UNIVERSITY OF CALGARY

Beyond Supervenience: an Alternative Approach to the Mental-Physical Relation

By

Eric van Iersel

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE

DEGREE OF MASTER OF ARTS

DEPARTMENT OF PHILOSOPHY

CALGARY, ALBERTA

AUGUST, 2001

Abstract

A critical analysis of the concept of supervenience as argued for by Kim is presented. This analysis concludes that supervenience is ineffective as a tool for approaching the mental-physical relation. An alternative approach that moves beyond supervenience is required. It is suggested that a hybrid model that incorporates the ontology of properties of Martin with the nomological pluralism and capacities/natures arguments of Cartwright provides such an alternative approach to the mental-physical relation. A detailed comparative analysis of a pair of neuroplasticity research articles is given to emphasize both the limited utility of supervenience and the potential of the hybrid model. The outcome is a discussion of where research into the mental-physical relation might direct itself. The suggestion is that the alternative approach to the mental-physical relation found in the hybrid model may be much more useful than any appeal to supervenience.

TABLE OF CONTENTS

Introduction

By a thoroughgoing and highly critical analysis of recent philosophy of mind work done by Jaegwon Kim, it will be made quite clear to the reader that the concept of supervenience (that favourite weapon for grappling with the mental-physical relation, championed by Kim) has fatal flaws. By the end of the first chapter, it will also become clear that an alternative approach to the mental-physical relation is required.

The second chapter will move to a new alternative to the inconsistent reductionism and narrow-minded causality models espoused by Kim. Such an alternative approach will be based upon a consistent, metaphysically realist world view, that involves a conception of physical and mental properties that will be seen to be very different from the conception envisaged by Kim and others. The new conception of physical and mental will rely in part upon Martin's (1996, p. 191) surprising identity of the qualitative and the dispositional. It will be argued that mental realism should be continuous with metaphysical realism more generally, and that this is a possibility by appeal to Martin's ontology of properties. It will be shown that the Martin ontology of properties and Compositional Model can accept all four of the principles which underpin Kim's supervenience theory, while still handily rejecting supervenience itself.

The third chapter will further challenge Kim's supervenience arguments by showing how they fail to cope with the locally realist, nomologically pluralist world-view of Cartwright which shall be laid out in detail. Cartwright's position will then be demonstrated to be compatible with Martin's ontology and Compositional

Model. So compatible that a new hybrid Martin-Cartwright approach will be recommended as not only a corrective to the failed supervenience experiment, but also as the best possible ontological starting point for research into the mental-physical relation.

The fourth chapter will provide an overview of neuroplasticity literature and detailed analyses of two dissenting neuroplasticity research articles. Kim's metaphysics will be shown to be useless in informing the ensuing plasticity debate. The plasticity debate will handily show the advantages of the hybrid Martin-Cartwright model, both in ontologically informing the research, and in giving a starting point for an alternative approach to the mental-physical relation. It will at the same time be argued that neuroplasticity research may be a central area of importance in on-going mental-physical relation research, and that it can be made more fruitful by being informed by the hybrid Martin-Cartwright model.

Chapter One: An Examination of Jaegwon Kim's Supervenience Theory

Jaegwon Kim has been developing and defending his interpretation of the concept of supervenience since the 1970's. Through a focus on Kim's (1984a) seminal paper "Epiphenomenal and Supervenient Causation[1]" (with extensive reference to his follow-up work since then), I intend to demonstrate that supervenience leads either directly to elimination of the mental, or to overdetermination, or even to downward causation. Supervenience will further be argued to be not at all useful as a potential tool for framing the mind-body problem.

Since it is Kim's choice as the most effective type of supervenience to tackle the mind-body problem, all mention of supervenience here will refer to strong supervenience. To briefly differentiate strong from weak supervenience, both are presented as follows:

> Weak supervenience – "A *weakly supervenes* on B if and only if necessarily for any x and y if x and y share all properties in B then x and y share all properties in A (Kim, 1984b, p. 58)."

This version is considered weak by Kim because it "only requires that *within* any possible world there not be two things agreeing in B but diverging in A (60)." Contrast this with the version that Kim believes is the more useful:

> Strong supervenience – "A *strongly supervenes* on B just in case, necessarily, for each x and each property F in A, if x has F, then there is a property G in B such that x has G and *necessarily* if any y has G, it has F (Kim, 1984b, p. 65)."

---

[1] References to this paper are from the version published in The Nature of Mind, ed. David M. Rosenthal (Oxford, 1991), 257-265. Original version in Midwest Studies in Philosophy 9 (1984): 257-270.

As for the idea of any autonomy for supervenient properties from their subvenient bases, Kim (1984b) claims that while weak supervenience may be consistent with the possibility of such autonomy, strong supervenience cannot allow it: "the base wholly determines the supervening properties. If strong psychophysical supervenience holds, what happens in the realm of the mind is determined in every detail by what happens in the physical realm" (p. 76). As Kim actively supports strong supervenience (especially as it applies to mind-body supervenience) it is very clear that Kim is implicitly committed to physicalism and a corresponding reductionism as given starting points. This will become clear as his notion of macro to micro supervenience is discussed below.

In "Epiphenomenal and Supervenient Causation", Kim develops the plausibility of his supervenience theory by first giving a series of examples. These examples are used to demonstrate that successive events need not be causally linked to each other. His point is to show that sometimes the supposed cause of an event has something between it and its supposed effect. Using a Jonathan Edwards example of successive mirror images, Kim (1984a) claims that, "two successive mirror reflections of an object are not directly causally linked to each other" (p. 257). He argues that "the succession of images is only a reflection of the real causal process at the level of the objects reflected" (*ibid.*). Another example of what Kim terms epiphenomenal causation involves the succession of symptoms associated with a given disease: "the symptoms are not mutually related in the cause-effect relationship, although to the medically naïve they may appear to be so related. The appearance of a causal connection here

merely points to the real causal process underlying the symptoms" (p. 258). Kim considers these examples to only roughly approximate his conception of epiphenomenal causation, but claims that they will help us to fix the concept in our minds (pp. 257-258).

Although it might not seem clear on a casual reading, Kim believes that presenting two events related to each other by an epiphenomenal causal relation does not "mean to suggest that the events themselves are 'epiphenomena'" (p. 258). Kim is not (he claims) using the modifier epiphenomenal in the traditional (mind-body causation) sense. He is using the term to qualify the causal relation, "not the events standing in that relation" (*ibid.*). Kim defines the word epiphenomenon "as 'secondary symptom', 'secondary phenomenon' or 'something that happens in addition'" (*ibid.*). Ultimately, the usage he has in mind, involving his relation-versus-event qualifications, does not seem to work. The macro-event (*e.g.* the mirror reflections or disease symptoms) still seems to end up as an epiphenomenon on Kim's formulation: causally impotent, and irrelevant other than as a pointer to real causal processes. But Kim wants to convince us that the macro-event (*e.g.* the mental) is potentially real and existent, in spite of having only an epiphenomenal relation to the micro-event (*e.g.* the physical)[2].

This insistence on the potential reality of the macro-event in relation to the micro-event, however, does not seem to resolve any of the problems already associated with epiphenomenal accounts. Kim himself touches on a fundamental challenge brought against traditional presentations of

epiphenomenalism as a mind-body theory: "to call an event an 'epiphenomenon' in this context is taken to mean that though it is a causal effect of other events, it has no causal potency of its own: it can be the cause of no other event, being the absolute terminal link of a causal chain. It is dubious that this notion of epiphenomenon makes sense - for example, it is doubtful how such events could be known to exist" (p. 258).

Mental causation, with its causal relation to the physical, qualifies as a form of macrocausation for Kim (but see the discussion of physical realization later in this chapter). Kim develops this notion as follows: psychological (mental) causation = macrocausation = epiphenomenal causation = supervenient causation (*ibid.*). "The paradigmatic examples of macroobjects and properties are medium-sized material bodies around us and their observable properties" (*ibid.*). Kim argues that all observable phenomena are to be taken as macrophenomena: "all causal relations familiar from daily experience – are cases of epiphenomenal causation" (p. 259).

The commitment to reductionism quickly becomes apparent, though: "modern theoretical science treats macrocausation as reducible epiphenomenal causation and ... this has proved to be an extremely successful explanatory and predictive research strategy" (*ibid.*). This viewpoint about the success of reduction as a research strategy is openly challenged by Chomsky (2000) in his historical review of the subject and its relation to the mind-body problem: "large-scale reduction is not the usual pattern; one should not be misled by such dramatic examples as the reduction of much of biology to biochemistry in the

---

[2] At least, he claims that he is not making any claim at all about the epistemic status of the macro-event.

middle of the twentieth century. Repeatedly, the more 'fundamentalist' science has had to be revised, sometimes radically, for unification to proceed" (p. 82). Even without Chomsky's warning about an uncritical embrace of pure reductionism, Kim (1984a) makes explicit the repercussions for the status of mental events with any commitment to physicalism: "a thoroughgoing physicalism can [not] tolerate the existence of irreducible psychological objects (*e.g.* Cartesian souls, visual images)" (p. 259).

Still, even though Kim's physicalism requires adherence to physical causal closure in developing his macro-micro distinction (see below), he fails to give us a clear picture of what he believes the causal status of macro-events ultimately to be within his model. Is it a simple identity between macro and micro events? Are mental properties thus to be construed as physical? Kim does not have an immediately apparent answer for these questions. His initial formulation of an epiphenomenal causal relation between the mental and the physical does not seem to allow for any real role or status for the mental. But Kim argues that there is not a strict identity relation between macro and micro events: "how could one and the same property be both a microproperty and a macroproperty? ... it may well be that from the explanatory-causal point of view, the possibly infinite disjunction of these underlying microproperties could hardly be considered as a unitary property suitable as a reductive base" (*ibid.*). Kim suggests that supervenience might be helpful here: his theory of supervenience allows for the macro to supervene on a multiplicity of potential supervenience bases. As Kim points out, "the core idea of supervenience as a relation between two families of

properties is that the supervenient properties are in some sense *determined by* or *dependent on*, the properties on which they supervene" (*ibid.*). Accepting such a multiple-supervenience-base version of supervenience allows Kim to deal with functionalist multiple realizability issues and yet still argue for some sort of event by event identity between macro and micro events. But this formulation of the macro-micro relation still does not seem to salvage any robust causal role or status for mental events, other than identifying them with their physical subvenient events.

Kim advances a whole-on-its-constituent-parts supervenience model for grappling with macro-micro or mind-body issues: "Mereological supervenience is usefully taken to be a general thesis affirming the supervenience of the characteristics of wholes on the properties and relationships characterizing their proper parts" (p. 261). This form of supervenience is favoured by Kim for its concern with the objective features of the world: "the macroworld is the way it is because the microworld is the way it is" (*ibid.*). Obviously this concept (of mereological supervenience) fits nicely with Kim's belief in the success of physicalism and modern science (and its micro-reductive research strategies). And through analysis of this focus on two theories that support a physicalist picture of the world (mereological supervenience and microdeterminism), we can derive Kim's main fear about the mental: if it were causally effective, it would "jeopardize the closed character of physical theory" (*ibid.*). Still, there is a simmering question about mereological supervenience that needs to be asked: are the characteristics of wholes (macro-events or macro-properties) really

distinct from the properties and relationships of their proper parts (micro-events or micro-properties)? If not, what is the use of the macro-micro distinction (even on a mereological interpretation), other than as a descriptive technique? This question obviously occurs to Kim, who defensively states the following: "To say that the causal relation between two macroevents is a case of epiphenomenal causation is not to be understood to mean that the relation is illusory or unreal" (p. 262). But of course, on such an understanding, the real causal relation is occurring between the micro-property subvenient bases...so the macroevents still seem to be functioning as nothing other than descriptive devices.

In his critique of traditional epiphenomenalism, Kim points out that by denying any mental-to-physical causation "[epiphenomenal] mental phenomena are [left] totally causally inert" (p. 263). It would seem that the same charge could be brought against Kim's initial examples of macrocausal relations, and Kim concedes this: "in a perfectly straightforward sense, mirror images, symptoms of disease, and so on are causal effects of the underlying processes – they are not mereologically supervenient upon those processes" (p. 262). And yet we are expected to discern some sort of important distinctions between traditional epiphenomena, the mirror/disease examples and the purportedly different successful supervenience cases (including cases of mind-body supervenience, apparently). In these successful instances of mereological supervenience, the macro is somehow fused to the micro in a new sort of causal way. And yet, to be a successfully real mereologically supervenient case (*e.g.* the causal relation between rising temperatures and increasing gas pressure),

means to be micro-reducible. And although Kim charges that "to take microreducibility as impugning the reality of what is being reduced would make all of our observable world unreal" (*ibid.*), his reducibility relation between macro and micro does seem to raise the ultimate possibility of elimination for his mereologically supervenient macro-events. Kim concedes that this as a real threat to his position, but chooses not to address it in his development of epiphenomenal, mereological supervenience. Kim (1993a) admits to the reductionist implications that challenge his supervenience theory: "But how do we capture this [supervenient] relation of determination, or dependence, in a way that escapes the threat of reduction?" (p. 194). He also struggles with the possibility that his supervenience theory leaves the mental as an "epiphenomenal dangler" (p. 209). Kim (1993b) sees a further weakening against charges of reductionist implications for supervenience (see especially pp.361-362). In Kim's recent work (1998), the reductionist outcome is largely conceded and he raises the possibility of what he claims to be a dilemma for mental causation: "If mind-body supervenience fails, mental causation is unintelligible; if it holds, mental causation is again unintelligible. Hence mental causation is unintelligible" (p. 46).

It seems increasingly obvious that Kim has no real causal role for the mental (macro) in his supervenient account of mind-body causal relations. So why does he attack Davidson's anomalous monism for exhibiting a weakness his own theory shares? Regarding Davidson, Kim complains about the following: "It seems to me that, for similar reasons, Davidson's anomalous monism fails to do

full justice to psychophysical causation – that is, it fails to provide an account of psychophysical causation in which the mental *qua mental* has any real causal role to play" (p. 263). And yet Kim has yet to persuasively argue that mereologically supervenient psychophysical causation gives the mental any real causal role, either.

Trenton Merricks provides an insightful overview of Kim's supervenience theory in his review of Kim 1993b (Merricks & Kim, 1995). He lays down what he sees as the four principles of Kim's supervenience theory:

1. Criterion of Reality: to be real is to have causal powers.
2. Causal Exclusion Principle: for each event, there is at most one complete and independent causal explanation.
3. Causal Closure Principle: pertains to closed nature of physical universe – to accept this, one must be a materialist, implying acceptance of reduction of mental states or eliminativism.
4. No Irreducible Causal Powers: Merricks describes Kim's view on this principle as follows: if a mental state's causal powers are reducible to that of a physical state, then the mental state itself is reducible to that physical state (pp. 156-158).

Merricks argues in favour of construing Kim as a full-on reductionist: "the premises Kim relies on in arguing for reduction in the philosophy of mind are so strong that they generate reduction not only of mental events, but also of macrophysical objects and events and properties...this sort of reduction might amount to elimination[3]" (p. 159). Merricks offers two potential outcomes that result from following through on Kim's reductionism: either there are base levels of things, or there are not. Regarding the former, "it is at least out of step with Kim's allegiance to physics as the most basic science that it is the philosopher,

and not the physicist, who discovers that matter is not infinitely divisible[4]" (*ibid.*). As for the latter, without a base level we end up with a vicious regress of level supervening on level supervening on level (p. 160). This dilemma leads Merricks to insist on the harsh eliminativism that seems to be the inevitable outcome of Kim's supervenience theory: "either macrophysical objects have irreducible causal powers or they don't (Kim, of course, says they do not). If they do not, then, by Kim's principles, it follows that they do not exist 'over and beyond' their parts that do have irreducible causal powers" (p. 161).

Kim wants nothing to do with the micro-reduction conclusions argued for by Merricks: "microreduction does not reduce macro-properties to micro-properties" (p. 162). Kim defends this assertion with an argument that is similar to one used by Paul Feyerabend against a formal presentation of mental-physical type-identity reduction. Feyerabend rails against physicalists who use the following hypothesis to claim that mental events are identical with brain processes: (X is a mental process of kind **A**) is identical with (X is a central process of kind **a**). As Feyerabend (1963) correctly notes, this hypothesis "not only implies, as it is intended to imply, that mental events have physical features; it also seems to imply (if read from the right to the left) that some physical events, viz. central processes, have nonphysical features...this consequence seems to be a result of the way in which the physiologist has *formulated* his thesis" (p. 295). In a comparable argument, Kim defends his assertion that microreduction does not reduce macroproperties to microproperties. He claims (Merricks & Kim,

---

[3] Kim's faith in reductionism and arguments for rehabilitating it are amply demonstrated in Kim, 1993.

