalent property whether or not anyone knows about it. In what follows, I will assume that some such notion is available. (An alternative line of thought, which I will not pursue, would be to take all of projectibility, nomicity, reduction and kindhood to be fundamentally epistemic.)

Now back to the argument. Both pain and the heterogeneous disjunction that is nomically equivalent to it are kinds or neither are. If both are kinds, then the multiple realizability argument against reductionism is no good. For the bridge law that associates pain with the disjunction links a kind to a kind, thereby disarming the Fodor-Putnam objection to the reductionist claim that pain is reducible to the disjunction. If the second alternative is right, if neither is a kind, then in particular pain (and thought) is not a kind and there is no genuine science of pain or thought. The power of Kim's argument is that reductionism beats the Many Levels view and the multiple realizability argument either way. If there *are* general psychological kinds, they may be reducible despite the

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entails D and so is confirmed by D. But T&A entails A, and so by (1), D confirms A. But A was arbitrary. In effect, we have derived that anything confirms anything. The role of the 'well' is to keep D from confirming T&A. A generalization is well confirmed by a datum only if it confirms "all" of it. Thus 'arthritis or lupus' is projectible (relative to the hypothesis) only if the evidence that well confirms 'Anyone who has arthritis is helped by Ibuprofen' also well confirms 'Anyone who has arthritis or lupus is helped by Ibuprofen'. Thus the projectibility of the disjunctive predicate depends on whether the evidence that confirms 'Anyone who has arthritis or lupus is helped by Ibuprofen' confirms "all" of it. The upshot is that what makes the disjunctive predicate 'arthritis or lupus' unprojectible (relative to melioration by Ibuprofen) is that evidence of melioration by Ibuprofen can be relevant to confirmation of "part" of the disjunction but not "all" of it. The upshot is that there is not an enormous distance between the Principle used by Kim and the conclusion that heterogeneous disjunctions are not projectible. But that is no problem if the Principle is true.

multiple realizability argument. And if there aren't any general psychological kinds, reductionism wins in another way. For even if there are no *general* psychological kinds, there can nonetheless be restricted psychological kinds that are not multiply realizable with respect to lower level science. Pain in general and thought in general are multiply realizable. If that makes them non-kinds, perhaps human pain or human thought is not multiply realizable, or if not, Ned-pain or Ned-thought or Ned-pain-now. And so there is room for these restricted kinds to be reducible to physics and chemistry.

Kim's Argument II

Thus far we have seen a dilemma for the anti-reductionist: both pain and its disjunctive nomic equivalent are kinds or both are non-kinds. If the former, there is no multiple realization and reductionism avoids the multiple realization argument; if the latter, pain and other mental properties are not kinds at all and there is no science of them as such. Though Kim is inclined to emphasize the dilemma, he has a powerful argument in favor of the latter position--that there are no special science kinds as such, that is that there are no multiply realizable special science kinds, and the only special science kinds there are are those that are reducible to the physics and chemistry of the specific realizations. Pain is not a kind; human pain probably is, but only because it is reducible to a human physical kind. The argument is simple: the reasoning illustrated by the arthritis and lupus example establishes that heterogeneous disjunctions are not projectible and therefor not kinds. But if they are not kinds, then neither are the special science properties like pain and thought that are nomically equivalent to them. The upshot is that properties distinctive of psychology, economics and biology that are multiply realizable, being nomologically equivalent to heterogeneous physico-chemical disjunctions, are not kinds at all. There are no genuine multiply realizable sciences.

Kim illustrates the point with this example: consider the claim that jade is green. Suppose we send out our assistant for samples of jade and we find that all are green. Is the claim that jade is green well confirmed? No, for perhaps all the samples the assistant has brought in are *jadeite*. (There are two minerals that are classified as jade: jadeite and nephrite.) On that basis we should not expect that the next sample of jade that is nephrite will be green. So "Jade is green" is not a law. And the reason is that jade is not a kind (that is, not projectible) but rather a heterogeneous disjunction of two kinds, nephrite and jadeite.

In his paper in this volume, Jerry Fodor notes that the concept of jade is not the concept of a certain set of superficial properties like appearance and malleability. If one could transform glass so as to look and act like jade, that wouldn't make it jade. But this claim does not motivate any objection to Kim. Kim uses the example to argue that (heterogeneously) disjunctive properties are not projectible and therefor are not kinds. Jade is disjunctive and not projectible, and the latter because of the former, according to Kim. Fodor's point does not challenge that.

(Though it is irrelevant to the topic at hand, I note that the concept of jade may be the concept of superficial properties with one or two restrictions. If we find some previously unknown kind of stone that has all the superficial properties of jade, we might well count it as a third type of jade, even if no samples of it had been classified as jade before. It would be synthetic jade not artificial jade. Glass may be ruled out because it is not a stone or because it is a substance that has been classified in the past as non-jade.)