1995) that this assertion "should be apparent from the simple fact that if *x* is 'macro' in relation to *y*, *x* and *y* cannot be identical. If *P* is a macro-property relative to *Q* (which in turn is a micro-property relative to *P*), it logically cannot be that *P* = *Q*. Thus, micro-reduction of macro-property *P* does not turn *P* into a micro-property, or replace it with one" (p. 162). Unfortunately, while such an argument is perhaps easy to swallow with physical-to-physical supervenience examples (*e.g.* temperature of a gas supervening upon the kinetic energy of its molecules), it seems to leave unanswered all of our concerns about the causal status of mental events/properties when applied to mind-body supervenience. One worry is the seeming inconsistency of Kim's arguments and terminology. Remembering that by epiphenomenal, Kim is referring to causal relations between physical and mental, the following seems to lead to weird covariance-induced overdetermination and thus to the inevitable request for elimination of the mental: "in micro-reductions, macro-properties do not disappear; rather, they are identified with micro-based macro-properties, and retain their full causal powers *as macro-properties*" (p. 163). Such a macro-micro property identity claim does not really help Kim diminish concerns about the ultimate status of mental causation within his supervenience model. Just what are the full causal powers that macro-properties retain?

In a recent Searle symposium, Kim offers some more insight into his own programme under the guise of critiquing Searle's. Regarding Searle's 1992 work The Rediscovery of The Mind, Kim (1995) accuses Searle of causal

---

[4] Martin (1997) offers a brief *a priori* argument that suggests that one can do philosophical work that depends on a notion of fundamental particles without appealing to any physical theory (pp.199-201).

overdetermination in the mental-mental, physical-physical model Searle proposes: "all cases of mental-to-mental causation involve the overdetermination of the effect. This is a peculiar picture, indeed. And, given the fact that every mental event has a sufficient cause in biological processes, one wonders about the significance, or necessity, of appealing to its mental cause" (p. 193). But how can Kim accuse Searle of an unnecessary appeal to mental causation? Even if Kim avoids Searle's brand of overdetermination (and this may not be the most serious charge that could be brought against Searle[5]), he himself is guilty of the same mental causation problem. The causal efficacy claimed for Kim's supervenient mental causation seems to be no less susceptible to Kim's challenge than is the Searlean model. Terence Horgan (1993) provides some basic requirements for those (like Kim) who might be looking to argue for the causal reality of supervenient causation: "any genuinely materialistic metaphysics should countenance inter-level supervenience connections only if they are explainable in a materialistically acceptable way, and should countenance *ontological* inter-level supervenience relations only if they are *robustly* explainable in a materialistically acceptable way" (p. 563). It seems that Kim's supervenience relations are not, on Horgan's terms, very robustly explainable.

Herbert Feigl offers some background to this discussion of supervenient epiphenomenal causation. In discussing how many behaviourists and materialists manage to completely avoid/evade the mind-body issue, he brings

---

[5] Searle's mental ontology also faces the threat of elimination: he considers it an error to attempt to rewrite the mental in terms of epistemology and causation (Searle,1992:21), but his notion of the mental/the subjective is as a purely ontological category that is pure appearance; such an ontology is no use to save the causal reality of the mental and so seems to beg to be reduced. As Kim admits, "to identify the causal

up traditional epiphenomenalism as one way of addressing this problem. It has been argued above that Kim's supervenient epiphenomenal causation, when fending off elimination, suffers the same pitfalls as the traditional epiphenomenal model; Feigl's (1960) critical comments might (maybe even more than loosely) apply to Kim: "epiphenomenalism, while not evading the [mind-body] problem, offers a very queer solution. It accepts two fundamentally different sorts of laws – the usual causal laws and laws of psychophysical correspondence...These correspondence laws are peculiar in that they may be said to postulate 'effects' (mental states as dependent variables) which by themselves do not function, or at least do not seem to be needed, as 'causes' (independent variables) for any observable behaviour[6]" (p. 373). Feigl does give some credit to an epiphenomenal position, but he refers to it as more of a descriptive method for the mind-related sciences: "I admit that for the ordinary purposes of psychology, psychophysiology, and psychiatry an epiphenomenalist position is entirely adequate, if only the traditional, picturesque but highly misleading locutions (*e.g.*, 'substantial material reality and its shadowy mental accompaniments') are carefully avoided" (p. 376).

An important question to be raised here is this: if it is possible to see parallels between Kim's supervenience and Feigl's version of identity theory[7],

---

powers of mentality with those of its underlying physical base is, in effect, to deny it a distinct ontological status, and consider it reduced (Kim,1993:210)."

[6] Interestingly, Kim has come to admit that an epiphenomenalist could accept supervenient causation as consistent with epiphenomenalism and faces the worry that "might it not be 'causation' in name only? Is it a robust enough relation to vindicate the causal efficacy of the mental (1993b:359)?"

[7] Briefly, Feigl's version of Identity Theory is essentially a traditional account, with a major exception: Feigl is very uncomfortable with the explanation of the mental in his identity account, and concedes that "those thinkers who maintain that a "category mistake" is involved in mixing phenomenal and physical language are essentially right (1967:140)."

and if the I-T approach seems just as plausible (or not), what makes the supervenience theory any more desirable than Feigl's I-T? It would appear that Feigl's I-T offers as much causal reality to the mental as Kim's supervenience theory (when pushed to admit its inherent reductionist/eliminativist demands for the mental). Compare our reductivist interpretation of Kim's supervenience with Feigl's (1967) I-T: "It is one and the same event, say a decision or volition, or a sudden pain, described phenomenally in one way, and physically in another way, which is a causal antecedent of a 'bodily' response or movement; or, vice versa, some physical stimulus input causes a central state – described either in the familiar phenomenal language as a sensation, or in the (utopian) physical language as a feature of a cerebral process" (p. 139).

So much for the retention of full causal powers for the mental, as Kim hopes for. The Kimean macro seems to want to disappear into the Feigl-presented physical (micro) realm. And just as disturbing for Kim, another (potentially compatible with supervenience theory) alternative presents itself: that of emergent determinism, particularly as championed by R.W. Sperry. If we are to accept full causal efficacy for macro-properties, then we might argue that Kim should take Sperry's macro-bigger-than-micro approach very seriously (but the principles he bases his supervenience theory upon could not accept this). For Sperry (1992), "the flow and the timing of impulse traffic through any brain cell, or even a nucleus of cells in the brain are governed largely by the over-all encompassing properties of the whole cerebral circuit system...The neurophysiology, in other words, controls the mental effects, and the mental

properties in turn control the neurophysiology. ...*microdeterminism* is not abandoned...just supervened" (pp. 265, 270, 271). It is obvious that Kim cannot accept Sperry's downward causation, due to his claims for the epiphenomenal nature of his supervenient causal relations. But it is really only a short step from Kim to Sperry's model: if full causal power is given to the macro, this real causal power leads directly to a macro-bigger-than-micro approach, or (as discussed above) overdetermination. If the macro does not have real causal power, reduction or even elimination is demanded (given strong supervenience), as the causal power ascribed to the macro disappears into the micro. Kim wants to deny that his supervenient causation leads down either of these philosophical roads...but that leaves him attempting to find high ground where there is none (at least with his insistence on maintaining a thoroughgoing physicalism). What Sperry calls "a nonreductive dynamic emergent of brain activity [that] cannot exist apart from the brain" (p. 262), is suspiciously close to Kim's epiphenomenal (in a causal relation way) macro-property with its full supervenient/epiphenomenal causal powers. If Kim disagrees, reduction and indeed elimination is the inevitable fate faced by the mental (given his model).

Kim (1993b) continues to struggle with the apparent contradictions within his supervenience theory as it applies to the mind-body problem. He admits that the notion of supervenience of mental upon physical, which involves a covariance claim (there is a specific pattern of property covariation between mental and physical), and a dependence claim (the mental depends on the physical), is a limited notion at best (p. 165). Kim feels that there is a pressing

need to upgrade a mere supervenience claim to make a credible, substantive mind-body theory; a specification of the kind of dependence relation that accounts for mind-body property covariation is required (p. 168). Kim continues to believe that mind-body supervenience should be looked at as an example of mereological supervenience, which he construes to be a metaphysically basic kind of dependence (*ibid.*). Martin and Heil (1999) have asked for clarification of the relevance of such a whole-parts supervenience:

> The most basic domain over which supervenience floats is that of the supposed supervenience of wholes on their parts. The world, considered as a whole, owes its character to the nature and arrangement of elementary items that make it up. This is sometimes put in terms of supervenience: all the facts supervene on the elementary physical facts. We are happy to grant the supervenience claim, but we would like to be clear on its ontological significance. As we have noted, supervenience is consistent both with the idea that supervening items are 'nothing over and above' subvening items, and with the very different idea that what is supervenient, although ontologically distinct from its subvenient basis, covaries with that basis (p. 37).

Kim (1993b) is faced with the incompatibility of these two interpretations of mereological supervenience. He attempts to explain mereological supervenience in terms that will allow it to adhere to his belief in reductive physicalism, and avoid problems with physical causal closure and overdetermination; his approach is to do this by arguing for the idea of physical realization of mental events: "if a given instance of M occurs in virtue of being realized by P, the M-instance and its P-realizer do not compete for a causal role" (p. 362). This idea gives Kim a revised formulation of the supervenient relation as it involves mind-body supervenience: "An M-instance is identical with a Pi-instance, for some M-realizer Pi, and hence there is one event here, not two, and this dissipates the

causal competition" (p. 364). And so for Kim (1998), mental properties become the roles of which the physical subvenient properties are the occupants (p. 80). Yet with this physical realization concept for the mental-physical supervenience relation, Kim (1998) tries to break away from the generalized macro-micro argument that he himself has earlier (see 1984a) appealed to for support. As opposed to macro-micro hierarchical ordering of levels, physical realization of mental properties presents a different sort of relation: "*a second-order property and its realizers are at the same level in the micro-macro hierarchy; they are properties of the same objects*" (p. 82). Even here, Kim must still face causal exclusion worries with intralevel relations, but he feels that this is a way for macro-properties (i.e. mental properties) to avoid epiphenomenalism charges:

> So macrophysical, or mereological supervenience does not track the micro-macro hierarchy any more than the realization relation does; the series of supervenient properties, one mereologically supervenient on the next, when we go deeper and deeper into the micro, remains at the same level in the micro-macro hierarchy, just as the properties ordered by the realization relation stay at the same level. This means that the supervenience argument, which exploits the supervenience relation, does not have the effect of emptying macrolevels of causal powers and rendering familiar macro-objects and their properties causally impotent (p. 86).

But Kim (1993b) recognizes the dilemma that this physical realization view forces him into: "either embrace the realization view and save mental causation, or insist on the unique and distinctive status of mental properties, especially qualia, but be prepared to give them up as causal powers" (p. 366). Even this may turn out to be an illusory choice, as the two options appear to collapse into each other: to be real is to have causal power, and if mental properties are left without causal power, they cease to be counted as 'real'. Thus, all we are left with is

physical realization of purported mental events, and this strange, problematic idea of physically realized mental causation.

Clearly, supervenience theory has been argued to be very problematic, if not untenable: if Kim's faith in reductive physicalism is seen as being committed to the reduction of the mental to the physical, can elimination be realistically avoided? Formulated as having a supervenient epiphenomenal causal relationship with the physical, Kim's interpretation of the status of the mental seems to end up being about as causally useful as Churchlandesque 'folk psychology'. It is not really causally effective at all, but (see Feigl above) it helps to vaguely describe the situation in non-technical terms to the layperson. If one does not want to take the mental world to be causally ineffective/inert/eliminable, a new approach needs to be taken to resolve the apparently irreconcilable differences between the mental and physical and their purported causal roles. It is clear that Kim's supervenient epiphenomenal causation, (while hoping to work toward this ideal of a real/existent role for the mental that does not violate the principle of physical causal closure) does not offer such a new approach.[8]

[8] Kim has tried to refine his supervenience theory repeatedly over the past decade, increasingly facing up to the multiplicity of problems his approach faces. See especially Kim, 1998.

Chapter Two: Beyond Supervenience

To maintain a position as both a mental realist and a physicalist, what does one offer in place of the supervenience relational model espoused by Kim? What is the way forward? Attempting a full explanation of mental causation or consciousness is beyond the scope of this work, but at least a move can be made beyond supervenience – the previous chapter should have made it clear that the supervenience relation is at best trivial, even viewed merely as a way of describing the mind-body relation. If supervenience holds or does not? This is not even the appropriate question to be asking. A starting point is to look at a fundamentally dualistic assumption behind the mental-physical supervenience model[1]. Kim's Supervenience Theory has an outcome of fully eliminable mental events/properties that are merely identities with their subvenient physical events/properties. Even with such a reductive approach, the mental and physical are still considered to be two distinct subjects, hence all of the dualisms and related conundrums that were discussed in the first chapter.

A way forward is to appeal to Martin's (1996) surprising identity of the qualitative and the dispositional, of properties and capacities (see also a much more nuanced discussion of this identity in Martin, 1997). This identity arises from the conviction that there are no such things as pure functions or pure qualities with no implications either way (p. 191). As per Kim, to be real is to have causal powers, and further, as per Martin (1997), there is no causal power

[1] All references to supervenience theory in this chapter will be taken from Jaegwon Kim's strong supervenience model sketched out in Chapter One.

without properties (p. 194). And for Martin (1996), all properties share two fundamental aspects, both a qualitative and a dispositional. Martin attempts to express this dual character of properties by appeal to his Limit View of the qualitative and dispositional character of properties. This Limit View is argued for by the following three claims: 1. "To speak of a qualitative property is to take some real property as *only* at its bare potency-free purely qualitative limit, which, of course, it never is" (p. 74). 2. "To speak of a dispositional property is to take some real property as *only* at its purely dispositional non-qualitative limit which, of course, it never is" (*ibid.*). 3. "No real property of an object, event, process or even space-time segment or field can be thought of as existing at *either* limit" (*ibid.*). And lest anyone be tempted to think of expressing the Limit View of properties as a compound of purely qualitative and purely dispositional properties, Martin offers the following refinement to his three point position:

> The only way to express this Limit View of real properties that does not amount to treating real properties as compounds of purely qualitative and purely dispositional properties is to show how the attempt to abstract these as distinct elements is unrealisable in reality and only approachable as *limits* for different ways of being of the same unitary property such that they may be necessarily or contingently co-variant. This will hold for all real properties all the way down even to the most ultimate properties of elementary particles or fields (p. 86).

How this concept may apply to an understanding of the mind-body relationship will be expanded upon below, but the language of such a qualitative/dispositional identity should indicate a path away from the conceptual dualistic quagmire of distinct mental and physical property realms. There can be, on Martin's Limit View, only one unitary property form possessing both qualitative and dispositional aspects. Properties are therefore not to be separated into two

distinct groups (mental and physical). If there are mental properties, they must share the same surprising identity of qualitative and dispositional that physical properties possess on the Limit View.

If an argument is going to be made for mental realism (especially as concerns qualia – see pp.27-28 later in this chapter), the base conditions for what such a realism entails will need to be figured out. Kim's starting point for realism has been discussed in the first chapter: he holds that to be real is to have causal powers (Merricks calls this Kim's Criterion of Reality). While this is a useful point of departure, such a criterion needs to be reworked with a more robust understanding of causation, as per Martin's reciprocity and directedness of the qualitative/dispositional found in his Compositional Model.

For Martin (1997), the basic causal terms are "disposition" and "manifestation" (p. 202). These terms are much more reflective of causality in its most robust sense, as evidenced by the three general classes that Martin is able to divide dispositions into: 1. Recoverable dispositions (*e.g.* solubility), 2. Non-recoverable dispositions (*e.g.* explosiveness), and 3. Continuous dispositions (*e.g.* soundness of a bridge) (*ibid.*). A further key advantage that comes from couching causality in terms of disposition/manifestation is that "Dispositions can be actual though their manifestations are not" (*ibid.*). An object can have a disposition for having a mutual manifestation with a reciprocal disposition partner that may have ceased to exist or may never exist. An example often used by Martin is that of a certain type of chemical having the disposition of being soluble in a certain type of liquid that does not exist in the world. The disposition is

nevertheless real, even if the manifestation is not, or is not even possible. Martin thinks that the concept of cause and effect needs to be explained as "the Mutual Manifestation of Reciprocal Disposition Partners" (p. 204). Such a robustly interrelated and connected approach for properties is crucial for Martin's Compositional Model, which thinks of wholes/objects as (ontologically) nothing over and above their interrelated constituent parts. As Martin urges:

> This view of the innumerable interconnectednesses and dispositional reciprocities of properties, largely unknown but existent still, contrasts with the simple-minded view that because nature does not lay out *The Cause* of each event, causality is mind-dependent (*ibid.*).

Martin gives a further feel for the intuitively appealing fit of his dispositional/ manifestation model of causality in the following passage:

> With reciprocal disposition partners *each* being for the *mutual* manifestation, *each* must have the directedness and selectivity *for* such a manifestation. If, by misfortune one or more partners do not in fact *exist*, the reaching and directedness and selectivity *for* their manifestation is fully contained in the existent partner (p. 205).

Thus, a dispositional/manifestation model of causation is directed and selective in a manner that can not be easily or properly explained by appeal to a traditional cause and effect concept of causality. And later in this chapter, the 'Compositional' dispositional/manifestation model of reality will be utilized to demonstrate that (on behalf of mental properties) one can accept all four of the principles that Merricks ascribes to Kim's supervenience theory (Criterion of Reality, Causal Exclusion Principle, Causal Closure Principle, No Irreducible Causal Powers: see discussion in first chapter, pp.11-13), without accepting mental-physical supervenience itself. Mental realism needs to be shown to be

continuous with metaphysical realism, and this will have to be done without the aid of the supervenience relation.

Metaphysical realism is here understood as a belief that there are things that exist in the Universe whose existence is observer-independent. Further, it is a belief that all statements made about existent things have truth conditions, "being straightforward descriptions of aspects of the world and made true or false by facts in the world" (Blackburn,1996, under *realism* heading). This realist position adheres to what is known as the (*cf* Martin) Truthmaker Principle, here formulated by Crane (1996): "the principle that when a statement is true, there must be something (some fact or event or property) that makes it true" (p. 2). An added condition to these realist statements, is the insistence that there is only one fundamental level of being in the world: statements made about existent things, if true, can not be reduced to other kinds of statements that would reveal them to be, according to Blackburn (1996), "some different subject matter" (under *realism* heading). This being so, any notions of properties or capacities can only exist at one fundamental level. Support for this position will be presented later in this chapter.

Such a realist position may be problematic for quantum theory, in particular the avowedly anti-realist Copenhagen Interpretation (*cf* Neils Bohr) which claims that at the quantum level there is no reality, only probabilistic description. The realism being argued for here challenges such a theory of sub-atomic anti-realism. While the amazing consistency of realism at all but the sub-atomic level is a good starting point, there are actual arguments that have been

made to challenge the Copenhagen Interpretation: Einstein held the view that quantum theory was not a complete description of physical reality (*e.g.* see the Einstein-Podolsky-Rosen thought experiment, 1935). It will be seen later on in the comparison of Martin's and Cartwright's work, that quantum mechanical claims are based only on measurements of what can be experimentally measured. Just because one has a measurement from an experiment, does not mean that all of the phenomena (*e.g.* wave and particle characteristics) have been accounted for by the measurement. And not being able to (currently) come up with definitive resolutions to realism issues should not be a strong enough reason to cling to Copenhagen Interpretation anti-realism simply because it has a high success rate for purposes of measurement. Taking another approach held by Martin (1996), even at the quantum level there has to be directedness. Although sub-atomic activity may appear to be chaotic, it still exhibits directednesses for certain activities over others. One cannot have directedness without some sort of physical thing present, with "physical" being broadly conceived as ranging from a solid to a force field or wave, etc.. Even at the quantum level, claiming pure function and/or properties without existence-beyond-description seems incoherent. As Martin (1996) has argued, "elementary particles *whatever* they are, have properties that are not purely qualitative because they, like anything else, are capable of more than and something different from what at a given moment they actually manifest" (p. 169).

And we have further reason to argue for mental realism, beginning with an *a priori* starting point: as Martin has argued (unpublished paper, "What is mental

must be physical"), "in order to have numerical difference between just one mind and more than one mind qualitatively similar existing at the same time, it [is] necessary for minds to have a spatio-temporal location...it is sufficient for the ontological difference between one and many, that there *be* a difference in spatio-temporal location between qualitatively similar minds even if the epistemological difference of there being in fact or "in principle", as they say, a procedure for locating them is lacking." Having a spatio-temporal location leads to the having of all sorts of other necessary properties for the mental: size, shape and motion. So if a mental entity has a spatio-temporal location, it must also be physical (Martin, *ibid.*,and Martin, 1959). The challenge that Kim has struggled with – how the mental can be physical without causal elimination inevitably resulting – can only be resolved by developing a clear understanding of what constitutes the subjective/mental as opposed to the objective/physical, and how such an understanding fits into a realist picture of the Universe.

The mental is inextricably linked with physical (brain system/nervous system) activity. This much is known, and this is one of the basic starting points in understanding what the mental is. But to further begin to make sense of the mental-physical relationship, and to find a way out of the supervenience trap, it is necessary that the terms mental and physical be defined. By "mental" in the mental-physical relationship, I am (previously implicitly, now explicitly) referring to "conscious" and therefore "consciousness". I do not believe that this narrowing of the understanding of the terms "mental" or "mind" to "consciousness" has any deviant effect upon Kim's theory or my interpretation of it. But a definition will

help to move beyond some of the supervenience relational theory's often vagueness-induced problems. Consciousness is here understood to be referring to conscious experience itself (consciousness with awareness): the first-person attentional aspect of consciousness (that is, sensateness with awareness). This aspect of consciousness is where the qualia are found: I will happily follow Kim's (1998) definition of qualia, as "the felt, phenomenal qualities of experiences" (p. 102). The rationale behind this narrow interpretation of consciousness is an attempt to focus, as much as possible, on what most obviously gives the mental its unique status (as something different from the merely physical). At the same time, it needs to be remembered that only a small percentage of sensory stimuli (internal or external) are actually the focus of conscious attention at any given time. Further to this, it is clear that while such notions as consciousness without awareness (exemplified most crudely by the case of peripheral vision, and other background information received across all sensory modalities at any given time) are plausible and supported by experimental research, our focus needs to remain on that specific strand of consciousness that involves sensateness with awareness (Velmans, 1995, 2000a, 2000b supports this approach). As Velmans (1995) points out:

> Once a given reference for the term *consciousness* is fixed, the investigation of its nature can begin, and this may, in time, transmute the meaning (or sense) of the term...to understand what consciousness is we need to understand what causes it, what its function(s) may be, how it relates to nonconscious processing in the brain, and so on. As our scientific understanding of these matters deepens, our understanding of what consciousness *is* will also deepen. A similar transmutation of meaning (with growth of knowledge) occurs with basic terms in physics such as *energy* and *time* (p. 247).

And thus a rough sketch has been provided for what shall be here taken to constitute the mental (namely a narrow interpretation of consciousness). By appeal to the Limit View, and the spatio-temporal argument (both due to Martin), it follows that mental realism is continuous with metaphysical realism. It seems clear that, on the strength of the Limit View of properties, if one is a realist about mental properties, then mental properties must be continuous with physical properties (the trick is to explain the unique subjective/intentional aspect of the mental properties, but this explanatory problem does not challenge their existence as properties). A similar path now needs to be taken to develop an understanding of the concept of "physical" in the mental-physical relationship.

In his discussion of what constitutes the "physical", Kim defines his own usage of "properties". Kim (1998) adopts "the plausible view that distinct properties must represent distinct causal powers" (p. 103). Kim differentiates between "sparse" and "abundant" conceptions of properties. Abundant properties are such that every predicate is taken to denote/represent a property, as opposed to a sparse conception (Kim's view), which holds that "differences in properties must reflect differences in causal powers" (p. 105). And so on to Kim's presentation of the physical/physical properties:

> When we speak of physical properties in discussing the mind-body problem, we standardly include chemical, biological, and neural properties among physical properties as part of the physical domain. Without invoking a general criterion of what counts as physical and what counts as nonphysical, can we give some principled ground for this practice? (p. 113).

Although Kim is not so sure that we can, I believe that there is a way to ground this practice, by appeal to Martin's surprising identity/Limit View (1996 and

elsewhere) requirement that we demand the physical to be a holder of both the qualitative and the dispositional aspects that a property must simultaneously have to be real/existent. And although one might agree with Kim (1998) that it is wrong to construe the physical domain too narrowly, it must surely be plausible that the causally closed physical domain "includes only the basic particles and their properties and relations" (p. 113) in all of their complex, reciprocal, directed (as per Martin) relationships.

Kim's conception of the physical/physical properties runs into trouble when he develops his understanding of properties upon the physical realization or mereological supervenience model that he has elsewhere applied to the mental-physical relationship. His theory of properties begins by allowing that aggregates of basic particles count as part of the physical domain, as does mass (e.g. 1 kg) as both mass and aggregates are constituted of physical properties and relations (*ibid.*). As he argues: "On this understanding, being a water molecule is a physical property, and being composed of water molecules (that is, being water) is also a physical property. It is important that these micro-based properties are counted as physical, for otherwise the physical domain won't be causally closed" (p. 114). And from the concept of micro-based properties, Kim returns to supervenient second-order properties, where he concludes that "it seems entirely proper to count as physical any second-order property defined over physical properties" (*ibid.*). So by extension, "functional properties over physical properties count as physical" (*ibid.*). Kim asks that we rephrase such second-order/functional properties as physical property designators. There will be much

to criticize about this approach later, but first Kim allows the above line of reasoning to lead him to three closure conditions on what shall constitute the physical domain:

1. "any entity aggregated out of physical entities is physical" (*ibid.*).
2. "any property that is formed as micro-based properties in terms of entities and properties in the physical domain is physical" (pp. 114-115).
3. "any property defined as a second-order property over physical properties is physical" (p. 115).

As far as 1.: speaking of wholes constituted of aggregates is a useful descriptive technique, but following Martin, the whole just consists of the parts and their respective properties and interrelativities. With 2., Kim leads himself back to the physical-realizer elimination problem. If a property (second-order) is formed as a micro-based property, it is clear where the causal work is occurring, and on Kim's Criterion of Reality, it is clear that the second-order property is not real. And this leads to my outright dismissal of 3., which claims physical reality for that which under Kim's own strong realist criterion, is causally powerless. Soldiering on, Kim further entertains allowing conjunctive properties as a special case of micro-based properties ("if we waive the condition that the constituents of a micro-based property must be *proper* constituents" (*ibid.*)). From all of the above, Kim figures there are sufficient grounds to allow chemical properties within the physical domain. He also thinks that dispositional properties count as physical too, as either second-order or micro-based properties. I think that this is a sadly narrow understanding of dispositional properties. As should be clear from the above discussion of Martin's Limit View, dispositional properties are fundamental to the notion of basic (first-order) properties. And yet again, Kim's

second-order realities impinge on my unilevel conception of reality. Kim's argument for physical dispositional properties derives from the following:

> If transparency is taken as the property of passing light beams through without altering them, it counts as a second-order functional property. If transparency is identified with some microstructure, it will qualify as a micro-based property. The same can be said of such properties as water solubility, ductility, thermal conductivity, inflammability, and the like" (*ibid.*).

And Kim includes biological properties by the same sort of argument, where one is asked to consider a cell as a micro-based property, a heart as a second-order functional property ("i.e., being a heart is plausibly viewed as being an organ/device with powers to pump blood" (*ibid.*)) or a micro-based property as a kind of physical/biological structure. The heart example leads Kim to concede that "the distinction between micro-based and functional properties is probably not sharp or absolute; for example, there surely can be micro-based properties some of whose constituent properties are functional properties" (*ibid.*).

But Kim is leading us down the garden path of supervenience when he assigns second-order physical properties the same causal power as mental properties:

> [F]unctional properties, as second-order properties, do not bring new causal powers into the world: they do not have causal powers that go beyond the causal powers of their first-order realizers. According to the causal inheritance principle, the causal powers of an instance of a second-order property are identical with (or a subset of) the causal powers of the first order realizer that is instantiated on that occasion (pp. 115-116).

If the second-order property is a subset of the first-order realizer, Kim opens himself up to a strange sort of intra-level overdetermination, and as Chapter One should have amply demonstrated, Kim does not want overdetermination

anywhere (he explicitly grapples with the problems of intra-level overdetermination in Kim, 1998). More annoying, is Kim's belief that this strange micro-realization concept somehow does not invite reduction and elimination of the so-called second-order physical properties, or the mental (which seems to be construed as just such a second-order physical property by Kim). This odd result is made clear in what follows:

> This means that second-order properties represent heterogeneous causal powers, but none that go beyond the causal powers of the first-order properties already in our domain over which they are defined. There are therefore no special problems about the causal powers of functional properties. And if any mental properties turn out to be functional properties, there are no special problems about their causal roles either. This fits nicely with the model of reduction we have urged: reduction is essentially functionalization, and if the mental is reduced to the physical, we should expect no special problem about its causal powers (p. 116).

The above quote exposes a major weakness in Kim's platform, since "It is those mental properties that resist functionalization that present difficulties when we try to give an account of their causal powers. So long as we think there possibly are nonfunctionalizable mental properties, for example, qualia, which nonetheless supervene on physical properties, we are faced with the problem of mental causation" (*ibid.*). But the non-functionalizable mental properties are the ones we are interested in, as they are the ones that constitute consciousness-with-awareness in our view (Kim believes that intentionality, as opposed to qualia, can be functionalized, but I disagree, as to functionalize intentionality is to consider it an eliminable, second-order designator of a first-order property (p. 102). If intentionality counts as part of my narrow definition of consciousness, it has to be real, and thus a first-order property). My definition of the mental

revolves around its subjective nature and integral qualia aspect. These mental properties are the problem, not any putative other mental properties. Another area that needs to be focused on here is Kim's denial of the elimination dangers of his micro-realized supervenience. Kim claims to escape complete reduction and elimination by claiming that second-order causal powers, though fixed or determined by the underlying micro-realizer, are not identical with it. Without much extensive argument, Kim claims that "There is a world of difference between *determination* and *identity*" (p. 117). In general terms this is quite correct, but in the case of Kim's mental-to-physical reductive functionalism, the determination relationship disappears into an identity relationship.

A major concern I have with Kim's argument for his conception of physical properties is that he seems to conflate descriptive causal/nomological concepts with physical properties. This concern comes from Kim's flip-flopping between terming the functional or second-order properties either designators or properties...I think there is a world of difference. As has been argued above, the functionalization of so-called second-order properties is a reductive move: Kim sees functionalization as a natural partner for his reductive micro-physical realization model of causation. I have taken Kim's reduction to its natural conclusion: elimination of second-order properties. And here is where my concern about Kim's terminology rises up: property designator terms are merely (on my understanding, generally linguistic) descriptive tools, not explanatory ones. Properties, I would like to argue, are real and existent (*i.e.* anything that has properties has causal power). A purely descriptive role for second-order

properties denies them any existence as real properties, as they are merely descriptive designators for what is physically realized at the first-order level. Kim seems to concede as much when he suggests that second-order/functional properties really are just property designators that are useful and indispensable concepts "that group first-order properties in ways that are essential for descriptive and communicative purposes" (p. 105). As has been discussed above, I believe that mental properties and mental realism are continuous with general metaphysical realism. If this is to be the case, mental properties are just a subclass of properties generally...that is, they are real and must have causal power. And Kim's model does not allow this for so-called functionalizable mental and other second-order properties (including the comparatively uninteresting non-qualia mental properties) and his model can not even accommodate qualia. Discussion of second-order property designators is just not that philosophically interesting for the metaphysical realist who believes there is only one fundamental level of reality. Discussions of second-order designators are only useful for descriptive purposes when dealing with the complex reciprocal interactions of what is physically realized and what is doing the actual causal work. If one wants to talk about designators, one should completely ditch the property talk, and Kim seems to recognize that this may be demanded of his position. Still, if Kim could functionalize mental properties, he feels that he could explain them as second-order physical properties (contrary to our concerns). Unfortunately, the most unique aspects of mental properties, the qualia, are non-functionalizable on Kim's model. But still he labours on: physicalism apparently

does not have to equal micro-physicalism: with supervenient mental properties, Kim concludes that the physical base properties are at the same level as the supervening mental properties. Thus the above-noted intralevel overdetermination worries, which were discussed as they applied to Kim's physical realization model of supervenience in the first chapter.