Fodor makes a distinction between an open and a closed disjunction. Jade is a closed disjunction because (according to Fodor) only substances that are jade in the actual world (jadeite and nephrite, as far as we know) can be jade in any possible world. Realizers of pain (or thought) are an open disjunction because even if there are no actual silicon pains (or thoughts), there are possible silicon pains and thoughts. Fodor thinks that Kim's argument depends on ignoring this distinction. If Fodor is right about jade, jade is somewhat more projectible than Kim supposes, but the special science properties that Kim is concerned with do not gain in projectibility since they are open. So Fodor's distinction makes little difference. Kim's argument is could be put this way: since that open disjunction is nomically equivalent to pain, pain is just as non-projectible and non-kind-like as that open disjunction. Even taking Fodor's point into account, Kim's position profits from the plausible unprojectibility of an open disjunction.

For another illustration of Kim's position, consider dormitivity, the property of a substance that consists in its having some *other* property such that if the substance is ingested, that other property causes the ingester to sleep. Dormitivity is a *second order* property in that it is defined as the possession of some other property (usually a first order property) that has a certain causal role. The notion of a second order property is a slight generalization of the notion of a functional property that has played such a large role in the establishment of the anti-reductionist consensus. (A functional property is the possession of some property that has a certain causal role with respect to inputs, outputs and other properties that also mediate between inputs and outputs.) There is a simple account of the notion of *realization* in terms of the notion of a second order property. The realizations of dormitivity are just the first order properties that actually cause sleep.[6] Potassium bromide (KBr) and chloral hydrate ($CCl_3CH(OH)_2$ are chemically different substances that both cause sleep (in different ways), and they are therefor realizations of dormitivity. For simplicity, let's suppose KBr and $CCl_3CH(OH)_2$ are the only nomologically possible realizations of dormitivity. So either dormitivity is a kind and is reducible to the heterogeneous disjunction of KBr and $CCl_3CH(OH)_2$. Or the disjunction isn't a kind and neither is dormitivity.

Kim's argument commits him to the latter option. Suppose we ask our assistant to bring us dormitive substances. We test each one in our lab and find that they are all carcinogenic. Should we conclude that the next dormitive substance that the assistant brings to us is likely to be carcinogenic too? In other words, is dormitivity projectible? Kim's line of thought dictates no. For suppose that we find out that all the samples of dormitive substances that our assistant has brought to us and that we have tested are samples of KBr but the next dormitive substance is $CCl_3CH(OH)_2$. The reasoning just mentioned dictates that we cannot project carcinogenicity from KBr to $CCl_3CH(OH)2$. Dormitivity is not a kind because it is not projectible. The basis of kinds is similarity and that is precisely what heterogeneous disjunctions lack.

The upshot is that the supposed kinds of psychology and other multiply realizable special sciences are not kinds at all. Kim asks us to consider a possible law:

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[6]Actually, the realizations can be second order and according to me, dormitivity itself can be one of them. See Block (1990) for a discussion of some of these peculiarities. I will ignore these complications here.

> "Sharp pains administered at random intervals cause anxiety reactions". Suppose this generalization has been well confirmed for humans. Should we expect *on that basis* that it will hold also for Martians whose psychology is implemented (we assume) by a vastly different physical mechanism?...The reason the law is true for humans is due to the way the human brain is "wired"; the Martians have a brain with a different wiring plan, and we certainly should not expect the regularity to hold for them just because it does for humans. ..."Pains cause anxiety reactions" may turn out to possess no more unity as a scientific law than does "Jade is green." (Kim, 1992, p. 16)

The analogy between dormitivity and pain is apt from Kim's point of view. His arguments point towards the conclusion that there is no more of a science of pain than there is of dormitivity. In both cases, the real scientific kinds are those of the realizations, the chemicals that cause sleep in the case of dormitivity and the specific neural structures of specific pain-feeling organisms in the case of pain. What is common to pains in virtue of which they are pains (a question I pressed in Block, 1980b)? According to Kim, the answer is conceptual: the concept of pain is second order, the concept of a state of having some other property that has a certain role. Similarly, what is common to dormitive substances in virtue of which they are dormitive is simply that they fit the concept of dormitivity, that is that they cause sleep. Fodor notes that "What makes Wheaties the breakfast of champions?" (a question that sometimes appears in advertising in the U.S.) has two types of answers. There is a conceptual answer: it is eaten by lots of champions. And there is a scientific answer which you'll have to ask a nutritionist about, perhaps that it has just the right balance of vitamins, minerals and insect parts. Kim's answer to "What do pains have in common in virtue of which they are pains?" is an answer of the first sort. Pain has an a priori conceptual analysis as a second order property, as does dormitivity. And there is *no answer* of the second sort.

The anti-reductionist may be tempted to make a simple retort: "Look, there *are* special sciences, as a glance at any economics or cognitive science journal shows. So any argument that there aren't any is badly off base." But Kim's point is not so easily silenced. Of course, in *some sense* there are special sciences. But there is some latitude in interpreting what it is that they are about. The upshot of Kim's argument is that real scientific enterprises do not have multiply realizable domains. In Kim's view psychologists are real scientists, but they study *human* psychology which is a science precisely because it is not multiply realizable. Presumably, he will say that geology is the science of specific physical structures; to the extent that Earthian geology is similar to Jupiterian geology, that is because they intersect in various ways via branches of physics such as hydrodynamics. (Jupiter is a congery of gasses, some of which act like liquid metals. And the earth's core is molten.) This line is not at all plausible for computer science and economics. No doubt he will say that computer science is a branch of mathematics, not the science of any multiply realizable physical structure. And other special sciences are combinations of mathematics and structure restricted sciences like human psychology. Economics would be a good candidate for this kind of analysis.

Hartry Field has suggested (in conversation) that the reductionist can be refuted by examples of properties within physics. The property of being a rigid body plays a role in laws of mechanics—there are lawlike relations between rigidity, center of mass, moment of inertia and angular momentum, for example. So rigidity is a kind. Further,

Field argues that it is a second order property, the property of being subject to constraining forces (the first order properties) that keep the parts of the rigid object at constant relative distances and that do no net work in any motion compatible with the constraints. And it is multiply realizable because different rigid substances (e.g. amorphous rigid materials like glass and crystalline rigid materials like ice) have different constraining forces. Further, rigidity is not reducible to anything first order. No one would suppose that rigidity could be reduced to a vast disjunction of types of rigid bodies. In sum, we have a clear counterexample to Kim's argument.

I think that Kim has a straightforward reply: he should distinguish between *ideal* rigidity and real rigidity. Ideal rigidity can be defined purely geometrically: All points in a rigid body maintain constant relative distances. Ideal rigidity is not second order and it is not multiply realizable. Real rigidity is the property that Field defines. It is second order and multiply realizable, but there is a real issue as to whether there are any general laws about it. The need for quantification over forces comes into the definition of real rigidity because there are conditions in which genuine rigid objects lose their constant interpoint distances, e.g. inside a black hole. But it would seem that the general laws concern ideal rigidity. For example, the center of mass of a rigid body obeys the 2nd Law of Newtonian Mechanics, it maintains a constant velocity (which may be zero). If there are any laws about real rigidity, they concern the conditions in which it *breaks down*, but those will be different for different rigid substances.

You may wonder why ideal rigidity isn't multiply realizable. You may ask: aren't glass, ice, etc. all realizations of it? The problem with this objection is that glass, ice, etc., don't so much realize the property of rigidity as *have* it. One common notion of realization mentioned earlier appeals to parallel families of properties. The relations among temperature, pressure, entropy, etc are mirrored by relations among mean molecular kinetic energy, momentum exchange, etc, and the latter family provide a mechanism for explaining the relations among the former. That is what makes the latter properties realize the former, or anyway it is closely connected to what makes for this realization. Or to take another type of case, we can construct a multiplier from a system containing an adder, a decrementer-by-1 and a checker-for-zero. These items can be realized in one machine by one set of circuits and in another machine by another set of circuits. In both cases, we have a family of circuit properties that provide a mechanism for explaining how the adder, decrementer, etc interact to do the job. But it is hard to see a similar story for rigidity. Properties that are at the same level as rigidity include center of mass and moment of inertia. But if we want to explain the machinery by which the center of mass of a piece of rigid glass interacts in a certain way with moment of inertia, etc, we appeal to the same sorts of properties of mechanics, only applied to smaller things. There does not seem to be a "micro-family" of the right sort.

In my rendition of Kim's argument, I have left out one very important aspect, considerations of causality. Kim holds that kinds are causally individuated, that is that objects and events fall under a kind to the extent that they have similar causal powers. This idea is linked to the just mentioned notion of kinds as projectible by the common connection of projectibility and causation to laws. Kim argues that all causal powers, and hence all kinds are physical causal powers and that there are no causal powers at the level of multiply realizable properties. The property of pain is no more causally efficacious than the property of being a table. But human pain (or Ned pain if human pain is

multiply realizable, or Ned pain now if Ned pain is multiply realizable) is identical to a physical kind, according to Kim, and is therefore causally efficacious. (Kim calls this view multiple type physicalism.) I won't summarize Kim's argument that multiply realizable properties are not causal kinds. What will be relevant later is only the fact that Kim assimilates the causal kinds just mentioned to the projectible kinds I have been talking about. The link, as I said is that both causation and projectibility are to be understood in terms of law.

Recap

Kim's radical challenge to the anti-reductionist consensus has three parts (leaving out causation):

- If property M (say a mental property) is nomically coextensive with a heterogeneous disjunction of physico-chemical properties, then either both or neither are kinds.
- Heterogeneous disjunctions are not kinds because they are not (objectively) projectible; so M, being nomically equivalent to a heterogeneous disjunction, is not a kind. So there is no completely general science of psychology, that is, no science that covers all the heterogeneous realizations of human functional organization, both minds and machines. The sciences of the mental are the sciences of the realizations themselves.
- The anti-reductionists think that there are mental kinds which are second order, and there is a science of them. We can see why they think that and why it is wrong by noting that:
    1. There is something second order that applies generally, namely second order mental concepts
    2. There are structure-restricted sciences of the mental kinds that are not multiply realizable.

The Disney Principle and Forces of Convergence

It is important to note just how radical Kim's position is. It is very tempting to believe that in addition to the *concept* of pain, there is a *property* of pain, and that property is multiply realizable. Creatures with different physiologies might nonetheless all share that property, pain. But according to Kim, there is no serious property in common to pain-feeling organisms. What they share is just a matter of falling under the concept of pain.