Armstrong (1997) lays out the nature of the problem faced in presenting any position on properties, especially one that is critical of a second-order functionalization model such as Kim's:

> In the present climate of metaphysics nothing is more important, I think, than the recognition of properties and relations as fundamental constituents of reality. Once properties and relations are admitted, further questions can be raised. Should we, as our languages seem to urge us, admit alongside properties and relations, things, particulars, which have the properties and between which relations hold? Or should we instead try to construct particulars out of properties and relations, or even out of properties alone or relations alone? Again, should we take properties and relations as universals, that is, should we take it that different particulars can have the very same property, in the full strict sense of the word 'same', and that different pairs, triples, ... *n*-tuples ... can be related by the very same relation? Or should we instead hold that properties and relations are particulars (abstract particulars, tropes, moments) so that each particular has its own properties that no other particular can have, and pairs, etc. of particulars each their own relations? A third issue: should we allow that properties and relations themselves can be propertied and stand in relation? Or should we instead with Brian Skyrms allow nothing but a first level of properties and relations? (p. 160).

I think it should be obvious that Kim wants to recognize properties and relations as fundamental constituents of reality, but he does not look into what that might mean deeply enough before charging into second-order/functional properties as potential fellow constituents of reality. A major complaint with his causal role for for functional/second-order properties, is that it goes against Kim's own Criterion of Reality. As I have noted above, a conception of functional/second-order

properties/designators is one that gives no autonomous causal power to the functional/second-order. If the causal power is realized at the first-order level, the second-order level becomes a level of description only and not one of causation. And this is not excusable given Kim's own Criterion of Reality. In line with this complaint about functional/second-order properties is the following: these sorts of properties seem to only exist as macrolevel descriptions of complex microlevel reality. Unless one also believes that numbers and Unicorns have a real existence in the Universe, it seems hard to argue for an existence that is not physical, but somehow physically realized...such an existence is only one of description.

A further warning about how difficult it is to frame just what is the physical, and what qualifies as a physical property is given by Chomsky (2000). Chomsky argues that, while the mind-body problem made sense when framed in Descartes' understanding of the physical (as a plenum where a vacuum and the concept of action at a distance are impossible and whose essential attribute is extension), this problem was made incoherent/non-sensical after Newton did away with the Cartesian notion of the body within his new mechanics (where the Newtonian laws of motion and concept of gravity allow for action at a distance) (p. 84). Not having had a clear notion of body or material or physical since Newton, "the phrase "material" ("physical", etc.) world simply offers a loose way of referring to what we more or less understand and hope to unify in some way" (*ibid.*). Although Chomsky's pragmatic approach to scientific progress allows him to consider such a loose interpretation of the physical adequate for progress to

continue, I do not consider it adequate. But his historical corrective/complaint has been worth noting, and a dose of pragmatism as to claims for definitions and universal laws will be inserted into my position in Chapter Three, when I combine compatible elements of Martin's dispositional properties work and Nancy Cartwright's patchwork of laws theory.

Martin (1996), provides support for my position against Kim, and in favour of a single level of reality/properties. His approach is outlined as follows:

> A great advantage to discussing properties at the non-structural, non-macroscopic, elementary particle or elementary aspects of fields level is that one can avoid reduction vs. non-reduction debates. Discussion at a structural or macroscopic level is vitiated by debate concerning whether the properties at the higher level, are anything over and above properties at a lower level with the usual gesturing toward all of the many varieties of supervenience that are at best ontologically useless and at worst misleading. Discussion at an elementary particle level (even with epistemic qualms) stops the moves to attempt to account for the properties in terms of still other properties at a *lower* level because (if we are epistemically lucky) there aren't any! (p. 73).

Martin's approach demands that one differentiate between mere levels of description of the physical/physical properties and an actual explanation of what constitutes the physical (or at the very least what the limits are for physical properties). Kim's approach to physical properties has obviously been fraught with all of the difficulties that Martin alludes to in laying out his uni-level/single-order approach to the subject.

So, what is my ultimate definition/understanding of what constitutes the physical? I hope that the minimal criteria have been established above. To exist, to be a thing, means to have properties. To have properties (qualitative-cum-dispositional) means to have causal power, to be real. Following Martin's

lead, a compositional account for any given physical whole is arrived at by a determination of the spatio-temporal boundaries of the whole, its properties and relations, its capacities for affecting/being affected by "other actual and possible things, and what degrees of addition, subtraction, and substitution of parts are allowable" (Martin and Heil,1999, pp. 41-42). This is the first step in rendering an object or whole in terms of its constituents. As Martin and Heil happily admit, "A view of this sort is ontologically – but neither conceptually nor explanitorily – reductionist" (p. 42). So there it is, an ontologically reductionist definition of the physical, that along with the above definition of the mental, relies on a general understanding of properties as real particulars. And as a starting point to dealing with mental-physical property issues, "An ontology of properties constrains the empirical question of what properties in particular there are (or might be, or could be) in the material domain" (p. 48). This constraint goes a long way towards rejecting Kim's notions of second-order properties, and embracing his four principles necessary for supervenience while at the same time rejecting supervenience.

To recap, Trenton Merricks (Merricks and Kim, 1995) ascribes four fundamental principles to Kim's metaphysics which inform and are informed by Kim's supervenience relation theory. The four principles are once more outlined here:

1. Criterion of Reality: "To be real is to have causal powers" (p. 156).
2. Causal Exclusion Principle: "For each event, there is at most one complete and independent causal explanation" (p. 157).
3. Causal Closure Principle: "The physical universe is causally closed, *i.e.* every physical event that has a cause, has a complete causal explanation in terms of another physical event" (*ibid.*).

These three principles constitute Kim's attack on nonreductive physicalism. His reductive starting point and adherence to supervenience lead him to a fourth principle:

> 4. No Irreducible Causal Powers: "All causal powers of any object, event or property are reducible to lower level causal powers (unless, of course, there is no 'lower level')" (p. 158).

By accepting the Compositional Model, and the dispositional-qualitative conception of properties, one can accept 1 to 4 (although with a much more robust understanding of causality than expressed in 2 and 3) without accepting supervenience. Since I have argued, following Martin, that there is only one fundamental level of being, supervenience or second-order relations do not need to be appealed to to arrive at an acceptance of 4. At best, on a uni-level conception of reality, 4 becomes somewhat of a given. All causal powers of an object, event or property occur at the fundamental level, because, ontologically, there is only the fundamental level. And an understanding of mental properties as dispositional-qualitative properties, allows one to dismiss all appeals to second-order properties to explain the mental. The subjective character of the mental does need explaining, but its uniqueness can be tackled without further muddying of the waters by placing it on a unique, second-order ontological level (Kim's approach). Further, if one can dispense with thinking of the mental and physical in dualistic terms, some more rapid progress may be possible on the explanation front. And it has been shown in this chapter that the property-based Compositional Model of Martin does not need to appeal to general laws or the accuracy/success of Science for its persuasive and useful power to be taken seriously. This Compositional Model and dispositional-qualitative property

approach will be seen in the upcoming chapter to fit comfortably into a wider meta-theory of reality (espoused by Cartwright) as well as being uniquely qualified to inform mental activity-related neuroscientific research. It is in the next chapter that Supervenience will begin to be left behind, as I continue to move beyond Supervenience and demonstrate how a dispositional-qualitative property approach to the mental fits into a view of reality that is more plausible and of considerably larger scope[2].

[2] John Heil (1998) advances a fairly compatible interpretation of Martin's theory to tackle similar issues in the sixth chapter of his text, Philosophy of Mind.

Chapter Three:

Supervenience, the Compositional Model and the Dappled World

Supervenience has taken a beating thus far. It will suffer more in this chapter. The Compositional Model and dispositional-qualitative property concept will be seen to be able to deal with and comfortably conform to Nancy Cartwright's challenge to the idea of a unified, universal-law based science. Kim's supervenience theory will be shown to be unable to cope with the persuasive arguments given by Cartwright. First Cartwright's central arguments for local realism, for a patchwork of laws in a 'dappled world', will be presented and analyzed. Second, I will argue that Kim's supervenience relation/physical realization theories fail under Cartwright's picture of the world, or under any circumstance where the notion of a fundamental, basic science is challenged. Third, I will argue that Martin's Model and conception of properties is not only compatible with Cartwright's position, but should be joined with it to create a view of reality that would be a refreshing new starting point for research programmes within science, and especially neuroscience. Fourth, having presented my own approach to combining Martin and Cartwright's work, I will then demonstrate how their world picture can provide a successful framework for beginning to reconcile realism about the mental with general metaphysical realism. This demonstration will be made by appeal to the hybrid Martin-Cartwright model developed in this chapter. Finally, there will be a critical discussion of the hybrid Martin-Cartwright model, leading to the conclusion that it is not only a successful and dramatic

corrective to the failed supervenience experiment, but also the best possible current ontological approach to the mental-physical relation.

Nancy Cartwright (1999) suggests that "we live in a dappled world, a world rich in different things, with different natures, behaving in different ways. The laws that describe this world are a patchwork, not a pyramid" (p. 1).

Cartwright expands upon her patchwork of laws concept by appeal to her studies of quantum theory. Her conclusion is that quantum physics only works well within a very narrow, specific set of situations. These are the types of situations that actually fit the incredibly restricted set of models that quantum theory is capable of providing (p. 2). Interestingly, Cartwright notes that quantum theory has never been demonstrated to perform well in areas where classical physics continues to work at its best (*ibid.*). It is this analysis of quantum theory and its comparative place in the world of physical theory that has brought Cartwright to her belief in the concept of a patchwork of laws – "Physics in its various branches works in pockets, primarily inside walls: the walls of a laboratory or the casing of a common battery or deep in a large thermos, walls within which the conditions can be arranged *just so*, to fit the well-confirmed and well-established models of the theory, that is, the models that have proved to be dependable and can be relied on to stay that way" (*ibid.*). Cartwright's doctrines are thus designed to defend these three theses:

1. The empirical success of the best physics theories does not argue for the universality of those theories, even though such success may well argue for their truth. Thus, the laws of physics only apply where the models that physics creates actually fit. This, according to Cartwright, is a very limited range of actual situations in the world at large (p. 4).

2. When laws of physics actually do apply, they only apply *ceteris paribus*. Laws are here defined as merely necessary regular associations. They are descriptions of what happens with regularity, whether that regularity consists of regular associations or just singular causings that themselves happen with regularity. We can include counterfactual regularities with actual regularities if such an inclusive set of regularities occurs by necessity. Thus, for Cartwright, laws only hold as consequences of repeated and successful operation of what she calls a nomological machine[1] (*ibid.*).

3. The broadest scientific knowledge that we have is knowledge about the *natures* of things, their capacities – not knowledge of laws. It is knowledge about the natures/capacities of things that enable us to continually construct new nomological machines that lead to the creation of ever more new laws (*ibid.*).

For Cartwright, "our most wide-ranging scientific knowledge is not knowledge of laws but knowledge of the *natures* [capacities] of things" (*ibid.*). Cartwright advocates the scientific attitude (*cf* Otto Neurath), which is closely related to conventional empiricism, yet rejects many philosophical constructs (*e.g.* Humean impressions, inert occurrent properties, universal determinism) (p. 6). But, like conventional empiricism, the scientific attitude holds that "most important is the requirement that it is the world around us, the messy mottled world that we live in and that we wish to improve on, that is the object of our scientific pursuits, the subject of our scientific knowledge, and the tribunal of our scientific judgements" (*ibid.*). It is Cartwright's main aim to argue that any notion of one unified system of scientific law or theory is "the great scientific lie" (*ibid.*). As she notes in regard to the closure of successful physical theories: "The kind of closure that is supported by the powerful empirical successes of these theories, I shall argue, is of a narrowly restricted kind: so long as no factors relevant to the

[1] A nomological machine is defined as "a fixed (enough) arrangement of components, or factors, with stable (enough) capacities that in the right sort of stable (enough) environment will, with repeated

effect in question operate except ones that can be appropriately represented by the concepts of the theory, the theory can tell us, to a very high degree of approximation, what the effect will be" (p. 7). But, *contra* unified physical law theories, "to all appearances, not many of the situations that occur naturally in our world fall under the concepts of these [our best, interpretative] theories. That is why physics, though a powerful tool for predicting and changing the world, is a tool of limited utility" (p. 9). It is by noting the limitations of theory that Cartwright supports her image of a dappled world. She admits that she takes realists seriously when they insist that "where we can use our science to make very precise predictions or to engineer very unnatural outcomes, there must be 'something right' about the claims and practices we employ" (*ibid.*). But, this claim is two-edged for realists: "if it is the impressive empirical successes of our premier scientific theories that are supposed to argue for their 'truth' (whatever is the favoured interpretation of this claim), then it is the theories as used to generate these empirical successes that we are justified in endorsing" (*ibid.*). And if that is the case, how do we use theory to both understand and manipulate real concrete things? The mistaken and yet common answer to this question is here given and challenged by Cartwright:

> The core idea of all standard answers is the deductive-nomological account. This is an account that serves the belief in the one great scientific system, a system of a small set of well co-ordinated first principles, admitting a simple and elegant formulation, from which everything that occurs, or everything of a certain type or in a certain category that occurs, can be derived. But treatments of real systems are not deductive; nor are they approximately deductive, nor deductive with correction, nor plausibly approaching closer and closer to deductivity as our theories progress (*ibid.*)

---

operation, give rise to the kind of regular behaviour that we represent in our scientific laws (50)."

Further to this, Cartwright suggests that "The problem is that our beliefs about the structure of the world go hand-in-hand with the methodologies we adopt to study it. The worry is not so much that we will adopt wrong images with which to represent the world, but rather we will choose wrong tools with which to change it" (p. 12). Her conclusion is that a belief in the unity of science can lead to poor methodology.

How does the unity of science lead us to this poor methodology? A belief in a small set of first principles can lead us to attempt to manipulate our experiments and the world only in such a way as to have our experiments/the world agree with or comply with our first principles. Thus we could (and Cartwright contends that we often do) be using the wrong tools by exclusive appeal to first principles/the unity of science. The need is for a more dynamic, reflective of in-the-world-reality approach. Such an approach would not assume that there are universal laws, but if there are laws, they are to be taken as only true within their local (*e.g.* controlled experimental) environment. But even if we discover true local laws, the laws themselves are not to be understood as new properties in nature (p. 36). Cartwright wants us to realize that true knowledge is not of laws, but of capacities.

Cartwright is at pains, however, to make it clear that realism is not in dispute: it is fundamentalism in science that she takes issue with, and that is what her concepts of local realism and a patchwork of laws challenge. Local realism is realism "about a variety of different kinds of knowledge in a variety of different domains across a range of highly differentiated situations" (p. 23). And

Cartwright maintains that we can be realists about the laws of physics, without being fundamentalists: "To grant that a law is true – even a law of 'basic' physics or a law about the so-called 'fundamental particles' – is far from admitting that it is universal – that it holds everywhere and governs in all domains" (*ibid.*). Cartwright sees all nomologicals as *ceteris paribus* laws. Realism questions about laws arrive "when the model is compared with the situation it is supposed to represent" (p. 26). And Cartwright worries that the fit between the two is often not very good. For her, "The question is, how many of the scientific phenomena we prize are...local to the environments we encounter, or – more importantly – to the environments we construct. If nature is more wholistic than we are accustomed to think, the fundamentalists' hope to export the laws of the laboratory to the far reaches of the world will be dashed" (p. 31).

Cartwright draws some interesting conclusions from her attack on fundamentalism in science. She notes that although laws may be true, they do not introduce new properties into nature (p. 36). For Cartwright, it is capacities and not laws of nature that are basic (p. 49): "What is important about capacities is their open-endedness: what we know about them suggests strategies rather than underwriting conclusions" (p. 59). On this view, all properties bring capacities with them (p. 70). And against the Humean world of regularities: "regularity theorists cannot even get started unless they too take facts involving how capacities operate to be part of the constitution of the world" (p. 71). As it shall be made clear below, Kim's supervenience/physical realization theory brand of reductive realism does not cope well with Cartwright's metaphysical picture.

On the other hand, the similarities between her arguments and Martin's ontology should already be apparent: these will be discussed in some detail after taking a look at the problems Cartwright presents for Kim's theory.