In my view, this objection shows that Kim cannot in general be right. But this conviction is based on my view that pain—and other conscious states—have no functional conceptual analysis. (My view is that *if* pain is a functional state, it is what I call a *psychofunctional* state, a state captured by empirical functional analysis.) And I do not wish my reply to Kim to depend on controversial ideas about consciousness. So in what follows I will ignore consciousness, keying my reply to special science properties that are shared among a variety of special sciences, some of which do not traffic in consciousness.

Kim has produced an impressive challenge to the anti-reductionist consensus, one that in my view requires some important adjustments to that consensus. However, I still favor a modest version of the Many Levels view according to which psychology and other special sciences whose kinds are multiply realizable are autonomous sciences with

genuine kinds that are not on the whole reducible to a lower level. One way of leading into my disagreement with Kim is to note that these special science kinds are typically not nomically coextensive with completely *heterogeneous* disjunctions of physico-chemical properties.

In Walt Disney movies, teacups think and talk, but in the real world, anything that can do those things needs more structure than a teacup. We might call this the Disney Principle: that laws of nature impose constraints on ways of making something that satisfies a certain description. There may be many ways of making such a thing, but not just any old structure will do. It is easy to be mesmerized by the vast variety of different possible realizations of a simple computational structure, say that of an *and* gate, which can be made of cats, mice and cheese (Block, 1995) as well as mechanical or electronic components. But the vast variety might be cut down to very few when the function involved is mental, like thinking, for example, and even when there are many realizations, laws of nature may impose impressive constraints.

Of course we can only guess what constraints are imposed on realizations of mental properties. I've already mentioned one trivial constraint: a thinker requires a structure different from that of a teacup. Here is a guess as to a more general and slightly less trivial constraint: a thinking thing cannot be composed entirely of a liquid or a gas. This is a shot in the dark, but a plausible one based on current theories of either the classical or connectionist variety: both liquids and gases seem too amorphous to support the kind of structure that seems to be required for thought processes according to current theories.[7] Of course, the plausibility of such a suggestion may rest on ignorance or lack of imagination. But even if we can have little confidence in any specific guess, still it would be amazing if laws of nature imposed *no constraints at all* on what can think or be conscious. The reductionist may say that cutting down on the possible realizations still allows heterogeneous realizations, but this idea ignores the fact that constraints impose similarities. For example, if my speculation is right, all thinkers are similar in not being totally gaseous or totally liquid. This may seem not a very interesting similarity, but it is only a proxy for constraints that may some day be discovered.

These hypothetical constraints concern the the physical structure of realizations of thinking, but there might also be constraints at other levels. I mentioned that current theories of thinking fall into two paradigms, classical and connectionist. Perhaps thinkers can be made that fit both of these programs, but it may be that there are no other ways to make a thinker. The classical paradigm follows the model of the digital computer: explicitly represented rules that are applied to inputs via hardware that embodies much simpler implicit rules. The connectionist paradigm is associationist, involving vast arrays of nodes and interconnections; the nodes and connections have modifiable weights that control the extent to which they pass on activation, and these weights change according to the past activations they have participated in. There are no explicit rules. The essence of both of these paradigms is to be found at a level of abstraction far above that of

[7] One form of computational structure, production systems, could be realized in liquid form. An input-output conditional floats in a soup, waiting for the right output from another conditional to trigger its output. But the larger and more complex the computational structure of thought, the less plausible this sort of system seems as a realization of thought.

physics and chemistry. If thinkers can only be constructed according to those paradigms, laws of nature impose very abstract constraints.

Why believe that there *are* such constraints? Acidity is plausibly a second order property, the property of having some other properties that have certain effects. The effects in this case are producing a sour taste, reddening blue litmus paper, reacting with certain metals to release hydrogen and reacting with bases to form salts. My point isn't that we *initially* identify acidity in terms of its role (see Shoemaker, forthcoming, for a view of this sort) but rather that even a mature chemistry may see acidity this way. But are there restrictions on how this functional property can be realized? Apparently, yes: apparently what is required is that any realizer involve proton donation. Chemistry is full of such examples. (Another is solubility in water, which appears to require a structure that exploits water's dipole moment.) They illustrate constraints imposed by nature.

A second factor that points towards homogeneity and away from heterogeneity is that there are *forces* at work that can be expected to produce similarities. The first such force that comes to mind is natural selection. (After writing this, I read Papineau, 1993, which makes a similar point.) A famous example is the eye, a structure that has evolved more than once. (But not as often as once thought). Further, learning often produces the same mental structures by different means. The understanding of fractions, for example, is inculcated anew, in different ways, in each generation of elementary school students. Another force that produces similarities is conscious design. Pens tend to have similar properties despite a great deal of difference in materials and principles of operation, e.g. they don't dissolve in ink. And there are mixed mechanisms. For example, economies are constantly being tinkered with by governments. When catastrophe seems to loom, often changes are made. If the changes don't work, the government makes more changes. This is a kind of combination of (non-Darwinian) evolution and design.