Obviously, Kim's theory falls prey to Cartwright's concerns about fundamentalism in science. In fact, as opposed to my interpretation of the four principles behind supervenience in qualitative-dispositional property terms, Kim interprets these principles in a manner that leaves him vulnerable to the concerns about fundamentalism raised by Cartwright. There are also other key fundamentalist concepts that underly Kim's theory, as we have seen. His dependence upon the nomological consistency of Humean causality is one such concept: there is no good argument made by Kim that proves the success of such lawlike causality beyond the tightly-controlled models of classical physics. (The earlier discussion of Martin's alternative notion of causality as a disposition-manifestation concept beats the fundamentalist problem that Kim is prey to). And this limit of scope is just Cartwright's concern with fundamentalist laws of science – nomologicals (such as Humean, pipeline-view causal laws) may well be useful within the context of controlled experimental models – but they may not actually fit even closely with the real world situations that they are supposedly representing. Kim's fundamentalist starting point condemns him to fail when faced with Cartwright's natures/capacities argument against fundamentalism.

As for the four principles that underly Kim's supervenience theory, it has been shown above that Kim's Criterion of Reality is only workable and not prone to fundamentalist qualms when seen as appealing to properties (capacities) and

not laws of nature alone. As Cartwright makes clear, one can be a (local) realist about successful physical laws without being a fundamentalist (p. 23).

The Causal Exclusion Principle has been shown to be narrow and in need of a robust understanding of the multiple potential reciprocal disposition partners for any causal event. Indeed, in the world view argued for by Kim, this principle also easily falls down when faced with the possibility of a patchwork of laws universe, and within the wholistic world argued for by Cartwright. The Causal Exclusion Principle on Kim's understanding of causality is at best a *ceteris paribus* law: but I do not (and Cartwright certainly does not) believe that the real world is often kind to such simplistic in-a-figurative-vacuum laws.

A similar fate befalls Kim's Causal Closure Principle: as has been noted, it is a sadly narrow view of causality that relies upon what Martin has termed "the pipeline view of causality". And such a view of causality (by ignoring where the causality is really generated from within the dispositional nature of properties) only exists as a (in Cartwright's terms) nomological. And Cartwright has quite rightly suggested that it is just these sorts of causal laws, argued as fundamental, that are flawed and over-reaching. Even if true, such a view of causality only holds within the domain that it works in. And Cartwright believes that the real world is much more robust and varied than the one created for experimentally-provable and proven laws.

Kim's No Irreducible Causal Powers Principle (to recap, the principle that in the event that a mental state's causal powers are reducible to that of a physical state, the mental state is itself reducible to that physical state), does not

have a lot of meaning given my earlier arguments for a uni-level ontology that prominently supports the concept of intrinsic capacities/properties. Powers are powers: they are either real or not. A uni-level ontology only allows for one layer of reality. Cartwright's local realism can also be used to challenge this principle from another angle – even if it were true, it would hold only *ceteris paribus*. Cartwright's theory also reminds us that capacities/powers are intrinsic properties, which go beyond externalist causal reductions. Cartwright's earlier anti-levels of being conclusions about misguided appeals to supervenience to explain macro (or mental) properties are appropriately mentioned here : "There is nothing of the newly landed about these properties. They have been here in the world all along, standing right beside the properties of microphysics" (p. 33). Such a position for mental properties places them where I want them to be: a subset of real properties...even if physics has yet to satisfactorily come to terms with them as real properties. So, on Cartwright's and Martin's terms, there are indeed no irreducible powers: mental properties, if they are real properties, are not in a supervenient or other causal multi-level relation with physical properties – properties are only properties if they have a dispositional-qualitative character, so if there are mental properties, they must be no more than a subset of properties in general. The Cartwright and Martin intrinsic/unilevel theory of properties argues that the irreducible mental causal properties that Kim rails against actually are irreducible if they are properties, as per the above uni-level structure. But if they are not real properties, then they are not real in any sense, and so whether or not they are irreducible becomes meaningless.

Clearly, (and corresponding to its disastrous eliminativist implications for the mental outlined in the first two chapters), Kim's supervenience theory relies too much on an externalist, fundamentalist science to live within a patchwork of laws universe. In the dappled world of Cartwright, capacities/dispositional-qualitative properties are the only fundamentals, not so-called universal laws. Martin's ontology of properties will now be argued to fit nicely alongside Cartwright's patchwork of laws.

Cartwright (1999) presents an argument that replaces fundamental law talk with the idea that it is what she calls capacities that are basic, not laws of nature. This ontology of capacities is very much in tune with Martin's ontology of properties. As Cartwright proclaims, "laws of nature obtain – to the extent that they do obtain – on account of the capacities" (p. 49). Cartwright's notion of capacities is very similar to Martin's of dispositions. She is in tune with Martin's concept of the readiness, directedness and multiple-potential-reciprocal dispositional partners of dispositions (understood as dispositional-cum-qualitative) when she notes that "what is important about capacities is their open-endedness: what we know about them suggests strategies rather than underwriting conclusions" (p. 59).

Cartwright differentiates capacities from dispositions, due to a strict Rylean understanding of dispositions that is clearly not shared with Martin. She argues that "Disposition terms, as they are usually understood, are tied one-to-one to law-like regularities. But capacities, as I use the term, are not restricted to any single kind of manifestation. Objects with a given capacity can behave

very differently in different circumstances" (*ibid.*). So it seems that Cartwright's notion of capacities is at least roughly similar to Martin's notion of dispositions. As she emphasizes, "The point I want to stress is that capacities are not to be identified with any particular manifestations" (p. 64). Cartwright even seems to grasp the need to uphold the surprising identity of dispositional and qualitative in an understanding of properties: "For us, there are properties, and all properties bring capacities with them" (p. 70). Contra a Humean view of the world, one which Kim seems to be too easily persuaded by, and in full agreement with Martin, Cartwright notes that "regularity theorists cannot even get started unless they too take facts involving how capacities operate to be part of the constitution of the world" (p. 71).

So, what is the benefit of connecting the Martin and Cartwright metaphysical pictures to each other? For the purpose of tackling the mental-physical problem within the bounds of a new, metaphysically coherent framework. And equally importantly, to give us a set of ground rules and conceptual starting points to keep the methodology of research programmes (especially those seeking to understand the mental) as clean and honest as possible. It is time to sketch out what such a combined Martin/Cartwright metaphysics would look like.

The result of joining together the above concepts is a hybrid Martin-Cartwright model. Cartwright's capacity-rich properties are clearly substantially similar in form and function to Martin's qualitative-dispositional properties. We have seen above that Cartwright understands that properties have both

intrinsically dispositional (or capacity-rich) and qualitative aspects (p. 70). Thus, it should not alarm either philosopher if the hybrid model rolls both Cartwright's capacity-rich properties and Martin's qualitative-dispositional properties (properties as particulars, not as universals – see Martin and Heil, 1999) into one basic property ontology (even if the somewhat gestural picture of the capacity-manifestation relationship that Cartwright provides leaves some questions as to the richness of her understanding of such a relation). For terminological continuity, this property ontology will be described using Martin's language: *i.e.* qualitative-dispositional properties. This hybrid ontology of properties will thus focus on the natures of things – properties taking priority over theory or laws as most basic. And because it is at the uni-level of the basic properties that the causal work gets done, this ontological picture sidesteps the reductive quagmires of supervenience and physical realization theories. When uni-level properties are held as basic, multi-levels of being are disallowed by the basic ontology. And this basic ontology-as-limiting factor for explanatory development is the first useful role for the Martin/Cartwright metaphysics within consciousness research specifically, and neuroscience generally: researchers and theorists (if they are going to start with the basic ontology of properties) have to consider the ground rules of the basic ontology at all times. This helps to keep the methodology honest, and the resultant research and theories honest as well. It further keeps the theories metaphysically realist at all times (*contra* instrumentalists and quantum anti-realists), since if one starts with the premise of being a realist about properties, one can not later forget this as a theory or physical law is developed.

An obvious extension of this ontology of properties is Martin's Compositional Model, which is another pillar in the hybrid Martin-Cartwright model. And as an *a priori* and pre-theoretical model, the Compositional Model is impervious to the various potential local realisms, the patchwork of laws that may exist in the world: the Model is merely laying down the basic ontology of wholes/objects: the theoretical explanation of a specific whole can come after, and indeed can progress as research dictates. The Model keeps the researcher honest about the relationships of wholes to their constituent parts. And it is specifically in the interrelatedness of mutual manifestation of reciprocal (potential and actual) disposition partners that there is an ontological framework for a wholistic world that can and does go beyond what physics explains. For no matter what laws are ascribed or what theories are developed, the Compositional Model and its ontology of properties dictate that all things have directedness, and are capable of more than they manifest at any given time. This ontological directedness is prior to and independent of any physical law or theory (Martin, 1996 and elsewhere).

How exactly does the basic ontology grapple with the patchwork of laws and local realism argued for by Cartwright? The underlying approach of Cartwright (1999) needs to first be clarified, and is expressed as follows: "Metaphysical nomological pluralism is the doctrine that nature is governed in different domains by different systems of laws not necessarily related to each other in any systematic or uniform way; by a patchwork of laws. Nomological pluralism opposes any kind of fundamentalism" (p. 31).

The related concept of local realism is motivated similarly, and as has been noted above, is a realism "about a variety of different domains across a range of highly differentiated situations" (p. 23). Cartwright divides knowledge between objective local knowledge based upon "inexact facts" and knowledge provided by natural sciences, a very precise, exact knowledge. Cartwright argues that objectivity is grounded in inexact facts, which are very different from scientific, exact facts. Exact facts require perfectly controlled scientific environments to be identified. This is not the case for inexact facts (*ibid.*). Cartwright gives legitimacy to the concept of inexact facts by presenting the following examples of 'perceptual knowledge':

1. We know that oak trees come exclusively from acorns, whereas they do not come from pine cones.
2. We know that homeless people are going to have their difficult and unhappy situation remedied somewhat if they are fed and housed.
3. We know that if we want to lower the rate of cervical cancer, there needs to be a higher rate of smear tests done.
4. We know that a [British] pound coin dropped from the upstairs window of a house could easily be caught by someone standing on the ground below the window, but a tissue paper dropped from the same place probably could not be caught.
5. We know that if a compass is used, one could walk but not drive due north (all examples, p. 23).

Cartwright explains how these examples qualify as genuine items of knowledge in the following words:

> I know these facts even though they are vague and imprecise, and I have no reason to assume that that can be improved on. Nor, in many cases, am I sure of the strength or frequency of the link between cause and effect, nor of the range of its reliability. And I certainly do not know in any of the cases which plans or policies would constitute an optimal strategy. But I want to insist that these items are items of knowledge. They are, of course, like all genuine items of knowledge (as opposed to fictional items like sense data or the synthetic *a priori*) defeasible and open to revision in the light of further evidence and argument. But if I do not know these things, what do I know and how can I come to know anything? (pp. 23-24).

It is clear that the basic ontology can survive (and indeed, embrace) both of Cartwright's related doctrines: we can get to a better understanding of the world, and to ever-better theories by starting with the ontology of properties, and using that ontology to build the new theories that we constantly require. And the local realism and nomological pluralism concepts hold up as well, since the criterion of reality as I have made clear, is to have properties (causality, we have seen, comes with the properties), not to adhere to any fundamental causal law.

A notion that Martin and Heil (1999) use to challenge multiple realization arguments is very much sympathetic with Cartwright's focus on natures/capacities and local realisms: the notion of similarity is spelled out as follows, using the purportedly multiply realizable example of pain : "If pain is multiply realizable...this means only that the predicate 'is in pain' applies to different kinds of object in virture of their possessing different, pertinently similar (though not exactly similar), properties. We are now in a position to see how something like this is precisely what we ought to expect, and why statements of

laws in which multiply realizable predicates figure are bound to be hedged" (p. 52). Such a particularized, non-universalized, non-fundamentalist approach is clearly in tune with Cartwright – it challenges externalist nomological infallibility in a way that wonderfully introduces an element of necessary vagueness to statements of laws...in essence 'localizing' them to a much less fundamental scope. The point that statements of laws that involve multiply realizable predicates are hedged at best is spot on with Cartwright's patchwork of laws/local realism. This local realism of sorts is further exemplified by the following comments by Martin and Heil: "The lawlike generalizations we construct in which the predicate 'is in pain' figure, will hold of objects that can be counted on to behave similarly, though not necessarily identically, in similar circumstances" (*ibid.*). Note the important point here: the implicit *ceteris paribus* and localized nature of nomologicals that Martin keys into. The fit with Cartwright is clear. Furthermore, I think that a lot of the arguments for mental chauvinism (as Martin calls it), for realism about the mental, start from inexact facts of just the sort that Cartwright gives examples of above. It seems important to note that we could not even begin to sketch out all of the subjective aspects of the mental without appeal to both the inexact facts of perceptual knowledge as well as the precise ones that research can organize and easily identify. Martin (1996) has keyed into this with his referencing of the 'gut feels' that can function as cue manifestations within his ontological system – such internal, subjective, cueing instances which can do so much – these seem to be part of the bedrock of inexact facts that subjective, perceptual knowledge is built upon (pp. 190-191).

And in a sense, these inexact facts can be just as important as the precise, scientific ones: especially if we are looking for as robust an understanding of the mental as possible.

Will such an ontological approach yield a successful framework for reconciling realism with the mental-physical relation? It can at least guide the theories that are developed, leading researchers away from second-order supervenient properties and relations as possible explanations of the mental back to the basic property ontology. The researcher will do most of the work here, but the ontology must, as Martin has often noted, lead. If we want to begin to build useful scientific models, theories and laws about the mental, we will have to begin by looking at the nature of the mental, at its unique properties. Identifying mental properties (within the framework of the hybrid Martin-Cartwright model) as real properties gets the research ball rolling with ontological ground rules built in. There will always be room for theoretical advance on this subject (mental properties), especially within the still very narrow confines of physics. A sense of this narrowness problem is given by Cartwright (1999) when she notes the following: "The kind of closure that is supported by the powerful empirical successes of these theories... is of a narrowly restricted kind: so long as no factors relevant to the effect in question operate except ones that can be appropriately represented by the concepts of the theory, the theory can tell us, to a very high degree of approximation, what the effect will be" (p. 7). Cartwright reminds us, though, that "to all appearances, not many of the situations that occur naturally in our world fall under the concepts of these theories. That is why

physics, though a powerful tool for predicting and changing the world, is a tool of limited utility" (p. 9). It is obvious that the most prevalent situations/properties that occur naturally in our world and yet do not currently fall under the concepts of fundamental physics are the situations/properties that we identify as mental. And thus, the hybrid Martin-Cartwright model will provide the best possible framework for beginning the arduous scientific task of reconciling subjective mental properties with non-subjective, non-mental properties in the world. Keeping to the consistent metaphysical realism that the ontology of properties demands should operate as a very important set of rails (or placeholders as Martin likes to refer to them) for research programmes studying the nature of mental properties. This framework maintaining role for the ontology, should allow science to continuously expand the scope and predictive power of physics itself.

Are there any challenges that such a realist ontology might face? One of the major problems that any ontological model faces is the possibility that the facts-as-they-appear-on-the-ground might prove it to be false. As Martin himself has noted, every ontological commitment carries with it the possibility of epistemic embarassment. There is an even more extreme further question as to the possible problem of the unfalsifiability of the Martin-Cartwright ontology. Yet, Martin wants us to test the plausibility of his ontology. As he notes, "it would be a mistake to imagine that an ontological thesis could be assessed *a priori*: by eye-balling, so to speak, its components. The test of an ontological picture is its power: how much it enables us to explain and tie together" (Martin and Heil, 1999, p. 49).

Chapter Four:

Two Case Studies from Neuroscience: Implications for Kim, The Hybrid Model and The Mental-Physical relation

After providing a thorough review of the topic of neuroplasticity, this chapter will provide concise yet detailed analyses of two dissenting neuroplasticity research articles that provide an interesting pair of examples for emphasizing the problems that have been found within Kim's supervenience theory. The research articles to be discussed will at the same time allow the merits of (and challenges to) the hybrid Martin/Cartwright model to be discovered in an on-the-ground-research sense. A further outcome will be a discussion of where research into the mental-physical relation should direct itself, given the concerns raised in the two following journal article studies.

The first article is entitled "Topographic reorganization in the striate cortex of the adult cat and monkey is cortically mediated", and is authored by C. Darian-Smith and C.D. Gilbert (1995). Darian-Smith and Gilbert are concerned with establishing which systems (whether cortical or subcortical) mediate visual system cortical reorganization (cortical plasticity) following focal binocular retinal lesion surgery. Discussion of the hypotheses developed in this article will revolve around an application of both Kim's supervenience model and the hybrid Martin-Cartwright model to the research methods and conclusions reached by Darian-Smith and Gilbert.

The second article is entitled "Immediate and simultaneous sensory reorganization at cortical and subcortical levels of the somatosensory system", and is authored by B.M. Faggin, K.T. Nguyen, and M.A.L. Nicolelis (1997).

Faggin *et al* are concerned with the role of cortical and subcortical systems in affecting cortical reorganization (cortical plasticity) following reversible sensory deactivation. It will be argued that the hypotheses that develop from the experimental results in this article have particularly interesting potential consequences for Kim's mereological supervenience model, as well as for the hybrid model. The arguments will be developed by applying both models to the methods and research used by Faggin *et al*.

The research methods of and hypotheses developed by both Darian-Smith and Gilbert and Faggin *et al* will be discussed. This discussion will then be placed in the context of both Kim's notion of the physical and of supervenience. After discussing the analysis on Kim's terms, the material will be set against the alternative idea of the physical that has been presented here, as well as the hybrid Martin/Cartwright models. The problem of interpretative ambiguity will be seen to impact negatively upon Kim's concepts of physical and supervenience. The alternative notion of the physical and corresponding Martin and Cartwright models will be argued to be much more reasonable conceptualizations of reality. But first it will be necessary to work through an overview of the subject of neuroplasticity, in order to properly frame the conflict between Faggin *et al* and Darian-Smith and Gilbert.

NEUROPLASTICITY: BACKGROUND AND TERMINOLOGY

1. Background to neuroplasticity

It used to be thought that the primary, secondary and association areas of

a sensory system were functionally homogeneous: *i.e.*, all areas of cortex at a given level acted together to perform the same function. Recent research dismisses this model in favour of some sort of cortical functional segregation as characteristic of sensory system organization. This notion proposes that each level of cerebral cortex contains functionally distinct areas. Each functionally distinct area specializes in a different kind of analysis. Contra traditional linear, serial-pathway system models, a large amount of current research evidence seems to demonstrate that sensory systems are also parallel systems: they allow information to flow through various sensory components over multiple pathways of the neural network involved (Pinel, 1997, pp. 181-182).

This concept of a neural network is discussed by Getting (1989). For Getting, knowledge of the connectivity of neurons is not enough to account for the operation and capabilities of neural networks. Neural network operation depends upon the cooperative interaction that occurs amongst multiple networks, synaptic and cellular properties: all often non-linear. For Getting, even neurons may have many intrinsic properties that might further complicate any account of neural network operation (p. 187). There is a "vast diversity in properties employed within neural networks" (p. 193). Further: network, synaptic and cellular building blocks "can all be controlled by a host of modulatory mechanisms" (pp. 193-194). The neural network model proposed by Getting clearly favours dynamic as opposed to fixed control of neural network activity. (This discussion of neuroscience-derived neural networks is not meant to be confused with 'neural networks' derived from parallel distributed processing

connectionist models. See Segalowitz and Bernstein, 1997 for concerns about the utility of connectionist and computationalist network models).

This notion of dynamic versus fixed or static control for neural activity is echoed by Gazzaniga's (1988) research. Studying cerebral specialization and corresponding modular interactions, Gazzaniga strongly challenges traditional hierarchical, linear models of sensory system and cortical activity control. Although the idea of functional segregation maintains throughout Gazzaniga's research, his findings emphasize the apparent need for interaction between both hemispheres: there seems to be a question as to the effectiveness of individual, modular brain-function components when cut off from the whole brain:

> The concept of modularity, in the componential sense, has many implications for neuropsychology. With dozens if not hundreds to thousands to billions of components, it seems highly unlikely that their distribution in the brain would be constant and exact...the distribution of components known to be active in a particular mental act may vary not only within a cerebral hemisphere but also between hemispheres...It is the integrated brain that generates our cognition, and how we process a particular piece of information [depends] on far more variables than what our left or right brain is doing with the stimulus (p. 432).

2. Neuroplasticity introduced[1]

Neuroplasticity is a term that covers the dynamic changes and responses of the nervous system to: neural development, learning and memory, recovery from brain damage, and responding to the environment (Pinel, 1997, p. 379). It was once thought that the plasticity of the adult mammalian NS was limited to the complex functional changes that mediate learning. But as studies of neural reorganization have advanced, it has generally been concluded that the mature

[1] This introductory section about neuroplasticity is entirely based upon/derived from J. Pinel's (1997) text. In particular, see Ch. 15, Neuroplasticity: Development, Learning, and Recovery from Brain Damage.

mammalian brain retains the ability to undergo significant slow or rapid reorganization. This reorganization or plasticity can be effected due to nervous system pathway damage, sensory cortex damage or experience change (pp. 400-402).

The function of neuroplasticity is twofold: in the case of slow change, reorganization is generally to compensate for NS damage; in the case of fast change, reorganization aims at tuning the brain to changes in experience (p. 402). Collateral sprouting (the growth of axon branches from mature neurons, usually to postsynaptic sites abandoned by adjacent axons that have degenerated) effects long-term reorganization that is too great to be explained by changes in existing connections. With fast changes, a strengthening of existing neural circuit connections occurs that is too rapid to be explained by neural growth (*ibid.*). Pinel provides a compelling example of fast reorganization:

> Pettet and Gilbert, 1992 created the experience of a scotoma (a blind spot) without damaging the visual system by occluding a small area of one retina while applying visual stimulation to the remainder of the retina. Remarkably, after only several minutes of this treatment, primary visual cortex neurons with receptive fields in the occluded area had expanded the size of the receptive fields several-fold (p. 401).

3. A neuroplasticity research overview

Gazzaniga *et al* (1996) do further split-brain patient/cerebral specialization work. They introduce the notion of long-term neural plasticity with their patient J.W. (a subject also discussed in Gazzaniga,1988, above). Their research findings stress the reciprocal interconnectivities between hemispheres and challenge the exclusivity of function accorded the left brain for language (also see Peterson, 1989). It is noted that "if J.W.'s right hemisphere is now capable of

deriving a phonological or articulatory signal interpretable by the left hemisphere speech system, this is...a remarkable change in the right hemisphere's language capacity" (p. 1260).

Sugita (1996) studies visual systems and suggests that "large-scale functional reorganization at an early stage in the visual processing pathway" (p. 523) explains transformation and reversion to normal behaviour after reversal of the visual image via prism spectacles. Sugita agrees with Gazzaniga's support for interhemispheric connections, providing further impetus to accept multichannelling, modular interaction explanations of brain function. Sugita introduces the notion of global plasticity: citing work by C.D. Gilbert and T.N. Wiesel, Sugita indicates that "it was already known that the receptive field structure changes after the removal of visual input...however...these changes are not restricted to local regions but may take place in the whole area of the primary visual cortex" (p. 526). Global plasticity as a concept is helpful in understanding both Gazzaniga's (1988) discussion of causal location variance, and Gazzaniga *et al*'s (1996) study of long-term neural plasticity.

Important work by Faggin *et al* (1997) and Darian-Smith and Gilbert (1995) on the topic of plasticity and cortical and subcortical roles in mediating it, will now be fully presented and analysed.

DARIAN-SMITH AND GILBERT

Preamble

Darian-Smith and Gilbert (1995) organized their experimentation around the need to identify where visual cortical reorganization is mediated: "To determine the loci along which the [topographic] reorganization takes place, we compared the course of topographic alterations in the primary visual cortex and dorsal lateral geniculate nucleus (LGN) of cats and monkeys" (p. 1631). They conducted tests of topographic reorganization that examined long-term cortical reorganization and its correlation with "subcortical and thalamocortical contributions within the visual pathway, using both physiological and anatomical approaches" (p. 1632).

Materials and Methods (including surgical procedures)

Darian-Smith and Gilbert conducted experiments using seven adult cats (13 brain hemispheres, over 21 recording sessions), and 4 adult macaque monkeys (7 hemispheres, over 17 recording sessions) (*ibid.*). A very defined region of visual input of the test animals was surgically removed by "focal, homologous binocular lesions" (*ibid.*). Once lesions were made in matching regions of each of the eyes of the test animals, "visually driven activity could not be elicited from neurons within a corresponding 5-10 mm diameter region of cortex" (*ibid.*). Over an ensuing period of 2 to 12 months, the visually unresponsive area (visual scotoma) regained a significant level of responsivity" (*ibid.*).

To map the cortical receptive fields involved in these experiments, the researchers used insulated tungsten microelectrodes "to obtain single and small multiunit recordings in both cats and monkeys" (*ibid.*). Mapping of cortical receptive fields was completed with a handheld stimulator that took readings "from cells within a series of penetrations made perpendicular to the cortical surface and restricted to the superficial layers..." (*ibid.*). In the monkeys, 30-40 vertical penetrations were made. The researchers used minimum response characteristics to map the cortical receptive fields, as well as recording the orientation, selectivity, ocular dominance, and directionality within each receptive field (*ibid*).

To map the LGN receptive fields, maps (which were all obtained exclusively "during the final acute experiment" (*ibid.*)), were created by mapping at intervals throughout the topographical area of each individual penetration (*ibid.*). It is interesting to note that, as opposed to the 30-40 penetrations used in the mapping of cortical receptive fields, only 2-4 were used in the mapping of LGN receptive fields. This was probably due to the difficulty of accessing the LGN to make multiple penetrations (see Faggin *et al* 1997, and their criticism of this aspect of Darian-Smith and Gilbert's experimental methods, which will be discussed later in this chapter).

After the visual cortical receptive fields had been preliminarily fully mapped, each electrode was repositioned at the cortical location that correlated exactly with the centre of the planned lesion site. By using an audio signalling technique emanating from the electrode the researchers were able to position the

opthalmic laser's guide light and focus it upon the exactly correlated retinal region. The guide light stimulated the visual cortical neurons in the exactly correlated retinal region. This stimulated visual cortical neuronal activity was used to guide the retinal lesion positions. Cortical cells in the location corresponding to the retinal lesion became silent and thus completely stopped responding immediately upon completion of the retinal lesions (*ibid.*).

Fluorescent dye injections (3 to 4 different colours were used in each test animal) were "made into the striate [visual] cortex 2 weeks before the final experiment" (p. 1633). These injections were used to measure cortical receptive field changes due to the cortical reorganization. Neurons within the dLGN were mapped by staining and counterstaining sections and alternate sections of either the serial coronal region of the dLGN in the monkeys, or the parasaggital region of the dLGN in the cats. This mapping was primarily done to allow identification of and measurement of layer by layer distribution of retrogradely labeled neurons within the LGN (*ibid.*).

Results

Before the surgery to create retinal lesions, there was a control phase mapping of receptive fields for both eyes and both hemispheres in each of the test animals. Visual cortex recordings were completed via a row of vertical penetrations (11-16 penetrations were made per test animal) (*ibid.*). Cortical neuron receptive fields that matched the location of the retinal lesions were immediately silenced after the lesions were made. Correspondingly, the receptive fields of cortical neurons that were either just outside or just inside the

cortical scotoma region demonstrated increased receptive field size that was both immediate and dramatic (pp. 1634-1635). The researchers have added the following qualifier onto these results: "While it could be argued that individual RF [receptive field] shifts are small and may result from small eye movements, their consistent centrifugal displacement from the lesion center indicates that they are directly related to the effect of the lesion" (p. 1635).

Over a period of 2 to 12 months after the retinal lesions were created, the researchers observed a substantial long-term topographic cortical reorganization. Cortical neurons moving from the edge of the cortical scotoma boundary inwards returned to a responsive state, although such responsivity was "to stimulation of perilesion retina" (*ibid.*). The researchers discovered that this inward-moving return of function that occurred all around the perimeter and into the cortical scotoma region was common to all test animals (pp. 1635-1636).

According to Darian-Smith and Gilbert, there are two ways to express cortical reorganization – "either in terms of the area of cortex recovering visually driven activity and undergoing reorganization, or, for cells at a given cortical site, in terms of the extent of visual field over which one observes shifts in their RF [receptive field] positions" (p. 1636). The researchers further provide a quantitative description of cortical reorganization. This is a description that involves measurement of the fill-in of cortical neural activity from any particular scotoma outer edge (Darian-Smith and Gilbert favour this description) (*ibid.*).

Darian-Smith and Gilbert discovered a very different outcome for subcortical reorganization following retinal lesions. In 15 animals (10 cat LGNs

and 5 monkey LGNs) where substantial cortical reorganization had already been recorded, LGN receptive field maps were constructed and reviewed. "In all animals, the passage of electrodes through the central medial portion of the LGN in the cat revealed a large visually unresponsive zone...This visually unresponsive region of LGN contrasted dramatically with what was frequently complete reorganization within the cortex" (p. 1637). The experimental results derived by Darian-Smith and Gilbert are dramatically different from those of Faggin *et al*, as shall be seen later in this chapter. The researchers do, however, qualify their conclusions about the lack of reorganization apparent in the measured LGN receptive fields: "Though we cannot rule out small changes...occurring along the boundary of the deprived LGN...the size of the silent region [within the LGN] approximated the normal representation of the lesioned portion of retina" (*ibid.*).

Darian-Smith and Gilbert are thus led to their principle conclusion from the results tabulated during their experiments: "The absence of appreciable physiological reorganization within the LGN indicated that the mechanism involved [for cortical reorganization] is intrinsic to the cortex" (*ibid.*). This exclusively intracortical reorganization region was arrived at by discounting the role of the LGN, as noted above. It was further buttressed by the fact that "It was unlikely that any reorganization was being mediated within the retina since damage from the lesion was permanent..." (*ibid.*). The physiological measurements that dismissed a reorganizational role for the LGN were augmented by an anatomical supplementary experimental procedure: Darian-

Smith and Gilbert "employed an anatomical approach to explore...[the possibility of thalamocortical afferents being involved in the cortical reorganizational process], labeling populations of cells in the LGN projecting to different sites across the regions of normal and reorganized cortex" (p. 1638). The main features of the geniculostriate (thalamocortical) projections to the cortical scotoma region will now be presented.

Darian-Smith and Gilbert examined the entire width of projection territories that terminated in injection sites located both inside as well as just outside of the original cortical scotoma/reorganization region (*ibid.*). As they note:

> If an extension of afferent terminals within the cortex was responsible for sending perilesion information to the reorganized zone, then we would have expected to see a widening of projection territories within LGN, specifically for populations projecting to injections located within reorganized cortex. Moreover, we would have expected dye injections inside the reorganized cortical area to label cells outside the boundary of the silent LGN, or on the active side of the LGN scotoma (pp. 1638-1639).

But this was not the case, on analysis of the data collected: "any injection placed inside the cortical scotoma labels LGN cells within the unresponsive part of the LGN; and so the scotoma receives no direct input from visually responsive cells within the LGN" (p. 1639).

Discussion

The fundamental observation made by Darian-Smith and Gilbert is as follows: retinal lesion-induced cortical reorganization is both begun in the cortex and "is [also] likely to be mediated, at least in part, by the long-range collaterals of cortical cells rather than by thalamocortical afferents" (p. 1641). Thus, a further important observation that derives from the first is that widescale cortical

reorganization is not mediated at the subcortical (LGN/thalamic) level. "Rather, input to the cortical scotoma is likely to be conveyed through cortical cells lying outside of it" (*ibid.*).

A role for thalamocortical connections is not completely ruled out, however: Darian-Smith and Gilbert merely argue that, since there has been no extension of afferent thalamocortical terminals to the cortical scotoma found during their research, the role (if there is one) must be limited. The researchers set the limit for thalamocortical afferents at the "normal [minimal] physical bounds of the available terminal arbors" (pp. 1641, 1644). But they do make another qualification to these observations, one that Faggin *et al* will later take issue with: "It is also possible that thalamic afferents play an important role in the mechanisms of short-term changes...where the expansion of RFs [receptive fields] suggests an unmasking of subthreshold afferent inputs (in addition to intrinsic connections) normally held in check by local inhibitory pathways" (*ibid.*).

In a discussion that will be seen as quite pertinent when compared to the results generated by Faggin *et al* (see below), Darian-Smith and Gilbert attempt to explain why their visual pathway experiments contrast so strongly with somatosensory system research. They allude to the large amount of somatosensory system research that has been found to accord a very substantial role to the subcortical regions in mediating cortical reorganization (see Faggin *et al*, below). The argument that Darian-Smith and Gilbert make is that there are fundamental architectural differences between the visual and somatosensory pathways. One difference is that "there are more synaptic steps along the

somatosensory pathway at which modifications may take place" (p. 1644). Another difference appears to be that the retinal lesion visual system model is not part of the peripheral nervous system (*ibid.*). As to the purportedly differing architecture of the two systems (visual and somatosensory), Darian-Smith and Gilbert note the following:

> The topologic and spatially overlapping organization of the somatosensory and motor thalamus (particularly in the monkey) also provides an ideal forum for circuitry modification...small alterations at each synaptic level will magnify by the time information is distributed from the thalamus to the cortex. By comparison, in the visual pathway perilesion retina does not reorganize, and information is transported directly from a spatially smaller receptor sheet at the retina to the LGN and primary cortex (*ibid.*).