Such forces acting by themselves, however, are unlikely to produce much in the way of deep scientific similarities of the sort that the experimental special sciences investigate. To the extent that evolution and design produce similarities *all by themselves*, they are likely to be relatively superficial. (A type of exception will be mentioned later.) There are no deep scientific laws of pens. If there are any surprising uniformities among pens, it will only be because there are some hidden consequences of rational design for certain purposes. Natural selection doesn't care about the deep scientific nature of, e.g. a language aquisition device but only that it do the job.

The power of natural selection to produce similarities in realizations derives from the fact that the two factors just mentioned interact, for the forces that create complex functions can only move in certain *channels*, the ones provided by the restrictions mentioned in the Disney Principle. In the case of simple functions such as that of a pen, one can expect little channeling. But in the case of a more complex function such as that of a computer, one expects—and finds—more. Further, if my speculation is right that a thinker can only be constructed according to classical or connectionist principles, then forces of design or selection will have to move in one of these two channels to make a thinker. Evolution, learning and the like impose similarities at the more superficial levels. We expect evolutionarily unrelated eyes to be similar in at least some general principles of operation, for they have to solve the same problem. Light has to be conveyed to some light-sensitive surface while preserving its informational content. But evolution and learning do not impose similarities in realization.. The Disney Principle, by contrast,

indicates similarities at all levels. There are constraints on how one can make an eye at the "design" level, but there are also constraints imposed by the fact that only some materials are transparent enough to transmit light without destroying much information. An eye requires some such material at least in the part that points at the world. So there are reasons to expect less than total heterogeneity at both the design and realization levels. Since evolution enforces similarity only at the design level, we should expect more variation at the levels of realization than at the design level. And this is why we expect multiple realization.

If there are distinct constraints at different levels, it is no surprise that as Putnam (1975) noted, different idealizations are appropriate at different levels. From the point of view of a programming theorist, the flip-flops in computers are all-or-nothing devices. But from the point of view of someone who studies those devices in somewhat greater electronic detail, they are continuous. E.g. a flip-flop may have two states, a 4 volt potential for 'off' and a 7 volt potential for 'on'. And in changing values, it will move through intermediate values. But a still deeper level sees these devices as digital again, since the charge is carried in packets.

In the light of these points, consider, Kim's putative law "Sharp pains administered at random times cause anxiety reactions. First, any creatures who are the products of evolution of the sort that has taken place on earth can be expected to have the kinds of relations among mental states that are favored by evolution. If there is an evolutionarily inculcated relation between random sharp pains and anxiety reactions in us, then there is *some* reason to expect it in any other evolved intelligent creature capable of pains and anxiety reactions. Further, given that there may be substantial restrictions on ways of making a pain-feeling organism, we shouldn't be surprised if the same relation applies to extraterrestrials. A better example of the sort of properties that are selected for in the case of pain (better than causing anxiety, that is) would be the relation between pain and distraction. A moment's thought suggests that the tendency of pain to distract serves the function of making sure the pain is a focus of attention, thereby raising the probability of efforts to get rid of its source.

I said a moment's thought would lead us to expect naturally evolved creatures who have pain to be distracted by it. But another moment's thought should lead us to doubt this claim. After all, distraction can be counterproductive. A human with a sprained ankle who is being pursued by a bear would do well to concentrate all her attention on escaping instead of dwelling on the pain of the ankle. If one were designing a pain feeling creature, one might want to make sure that the creature knows about her pains and that avoiding pain is fairly high up on the creature's list of preferences, but if one can do this without soaking up attention paid to the pain itself, so much the better. Another reason to doubt that it is adaptive for pain to be attention-grabbing is that we ourselves have pains that do not appear to engage attention. People are forever changing the disposition of their limbs (e.g. crossing and uncrossing legs) in response to discomfort without any obvious use of attention. People who are unable to feel pain do not do this and for that reason have medical problems. If one were designing a body, one might want such things to happen automatically without using up any attention.

The point I am making with this example is one that has been emphasized by Lewontin and Gould. Adaptationist reasoning is cheap. One can come up with a "just-so story" about why evolution should favor some trait, but a bit more imagination will often

yield an incompatible just-so story. The fact is that for most traits, we are just not in a position to know whether they are adaptations that have been selected for or mere by-products of such adaptations, "spandrels" in the lingo of Gould and Lewontin (1979). (The spandrels of San Marco in Venice seem to be included in the design because of their beauty, but they are a by-product of design that puts a dome on a square base. 'Spandrel' can be glossed as "by-product".)

The upshot is that we do not know which of the regularities that exist in human mental life are specifically selected for (and thus could be expected in other evolved creatures with the relevant mental states) or are spandrels. Perhaps many of the regularities are spandrels. This is where the Disney Principle comes in for it tells us that we can expect a different sort of spandrel from the kind usually considered by evolutionists. Consider the eye. On the basis of evolution considered in abstraction from channels, there would be little reason to expect deep scientific similarities among evolutionarily unrelated eyes. If evolution wants an eye that has the same function as ours, why should it also make it scientifically like ours? But the Disney Principle tells us that there are channels in which evolution must move, for there are constraints on how one can make an eye given certain materials in conditions of a certain range of temperatures, gravitational force, etc. If these constraints mandate deep scientific similarities among eyes of creatures that can exist in a certain range of conditions made out of a certain range of materials, then those similarities are themselves a kind of spandrel.