Given the research data from this experiment on the visual system, even though "reorganization and functional compensation may occur along a sensory pathway wherever widespread, converging, and spatially overlapping projections exist, the particular architecture of the visual system would seem to support the conclusion that "some of the reorganization seen in the somatosensory cortex may at least in part be due to changes intrinsic to the cortex" (*ibid.*).

Such an intracortically mediated model of cortical reorganization leaves Darian-Smith and Gilbert puzzled by two aspects of the thalamocortical system (visual):

1. If visual cortical reorganization appears to be exclusively intracortically mediated, what is the function and role for the corticogeniculate (thalamocortical) pathway?
2. Is there any sort of active connection being made by the efferent neurons that leave the reorganized cortical zone? (p. 1645).

The only response that Darian-Smith and Gilbert are able to give is that the seeming loss of a strong projection of neurons from the cortex to the LGN, indicates that "feedback is modulatory under normal circumstances and, even when reorganized, would not produce a measurable change in the absence of active input from the retina" (*ibid.*).

Conclusion

The ultimate conclusion that Darian-Smith and Gilbert make, given their observations, is that, lacking evidence in support of thalamic mediation or spread of thalamocortical arbors, the "most likely candidate for the extensive...[cortical] reorganization observed is a preexisting framework of intracortical connections" (*ibid.*).

There are a number of researchers who share the cortically mediated view of cortical reorganization with Darian-Smith and Gilbert. Diamond *et al* (1994) have come to similar conclusions as those reached in our first case study. Diamond *et al*'s research findings with rats, while not in principle excluding the subcortical, find significant cortical plasticity and no thalamic change:

> Afferent activity was manipulated by clipping all except two whiskers on one side of the snout ("whisker pairing"), and the receptive fields of neurons at different cortical depths were mapped 24 hours later. Neurons in layer IV, the target of the primary thalamic pathway, were unaltered, whereas neurons located above and below layer IV showed significant changes...The findings support the hypothesis that the layers of cortex contribute differently to plasticity (p. 1885).

Wang *et al* (1995) would also seem to be in conceptual agreement with Darian-Smith and Gilbert, as they develop a cortical-only notion of plasticity from their study of topographic representation in the somatosensory cortex:

> ...we show, using adult owl monkeys trained to respond to specific stimulus sequence events, that serial application of stimuli to the fingers results in changes to the neuronal response specificity and maps of the hand surfaces in the true primary somatosensory cortical field...In this representational remodelling stimuli applied synchronously to the fingers resulted in these fingers being integrated in their representation, whereas fingers to which stimuli applied asynchronously were segregated in their representation...thalamus response maps derived in these monkeys were not equivalently reorganized. This representational plasticity appears to be cortical in origin (p. 71).

Wang *et al* find no subcortical plasticity in their testing. Comparing their results to Diamond *et al*'s rat testing they conclude that, "In that model, as in these monkey studies, behaviourally induced changes were believed to be primarily cortical in origin" (p. 73). And such a conclusion is certainly not in conflict with the work Darian-Smith and Gilbert presented earlier.

FAGGIN *ET AL*

Preamble

An interesting implication of some current research into adult cortical plasticity has been its calling into doubt of the traditional exclusive and all-powerful role ascribed to the cortex in mediating human behaviour and especially mental activity. The article that is about to be discussed calls into doubt the previously widely held view that the cortex alone mediates its own plastic reorganization through intrinsic cortical circuitry (Faggin *et al*,1997, p. 9428). The suggestion is made that plasticity involves concomitant reorganization at both the cortical and subcortical levels. Faggin *et al*'s data "clearly demonstrate that peripheral sensory deafferentation triggers a system-wide reorganization, and strongly suggest that the spatiotemporal attributes of cortical plasticity are

paralleled by subcortical reorganization" (*ibid.*). How was this conclusion arrived at? In what follows, the experimental materials, methods, results and ensuing discussion will be presented and analysed.

Initial experimental challenges to be overcome

One of the principle challenges to researchers attempting to identify correlative activity between cortical and subcortical regions has been the difficulty of simultaneously recording both cortical and subcortical plastic/reorganizational activity within a controlled experimental environment. Prior attempts at correlating cortical and subcortical activity have relied upon independent experiments upon the subcortical region, "without simultaneous characterization of the presumptive changes that it may have caused at the cortical level" (*ibid.*).

Materials and methods

In the Faggin *et al* study, a matrix-like array of sensors were implanted within cortical and subcortical regions of the rat somatosensory region and a reversible sensory deafferentation induced to allow simultaneous investigation of both subcortical and cortical relays (*ibid.*). Their experimental set-up allowed them to simultaneously monitor the activity of large populations (up to 135) of single neurons at cortical and subcortical (thalamic and brainstem) levels. This monitoring occurred both "before and after the induction of a reversible sensory deactivation obtained by a subcutaneous injection of the local anesthetic lidocaine" (*ibid.*). Twelve rats were used in the experiments. The short-term plastic effects of sensory deactivation (completely reversible) were quantified by

recording the simultaneous activity of single neurons which were spread across both the cortical and subcortical relays of the rat trigeminal pathway (*ibid.*).

Surgical and recording procedures

A week prior to the recording sessions, anesthetized rats were surgically implanted with up to three electrode arrays which contained 8-16 microwires. These were specifically implanted in the whisker representation area of the rat primary sensory cortex, the ventral posterior medial nucleus of the thalamus, and the pars interpolaris of the spinal trigeminal complex (*ibid.*).

A week later, the rats were again anesthetized and placed into a recording chamber. A multi-neuronal acquisition processor was used to identify and record action potentials [an action potential is the firing of a neuron (Pinel,1997,86)] of cortical and subcortical neurons. As Faggin *et al* note, "In the control phase of the experiments, the sensory responses of all single neurons were simultaneously characterized by using a computer-controlled probe to produce mechanical deflection of all facial whiskers, one at a time in random order" (*ibid.*).

Immediately upon completion of the control phase, the experimenters induced a reversible sensory deafferentation by injecting the local anesthetic lidocaine in only one of the following locations in each rat: the maxillary gum behind the upper incisors, the whisker pad, different regions of the upper lip. Immediately following the lidocaine injection, the same single whiskers and facial regions stimulated in the control phase were again stimulated in the same fashion (p. 9429). Responses derived from this experimental phase were

compared to the responses derived from the control phase. An advantage of this experimental method is described as follows:

> Because the same large set of neurons was held throughout this experiment, we were able to quantify the spatiotemporal nature of the reorganization process not only by measuring changes in single neuron RFs but also by reconstructing the spatial extent of reorganization somatosensory maps located in cortical, thalamic, and brainstem structures. This latter estimate was obtained by measuring the number of whiskers for which unmasked neuronal responses were observed after the peripheral deactivation (p. 9430).

Results

A total number of 1,022 cortical, thalamic, and brainstem neurons were recorded in 12 adult rats during the course of this study. Four animals had recordings derived from all three neuronal areas, seven animals had recordings derived from only cortical and thalamic neuronal areas, and in one animal only cortical neurons were recorded (*ibid.)*. As the authors note: "In every animal, the characterization of single neuron responses was performed before (*i.e.*, control phase) and after the induction of a peripheral lidocaine block" (*ibid.*).

In the first 3 to 5 minutes after lidocaine was injected, both cortical and subcortical neurons that had receptive fields around the injection sites started to respond to the stimulation of facial whiskers that had not elicited any significant response during the control phase of the experiment. Concurrent multi-site neuronal measurement recorded that these novel neuronal responses occurring almost immediately following the initial sensory deactivation, occurred essentially simultaneously in cortex, thalamus and the brainstem. As the authors note, "in all the experiments carried out, no clear sequence for the establishment of these novel sensory responses was observed. Instead, once the reorganization

process started, it appeared at once at subcortical and cortical levels of the somatosensory system" (*ibid.*).

Analysis of the experimental data found that the reorganization process was distinguished by a huge amount of spatial overlap in the cortex, thalamus and brainstem. This was demonstrated by similar sets of whiskers in the rats consistently forming overlapping regions of unmasked sensory responses in both cortical and subcortical sensory maps. The authors conclude that, "Taken together, these results indicate the existence of a close relationship between the reorganization process in the VPM [ventral posterior medial] nucleus [of the thalamus] and the SI [somatosensory] cortex" (*ibid.*).

It should further be noted that the reorganization process described in this experiment was completely reversible. Only four hours after the lidocaine injection, the vast majority of cortical and subcortical neurons had lost their unmasked responses and had returned to express their original (control phase) receptive fields (*ibid.*).

Discussion

The results obtained by Faggin *et al* indicate that a reversible peripheral sensory deactivation, as induced by lidocaine injection, triggers an immediate and simultaneous sensory reorganization in the cortex, thalamus and brainstem of the rat trigeminal brainstem complex. When the neural receptive field reorganization data was analysed and quantified, "no statistical difference was found between the reorganization process observed in the SI cortex and in the VPM thalamus" (*ibid.*). Although the average latency of cortical responses was

much longer than equivalent thalamic responses, statistical distributions that depicted latency variations for the populations of both cortical and thalamic neurons overlapped considerably. Faggin *et al* note the following:

> Taken together, these findings strongly support the hypothesis that fundamental aspects of the process of cortical plasticity, particularly the ones involved in the early phases of the reorganization process, depend upon concomitant subcortical reorganization. These findings are also in agreement with recent observations that even long-term plastic changes in the primate somatosensory cortex are paralleled by thalamic and brainstem reorganization *(ibid.)*.

The authors credit their success at arriving at their observations as being due to the large matrix-like arrays of electrodes that they were able to rely upon to provide a large, concurrent, spatial sampling of all three of the brain structures of interest. This allowed them the opportunity to provide a much more quantitative description of the reorganization process at the cortical, thalamic and brainstem levels of the somatosensory system (p. 1931).

Surprising discovery from this study

Faggin *et al* were surprised to discover that their observations demonstrated a lack of any consistent ascending (*i.e.* from brainstem to cortex) or descending (cortex to brainstem) sequence for the establishment of the sensory reorganization at the recorded multiple levels of the trigeminal system. All experimental evidence that was recorded suggests that cortical reorganization is established almost simultaneously at both cortical and subcortical levels. The authors "interpret this finding as evidence in favor of our hypothesis that a peripheral deafferentation triggers very fast modifications in the balance of excitation and inhibition across the entire somatosensory system" (p. 9432).

Their overall conclusion is that their data suggest that cortical plasticity is quite likely both guided and constrained by reorganization in subcortical structures, even if the occurrence of subcortical plasticity does not necessarily precede cortical reorganization by much. The two processes would appear to take place almost simultaneously (pp. 9432-9433).

Conclusion

Faggin *et al* conclude with the following comments that neatly reflect their support for a fundamental role for subcortical structures in mediating cortical reorganization:

> In conclusion, our results do not support the hypothesis that alterations in intrinsic cortical circuits alone are responsible for the phenomenon of cortical plasticity [my note: see Darian-Smith & Gilbert, 1995 for argument in favour of this view]. Although our evidence addresses specific paradigms involving peripheral sensory deafferentations, our results also suggest that changes in sensory experience do not induce cortical plasticity which is independent of any short- or long-term subcortical reorganization. By simultaneously characterizing cortical and subcortical reorganization and observing that these processes are very similar in nature, our results clearly implicate subcortical structures, particularly the thalamus, as fundamental contributors in the establishment of cortical reorganization (p. 9433).

There is a tremendous amount of cautious support for the thalamocortical position arrived at by Faggin *et al* as regards the mediation of cortical plasticity. Guillery *et al* (1998) criticize opponents of thalamocortical plasticity (such as Darian-Smith and Gilbert) for leaping too quickly to their conclusions: "we need much more detailed information about these highly organized connections [both intra-thalamic and thalamocortical] before we can understand exactly how the thalamic reticular nucleus might be influencing thalamocortical pathways in attentional mechanisms or in other, as yet undefined roles" (p. 28). And while

they maintain that there is currently a lack of detailed information available, Guillery *et al* offer recent evidence that supports thalamocortical plasticity in attentional mechanisms: "the pattern of thalamic reticular connections to the auditory thalamus of the cat resembles that of the somatosensory pathways in this species. However, cortical connections in the auditory sector of the cat have not yet been defined" (p. 32). Pinel (1997) defines the reticular formation as a "complex network of nuclei in the core of the brainstem..." (p. 223). Guillery *et al* (1998) claim that the thalamic reticular nucleus divides into "a number of sectors, each concerned with a different function (sight, touch, hearing, movement or 'limbic' functions)" (p. 28). Although Guillery *et al*, with the thalamic reticular nucleus, are offering an interactive nexus for cortical areas and thalamic nuclei, they make only tentative claims in the face of a need for more detailed information. Still, the general thrust of their work and observations strongly concurs with the Faggin *et al* thalamocortical explanation for the mediation of cortical plasticity.

In the same cautiously supportive manner, Weinberger (1995) pleads for more study to be made of thalamocortical systems and plasticity: "This is perhaps the greatest area of ignorance in sensory cortical function" (p. 152). While suggesting that thalamic plasticity might be the mediator of cortical plasticity, he offers two other possibilities: descending plasticity in the traditional corticothalamic hierarchy fashion, or a parallel plasticity between cortical and subcortical levels featuring different natures of plasticity, and having the thalamic plasticity support the cortical plasticity. Whichever of the above discussed

alternatives (or any other competing alternatives) are shown to be successful, "Plasticity and reorganizations in sensory systems undoubtedly have functional consequences wherever they are observed, regardless of the levels or sites that are causative" (*ibid.*).

COMPARING DARIAN-SMITH AND GILBERT TO FAGGIN *ET AL*

It has been noted above that Darian-Smith and Gilbert were at a bit of a loss to explain the lack of thalamic reorganization observed during their experiments. Faggin *et al* make some interesting observations in an attempt to find reasons for the very different, active role that they observed for the thalamic system in mediating cortical reorganization. Faggin *et al* (1997) concede that they can not completely resolve differences between pro-intracortical reorganization supporters and pro-system wide reorganization supporters, "because of the differences in experimental paradigms used to induce cortical plasticity" (p. 9433). But they still are able to suggest three possible reasons for Darian-Smith and Gilbert not finding any thalamic reorganization in their experiments.

1. The limited size of the thalamic (LGN) sampling area and limited number of thalamic (LGN) sampling area penetrations used by Darian-Smith and Gilbert may have been a factor. As Faggin *et al* note, "Darian-Smith and Gilbert used 30-40 penetration to map the primary visual (V1) cortex and only 8-13 penetrations (5 in the silent zone) to map the entire lateral geniculate nucleus (LGN)" (*ibid.*).
2. The thalamic firing changes during reorganization may be too small to detect using the classic mapping procedures utilized by Darian-Smith

and Gilbert: "In their study, Darian-Smith and Gilbert reported short-term changes in the RFs [receptive fields] of V1 cortical neurons, but did not investigate the presence of similar alterations in the LGN. Our results suggest that the sizable cortical reorganization observed in the V1 cortex should be paralleled at least by short-term modification in the LGN" (*ibid.*).

3. Darian-Smith and Gilbert could not rule out the possibility that thalamic reorganization is at least partially transient "and, consequently, outlived by long-lasting cortical plasticity" (*ibid.*). But Faggin *et al* don't think that this is likely: from their observations, they hypothesize that "thalamic plasticity accompanies long-term cortical reorganization" (*ibid*).

It might be argued that Darian-Smith and Gilbert fall prey to one of Cartwright's major complaints: starting with a fundamentalist physics can lead to the choosing of poor research methods and tools. I would like to conjecture that Darian-Smith and Gilbert began with fundamentalist preconceptions about the role of the cortex in mediating its own reorganization. This may have led to their feeling vindicated by their conclusions, and closed them off from more fully examining thalamocortical roles in cortical reorganization. However, it must be noted that Darian-Smith has since recognized that there is a much stronger and more complex relationship between cortical and subcortical systems (both normally and during cortical reorganization) than she previously thought – see Darian-Smith *et al*, 1999, and Darian-Smith, I. *et al*, 1999). Faggin *et al*'s work

sees a continuity of approach and observations – see Krupa *et al*,1999 as one example.