How strong are the constraints imposed by the Disney Principle? We don't know. And not knowing, we don't know how right or how wrong Kim's picture of science is.

D Properties and Realization Properties

We can divide special science properties into the following two sorts: those that are selected (whether selected for or not) and those that are due to *peculiarities of the realizations*.

For an example of a property that is a peculiarity of a realization, consider the fact that certain kinds of stimulations cause "ghosts" of past pains. Stimulation of the nasal mucosa cause recreations of dental pains. This phenomenon, "aerodontalgia", was discovered by U.S. Air Force dentists who noted that pilots in unpressurized planes of World War II (in which the sinus cavities expanded) reported pains that turned out to be related to previous dental work in which local anesthetic had not been used. (Nathan, 1985) It is most unlikely that this property of pain was selected for, since the stimulations that elicit the ghosts of the pain tend to require unusual conditions, often ones that require technology that did not exist in our hunter-gatherer days. If this is just a by-product of the physical realization of pain, then there will not be a high probability that creatures whose pains are realized differently will have it unless we share a common ancestor with them from which we both derive it. But given that there no doubt are a limited number of ways of making a pain-feeling organism, we cannot expect the likelihood even in this case to be zero.

Another example of this type is that if a hand is amputated, the amputee later feels the sensation of the hand being touched when his cheek is touched. Indeed, the feeling as of fingers of the hand all map neatly onto the cheek. The subjects' sensations can be

used to draw a hand on their cheeks. The reason that the hand sensation "migrates" to the cheek is that the hand receptors and the cheek receptors in the sensory cortex happen to be adjacent. When the hand reception area stops receiving inputs, the inputs from adjacent areas spread into the hand reception area.

Let us call the properties that are the product of channeled selection, learning and design--in conjunction with the Disney Principle--"D properties" ('D' for design and Disney), and let us call the properties like aerodontalgia and the cheek/hand phenomenon "realization properties".

A dramatic example of a D property in psychology has recently been given by Roger Shepard (1987, 1994). Suppose you eat a piece of fruit of a sort that is new to you and you like it, so you reach into the fruit bowl for another one like it. Given a range of choices, you will be more likely to choose some items than others. All the data that Shepard has looked at are consistent with a very strong result: the probability of generalization approximates an exponential decay function of distance in an abstract psychological space. Further, these spaces have one of two metrics, Euclidean or City Block. The domains that Shepard has looked at include color perception in pigeons and Morse code perception in people. Further, he has shown that this sort of exponential curve is precisely what you would expect a good engineer to build into a creature given some very simple assumptions about the environment and needs of the creature. One of the assumptions, for example, involves Bayesian inference. The generalization "Stimulus generalization curves fit the Shepard description" is certainly projectible. We would expect the next evolved creature to show the same curve. And we would even expect an all-purpose artificial intelligent creature to show it.

Though the generalization just mentioned is a deep scientific one, it is not a model for all of experimental psychology. For as Shepard emphasizes, it can be discovered by thought experimentation without much need for real experimentation.

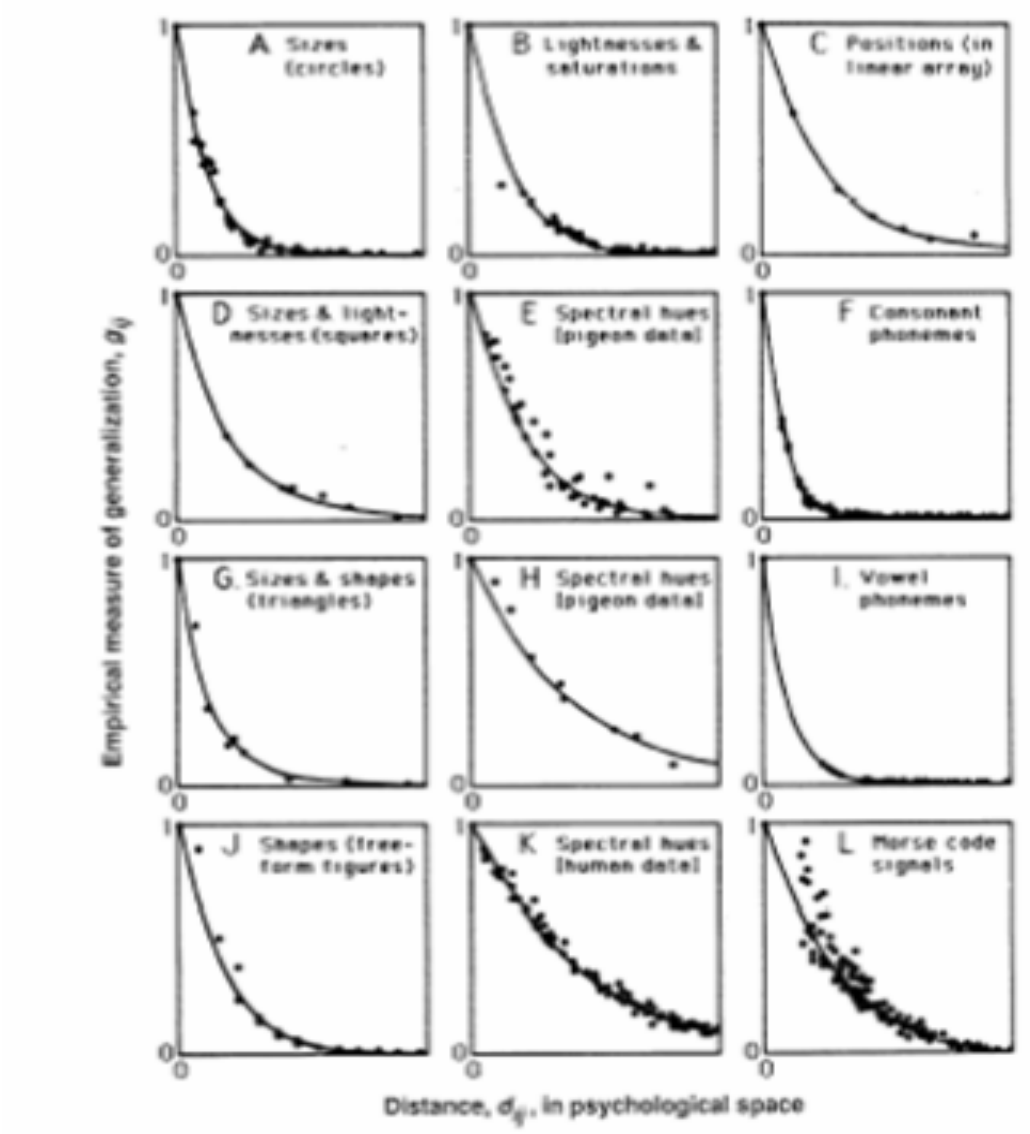

Figure 2: Twelve generalization gradients from Shepard, 1987

The scorecard at this point is this:

- Kim is right about realization properties. Aerodontalgia and the hand/cheek phenomenon depend on the realization of psychological phenomena. The science of such psychological properties is not part of psychology. We wouldn't expect such properties to generalize to pain-feeling creatures that are not evolutionarily closely related to us.
- Kim is wrong about D properties. Stimulus generalization is a property of perception that is common to creatures and perhaps machines that are not very similar in

realization of perceptual systems. Perception is both a scientific kind and multiply realizable, even multiply realized.

It is important to note the difference between two theses:

1. Perception is both a scientific kind and multiply realizable.
2. There is a science of all possible perception.

Kim is probably right on 2 but wrong on 1. If there is a science of all possible perception, it will be because nature imposes surprising constraints. More likely, what is common to all perceivers in virtue of which they perceive is that they fall under the concept of perception, as Kim would say. If Fodor and Putnam would deny this, their view is unsupported. But that is a very different matter from 1. We already know that Kim is wrong about whether perception is both a scientific kind and multiply realizable. Shepard's work is enough to establish that.

A general caution: As I mentioned earlier, I often simplify, talking as if there is only one level of "realization". In the case of psychology, I speak of "the" realization as being biology or physiology. But of course, one can also consider whether biology itself is multiply realizable in physics and chemistry.

Projectibility Again

In the light of these points, we should look back at the examples that I used to illustrate Kim's point about projectibility. Kim says that "Jade is green" is not projectible. But is it really true that a million samples of green jadeite give us *no reason at all* to think that the first sample of nephrite is green? The concept of jade is mainly a concept of a certain *appearance* (according to my dictionary, being pale green or white and used in carving or as a gemstone), and so jadeite and nephrite, since they are both classed as jade, must share *some* appearance properties. But no doubt there are some limits on ways of making things that have those appearance properties, and we can expect those limits to lead to other similarities, hence there will be some projection from jadeite to nephrite. Of course I agree with Kim that the similarity in appearance gives us little reason to expect any *deep scientific* similarity between jadeite and nephrite.

I said that given that jadeite and nephrite have some superficial similarities that gives us *little* reason to expect deep resemblances. Notice that I did not say *no* reason. In fact, there are two reasons for giving non-zero probability to deep resemblances. First, the Disney Principle: surely there are *some* constraints on ways of making something that looks and behaves in whatever ways define jade. (I doubt that you can make such a thing out of water) A second point is that any *real* resemblance makes *another* real resemblance a bit more likely.

(What's a real resemblance? Famously, any two things, x and y, share a property, if only the property of being x or y. Of course, this raises the issue of whether we can say what a real resemblance is without appealing to the notion of a heterogeneous disjunction or the notion of projectibility itself. Perhaps these notions are part of a family each member of which can only be clarified in terms of others.)

These points about jade also apply to dormitivity. Given that KBr and CCl3CH(OH)2 resemble one another in one way, in causing sleep, that gives us some reason to expect that they resemble one another in another real property. Causing sleep seems a relatively superficial property, though perhaps not as superficial as color. One

can imagine stories according to which the mere artificial production of sleep is carcinogenic, so there is certainly some small reason to expect that if one is carcinogenic, then so is the other. Of course, the degree of confirmation is small compared to the confirmation given to the hypothesis that all KBr is carcinogenic from finding that some samples of KBr are carcinogenic. Again, one lesson even in these cases of no serious selection is that one can expect different strengths of projectibility with respect to different sorts of properties. A second lesson, is that given the Disney Principle, there is a non-zero probability of similarity even in the realization properties.