KIM'S SUPERVENIENCE PRINCIPLES AND PLASTICITY

An attempt to apply Kim's supervenience principles and notion of the physical to plasticity research will be the final step in fully dismissing Kim's supervenience theory and concept of the physical (especially in consideration of the mental-physical relation).

Kim's Criterion of Reality Principle (Merricks and Kim, 1995, p. 156) – of marginal use given Kim's (already noted) narrow conception of causality. But it can be applied to both intra-cortical and thalamocortical mediation of cortical reorganization models. In the instance of responding to injury to the retina, a cortical reorganization takes place. So this criterion demands that the real cause of the reorganization be identified. For Darian-Smith and Gilbert this is an intracortically mediated event. For Faggin *et al*, this is a thalamocortically mediated event. But, as was noted earlier, Kim's narrow, reductive understanding of causality encourages interpretation of properties and events in a reducible levels sort of way. This does not help the researcher to define her methodology in any useful way.

Kim's Causal Exclusion Principle (p. 157) – given Kim's narrow and fundamentalist conception of causation, this principle is of little real help to the researcher. Such a principle is only fulfilled if a complete and independent causal explanation can be provided for a property or event. Neither of the opposing plasticity research camps have done so. Still, one can accept this

principle as a researcher without claiming a full causal explanation is possible. Like all nomologicals, as noted by the above Cartwright discussion, the Causal Exclusion Principle is purely an ideal: to provide a full, complete explanation for any event is essentially impossible – *ceteris paribus* conditions are always in effect when applying causal laws, and in the specific case of plasticity there is the added issue of metaplasticity. Metaplasticity is a concept argued for by Abraham and Bear (1996), who define it as a higher-order form of plasticity, manifest as a change in the ability to induce subsequent synaptic plasticity (p. 126). As they note, "one implication of such metaplasticity is that the degree or direction of synaptic plasticity induced by a particular pattern of conditioning stimulation cannot be predicted unless the previous stimulation history of the tissue is known" (p. 129). Such a concept would require that Kim's principle be tightened up to refer to only a specific manifestation at a time for an event: concepts like metaplasticity might throw nomological functions out of balance after each new event takes place.

Kim's Causal Closure and No Irreducible Causal Powers Principles have already been argued above to be rife with fundamentalist-nomological weaknesses (as per Cartwright). Another *ceteris paribus* clause needs to be added to the Causal Closure Principle, and we have seen that the No Irreducible Causal Powers Principle only makes sense if one is dealing with an explanatorily macro-micro levels of reality ontology. So, with all of the qualifications that need to be added to make any of these principles work, there seems to be very little instruction that Kim can provide the researcher.

It should also be clear that Kim's confused notion of the physical, as discussed in the second chapter, has no useful role to play as a model or placeholder for the researcher. Kim's supervenience theory dependent metaphysics does not seem capable of leading the research, only of following it.

THE HYBRID MARTIN-CARTWRIGHT MODEL AND PLASTICITY

The hybrid Martin-Cartwright model is obviously much more effective and useful for plasticity research, and ultimately for leading the research into the mental-physical relation and consciousness itself. A uni-level/no-level ontology of properties, a compositional understanding of wholes, and a local realism that allows for nomological pluralism is a highly workable package to bring to the research table. Giving up the fundamentalist, narrow conception of causality in favour of a disposition-manifestation model allows for much more clear-headed approach to both plasticity and the mental-physical relation (not to mention science generally). With the hybrid model, the researcher and theorist can fully enjoy the fruits of scientific research, without being held back from progress by slavish fundamentalist/nomological shackles. The plasticity research and neuroscience in general can be informed by an ontology of properties that emphasizes the robust interrelatedness of reciprocal disposition partners (Martin, 1996). It will be in the incredibly complex mass of interrelatednesses of the human nervous system that robust, metaphysically realist explanations of the mental-physical relation will be derived. Given its apparent dynamic role in learning, memory, and experiential-based adaptivity, plasticity may be where some good work on the nature of mental properties can develop.

IMPLICATIONS OF PLASTICITY RESEARCH FOR MODELLING OF CORTICAL FUNCTION AND THE NATURE OF THE MENTAL

The development of neuroplasticity theory and research should have a substantial impact on modelling of cortical function and sensory system organization. Cortical function modelling is being heavily influenced by the thalamocortical debate, between those, like Faggin *et al*, Martin, and others loyal to the notion of the thalamus as fundamental to cortical reorganization, and those who support an essentially intracortical organization for cortical plasticity (Darian-Smith and Gilbert, Diamond *et al*, and others). Ungerleider (1995) weighs into this debate with a plasticity-derived suggestion that the same functional output (perception, memory) can be generated from different brain regions, dependent on attention (so-called attentional modulation of cortical activity). This idea of a dynamic modularity for brain function challenges traditional static models, and coheres comfortably with more current parallel processing models. Ungerleider, however, joins Guillery *et al* and Weinberger in calling for caution with our modelling of cortical function and sensory system organization, as we lack adequate current knowledge about "the coordination of activity across the multitude of interacting cortical areas" (p. 774).

Faggin *et al* challenge the hierarchical structure of sensory system organization in their above discussed work. An implication of this would be that a sensory system model for plasticity would not be hierarchical, and therefore it

would be more of a horizontal and up-down (feedforward and feedback) model. This concept is in tune with Martin's (1996) work, where he eschews hierarchical descending feedback models in favour of a feedback-feedforward approach: "Homeostatic negative feedback has been found inadequate to explain the capacities for plasticity and adaptivity found in physiology at both the level of complex systems *and* at the cellular level" (p. 189). Thus plasticity is informed by the structure of Martin's reciprocal disposition partner model of causality: it takes the notion of reciprocal neural pathways to be an essential part of cortical function and sensory system modelling (see discussion of Zeki,1992, below).

The challenge to traditional hierarchical modelling presented by neuroplasticity also raises fundamental questions in the area of research into the nature of the mental, the mental-physical relation, and thus consciousness itself. The continuing thalamocortical debate challenges accepted roles for the cortex. Whether one favours the intracortical or thalamocortical arguments, it seems increasingly likely that the subcortical systems are to some (possibly great) degree involved in cortical reorganization. And importantly for consciousness and the mental-physical relation, this subcortical involvement in cortical processes could be interpreted as including the tuning of the brain to changes in experience. If any role is given to the subcortical systems for attentional/experiential neural reorganization, the cortex seems to lose its traditionally held title as the exclusive apparatus for conscious activity. And if the consciousness researcher or theorist still holds any chauvinistic ideas about an independent functional role for the cortex, these will need to be discarded or

modified to explain any thalamocortical dialogue occurring during neural reorganization.

Zeki (1992) in his research into the phenomenon of the unified visual image, argues in favour of both intracortical and thalamocortical interaction. He is supportive of the role neuroplasticity plays with his notion of reentrant connections, through which "all information is to flow both ways between different areas" (p. 75). The reciprocal connections he finds between visual areas are to be considered as a possible part of the explanation for our unified visual images. Zeki further proposes a multi-stage integration where perception and comprehension occur simultaneously.

Crick and Koch (1992) play on the memory function that has been ascribed to neuroplasticity (especially in the above article on metaplasticity). They invoke notions of active versus latent representations. Representations such as seeing a face are active, while latent representations are stored in the brain "as a special pattern of synaptic connections between neurons" (p. 154). Crick and Koch consider understanding the neural basis of attention and short term memory to be key to explaining consciousness. They link plasticity with perceptual change in a hope of understanding the mental-physical relation: "Studying the neurons when a precept changes, even though the visual input is constant, should be a powerful experimental paradigm" (p. 159).

Neuroplasticity's attentional/experiential aspect also provides one of the possible mechanisms for learning and memory. Donald (1997) pursues this possibility:

> Above all, neuronal plasticity must be the key to humanity's flexibility in acquiring such radically new cognitive adaptations [as literacy skills]. Recent work on brain plasticity shows that extensive skill-training can have a major impact on the way the brain allocates its available resources (Merzenich, 1987). ...Thus, the way such a recently acquired skill as reading sets itself up in the brain is probably a by-product of neocortical plasticity, amplified by and interacting with the rapidly changing human representational environment (p. 363).

Learning as a by-product of plasticity: if this is the case, might not the mental turn out to also be a by-product of this process? Or is suggesting this merely a wishful anthropomorphisation of neurological processes? Martin (1997) provides a caution for those eager to leap to conclusions about the possibility of a neuronal explanation of mental properties:

> The double helix had the right fit for the gene to the expert eye and smoothly tumbling molecules have the right fit for fluidity. It is not evident that neuronal firings have that same kind of right fit for the features of experience even for many expert eyes. This is why so many of the workers in neuroscience themselves keep coming back to the "problem" of sentience. The arguments, "What *else* can it be, stupid?" or "You'll get used to the idea" would not be considered conclusive in other areas of science (p. 227).

Learning how neural events might relate to mental properties is a long way from explaining the subjective nature of those properties.

CONCLUSION

An alternative approach to tackling the mental-physical relation is to begin with the hybrid Martin-Cartwright model. The hybrid model and its ontology of properties that has been subscribed to here is the best possible place to start a research programme from: and an ontological model that can offer researchers a solid, realist starting point is well ahead of the metaphysical mish-mash that we have seen within the supervenience-related work of Kim. Most unique here has

been the argument in favour of mental properties as real, existent properties: whatever the explanation of their subjective nature turns out to be, mental properties are just *properties* that have the same qualitative and dispositional characteristics as other properties. This idea of a single continuous notion of properties has allowed an argument in favour of a continuity of metaphysical realism from mental realism to physical realism. Starting with the concept of this realist continuity is essential if the mental-physical relation is ever to be demystified, and broken out of its levels-of-being-reductionist-eliminativist jail cell.

References

Abraham, W.C. and Bear, M.F. (1996). Metaplasticity: the plasticity of synaptic Plasticity. Trends in Neurosciences, 19, 126-130.

Armstrong, D.M. (1997). Properties. In D.H. Mellor & A. Oliver (Eds.), Properties (pp. 160-172). Oxford: Oxford University Press.

Blackburn, S. (1996). The Oxford dictionary of philosophy. Oxford: Oxford University Press.

Cartwright, N. (1999). The dappled world: a study of the boundaries of science. Cambridge, UK: Cambridge University Press.

Chomsky, N. (2000). New horizons in the study of language and mind. Cambridge, UK: Cambridge University Press.

Crane, T. (Ed.). (1996). Dispositions: a debate. London: Routledge.

Darian-Smith, C. & Gilbert, C.D. (1995). Topographic reorganization in the striate cortex of the adult cat and monkey is cortically mediated. Journal of Neuroscience, 15, 1631-1647.

Darian-Smith, C., *et al* (1999). Comparing thalamocortical and corticothalamic Microstructure and spatial reciprocity in the macaque ventral posterolateral nucleus (VPLc) and medial pulvinar. Journal of Comparative Neurology, 410, 211-234.

Darian-Smith, I., *et al* (1999). Parallel pathways mediating manual dexterity in the macaque. Behavioural Brain Research, 128, 101-108.

Diamond, M.E., *et al* (1994). Laminar comparison of somatosensory cortical plasticity. Science, 265, 1885-1888.

Donald, M. (1997). The mind considered from a historical perspective. In D.M. Johnson & C.E. Erneling (Eds.), Future of the cognitive revolution (pp. 355-365). New York: Oxford University Press.

Faggin, *et al* (1997). Immediate and simultaneous sensory reorganization at cortical and subcortical levels of the somatosensory system. Proceedings of the National Academy of Sciences – USA, 94, 9428-9433.

Feigl, H. (1960). "Mind-body, not a pseudoproblem" in S. Hook (Ed.), Dimensions of mind. New York: New York University Press.

Feigl, H. (1967). The "Mental" and the "Physical": the Essay and a Postscript. Minneapolis: University of Minnesota Press.

Feyerabend, P. (1963). Mental events and the brain. The Journal of Philosophy, LX, 11, 295-296.

Gazzaniga, M. (1988). The dynamics of cerebral specialization and modular interactions. In L. Weiskrantz (Ed.), Thought without language Oxford: Oxford University Press.

Gazzaniga, M., *et al* (1996). Collaboration between hemispheres of callosotomy patient: emerging right hemisphere speech and the left hemisphere interpreter. Brain, 119, 1255-1262.

Getting, P.A. (1989). Emerging principles governing the operation of neural networks. Annual Review of Neuroscience, 12, 185-204.

Gilbert, C.D, and Wiesel, T.N. (1992). Receptive field dynamics in adult primary visual cortex. Nature, 356, 150-152.

Guillery, R.W., *et al* (1998). Paying attention to the thalamic reticular nucleus. Trends in Neurosciences, 21, 28-32.

Heil, J., (1998). Philosophy of mind: a contemporary introduction. London; New York: Routledge.

Heil, J. and Mele, A. (Eds.). (1993). Mental causation. Oxford: Clarendon Press.

Horgan, T. (1993). From supervenience to superdupervenience. Mind, October 1993.

Kim, J. (1984a). Epiphenomenal and supervenient causation. Midwest Studies In Philosophy 9, 257-270. References from reprint in D.M. Rosenthal (Ed.), The nature of mind (pp. 257-265) Oxford: Oxford University Press, 1991.

Kim, J. (1984b). Concepts of supervenience. Philosophy and Phenomenological Research, 45, 153-176. References from reprint in Kim, J., Supervenience and mind, Cambridge: Cambridge University Press, 1993.

Kim, J. (1993a). The non-reductivist's troubles with mental causation. In J. Heil and A. Mele (Eds.), Mental causation. Oxford: Clarendon Press.

Kim, J. (1993b). Supervenience and mind. Cambridge: Cambridge University Press.

Kim, J. (1995). Mental causation in Searle's 'biological naturalism'. Philosophy and Phenomenological Research, March 1995.

Kim, J. (1998). Mind in a physical world. Cambridge, MA: MIT Press.

Krupa, D.J., *et al* (1999). Immediate thalamic sensory plasticity depends on Corticothalamic feedback. Proceedings of the National Academy of Sciences – USA, 96, 8200-8205.

Martin, C.B., (1959). Religious Belief. Ithaca, NY: Cornell University Press.

Martin, C.B. (undated, unpublished,) What is mental must be physical.

Martin, C.B., Armstrong, D.M, & Place, U.T., (1996). Dispositions: a debate. London: Routledge.

Martin, C.B. (1997). On the need for properties: the road to pythagoreanism and back. Synthese, 112,193-231.

Martin, C.B., and Heil, J. (1999). The ontological turn. Midwest Studies in Philosophy, 23, 34-60.

Merricks, T. and Kim, J. (1995). Supervenience and mind. Philosophical Books July 1995.

Peterson, S.E., *et al* (1989). Studies of the processing of single words using averaged positron emission tomographic measurements of cerebral blood flow change. Journal of Cognitive Neuroscience, 1, 153-170.

Pettet, M.W. and Gilbert, C.D. (1992). Dynamic changes in receptive field size In cat primary visual cortex. Proceedings of the National Academy of Sciences-USA, 89, 8366-8370.

Pinel, J. (1997). Biopsychology (3rd ed.). Needham Heights, MA: Allyn & Bacon.

Searle, J.R., (1992). The rediscovery of the mind. Cambridge, MA: MIT Press.

Segalowitz, S.J. and Bernstein, D. (1997). Neural networks and neural science: what are connectionist simulations good for? In D.M. Johnson & C.E. Erneling (Eds.), The future of the cognitive revolution (pp. 209-216). New York: Oxford University Press.

Sperry, R.W. (1992). Turnabout on consciousness: a mentalist view. The Journal of Mind and Behaviour, Summer 1992.

Sugita, Y. (1996). Global plasticity in the adult visual cortex following reversal of input. Nature, 380, 523-526.

Ungerleider, L.G. (1995). Functional brain imaging studies of cortical mechanisms for memory. Science, 270, 769-775.

Velmans, M. (1995). Consciousness, theories of. In M.A. Arbib (Ed.), The handbook of brain theory and neural networks. Cambridge, MA: MIT Press.

Velmans, M. (2000). Understanding consciousness. London;Philadelphia: Routledge.

Velmans, M. (2000). Investigating phenomenal consciousness: new methodologies and maps. Amsterdam;Philadelphia: J. Benjamins Publishing Co.

Wang, X., *et al* (1995). Remodelling of hand representation in adult cortex determined by timing of tactile stimulation. Science, 378, 71-75.

Weinberger, N.M. (1995). Dynamic regulation of receptive fields and maps in the adult sensory cortex. Annual Review of Neuroscience, 18, 129-158.