I have been insisting on fractionating projectibility, arguing that mental kinds project more to D features than to realization features. But is this a way of avoiding the main question? Are the huge disjunctions of physical properties that are nomically coextensive with money or thought, *kinds* or not? The dilemma for the anti-reductionist, you will recall, was that if they *are* kinds, then the multiple realizability argument against reductionism founders, and if they aren't kinds, then the mental properties such as thinking that are coextensive with the disjunctions are not themselves kinds. So how do I avoid the dilemma? My answer has two parts:

1. I say that the issue of whether a property or a disjunction of properties is a kind or not is *relative.* The relativity comes in with the question of "Projectibility with respect to what type of property?" The physical disjunction that is nomically coextensive with thought is a kind relative to projection to D properties of psychology, but less so with respect to projection to realization properties or with respect to D properties of neurophysiology. For example, perceptual mechanisms are kinds with respect to properties that have to do with stimulus generalization. But there will be less reason to think of them as kinds with respect to the question of whether or where a hand sensation will be felt if the hand is removed.
2. A second point is that given that similarity comes in degrees and since kindhood is based on similarity, kindhood comes in degrees too.

The upshot is that if pain is nomically equivalent to a physico-chemical disjunction, then both pain and the disjunction will be kinds with respect to some properties, but to a lesser degree with respect to others. *Kinds are relative and graded.*

The point is partially supported by reasons to reject talk of projectibility of *properties* altogether. As Davidson has argued, even *grue* is projectible with respect to the right property. "All emeralds are grue" is not projectible (i.e. it is not supported by finding a given emerald to be grue). But suppose we define 'emerire' as discovered before 2000 and is an emerald, otherwise a sapphire. "All emerires are grue" (arguably) *is* projectible. So there is reason to think that it is hypotheses that are projectible, not *properties*. And if this is right, the relativity of kinds can be derived in one step from the relativity of projectibility.

The upshot if I am right is that most of the uses that both Fodor and Kim make of the notion of a kind are off base. In the cases of interest, the answer to whether a given property is a kind is almost always going to be "Yes and no, to various degrees."

Kim and Fodor, despite very different points of view, agree that if a mental property is nomically coextensive to a physico-chemical disjunction, the disjunction will be heterogeneous and therefor not a kind. By contrast, I say that such disjunctions can be expected not to be completely heterogeneous even with respect to realization properties, and far from it with respect to design properties.

Perception in evolved organisms is nomically coextensive with a physico-chemical disjunction. Is evolved perception reducible to physics and chemistry or not? Is the disjunction a kind? The answer, as I said, is yes and no, in various degrees. The disjunction is a kind relative to psychological design properties, but to a lesser extent relative to physico-chemical properties themselves. One could define 'reduction' so as to require kinds relative to the reducing science; or one could define 'reduction' so as to allow kinds relative to design properties. The issue is terminological. If the notion of a kind is the nub of the reduction issue, then there is no matter of fact about reduction here. *One relevant fact that is free of the terms 'reduction' and 'kind' is that there are laws of evolved perception in organisms that are relatively heterogeneous from the point of view of physics and chemistry.* In that respect, Fodor and Putnam are right.

In the scorecard given earlier, I said:

1. Kim is right about realization properties like aerodontalgia and the hand/cheek phenomenon. They don't project from one perceiver to another
2. Kim is wrong about stimulus generalization. It does project from one perceiver to another despite differences in realization.
3. If Fodor and Putnam were committed to a science of all possible perception, there is no reason to believe that they are right.

But now I have to revise the first two of these points. The fact that kinds and projection are relative and graded shows all unrelativized attributions need to be qualified.

It is time to return briefly to causation. I mentioned earlier that Kim assimilates causally efficacious kinds and projectible kinds, the link being the notion of law which is key to both causation and projectibility. One upshot of the ideas presented here is that we should perhaps distinguish between causally efficacious kinds and projectible kinds. What is required for a high degree of projectibility is that processes like selection and design have connected properties that would not otherwise be connected. Thus pen design has coupled cylindrical shape, having a point at one end and allowing a fluid to come out the pointed end and other properties as well. For certain sorts of properties (e.g. not dissolving in ink), one can project pretty well from examined pens to unexamined pens. But does that make being a pen a causally efficacious property? Why should the mere grouping of properties together make the property of being a member of that group a causally efficacious property? And how could causal efficacy come in degrees? Once one agrees that the notion of kind is relative and graded, unless one is prepared to see causation as relative and graded, kinds will be poor candidates for the key to causation.

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Captions

Caption to Figure 1: U_1 is realized by a heterogeneous disjunction, L_1 or L_1*; U_2 is realized by another heterogeneous disjunction, L_2 or L_2*. There is a lower level law $L_1 \Rightarrow L_2$ and another lower level law L_1 *$\Rightarrow L_2$*. Each case of $U_1 \Rightarrow U_2$ is explained by one of these laws.

Caption to Figure 2: Twelve generalization gradients from Shepard, 1987