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Of Quantum Physics and DOMINDARs

"DOMINDAR" is an acronym for "Detector of Macroscopic Indetermination, and Restrictor". In my paper "New Perspectives for a Dualistic Conception of Mental Causation",[1] I presented the hypothesis that the brain, taken together with the entire nervous system, is a DOMINDAR. I argued for this hypothesis by inference to the best explanation: The fact that there are brains and that they obviously are a widespread survival asset in the animal kingdom, produced and perfected by evolution in the course of millions of years, *is best explained* by the hypothesis that (*a*) there is macroscopic indetermination in the physical world that is relevant for the survival and well-being of animals, and that (*b*) their brains serve to detect this indetermination (making essential use of the sensory system) and to restrict it (making essential use of the motor system) in ways that are advantageous for the animals' survival and well-being. If brains are DOMINDARs, it is a further question whether they are DOMINDARs *in their own right* or, on the contrary, *instrumentally*. The latter alternative, if adopted, leads to the further hypothesis of *natural souls*—of souls that are not supernatural beings but a part of nature, each soul serving as an at least minimally rational decision maker for an animal, each doing so by using the DOMINDAR which is the animal's brain. I have defended this further hypothesis in several of my publications.[2] The basic fact that points in the direction of natural souls is that there are not only brains, likely to be DOMINDARs, but also consciousnesses produced by those brains, consciousnesses that each have a subject of consciousness. It is most likely that consciousnesses and subjects of consciousness are not produced as causally inert epiphenomena. What, then, is their likely causal *function*?

Instead of going into this question (my disquisitions would amount to a defense of naturalistic, evolutionary and interactionist *substance-cum-consciousness dualism*), I intend in this paper to present the conceptual basics of DOMINDARs, and to display the juncture where in DOMINDAR-theory quantum physics enters the scene. I will do so more or less abstractly. For illustration, I will use simple "abstracts" of DOMINDARs. The two *burning* questions of DOMINDAR-theory are of course: (1) What, precisely, does it mean to detect macroscopic indetermination and how, in principle, is this detecting implemented? (2) What, precisely, does it mean to restrict macroscopic indetermi-

1 Meixner 2008.

2 Meixner 2004, 2006, 2010.

nation and how, in principle, is this restricting implemented? I will delve into these questions—but I will do so more or less abstractly.

At the heart of every DOMINDAR is what I call a "REACTOR".[3] Every device of the type "Do something at one end of the thing and be sure (if all is well with the thing) to get something else at the other end" is a REACTOR (but not only such devices). It is obvious that a considerable part of our everyday life is filled by our manipulation of REACTORs: cars, pianos, dish washers, computers, but also simple tools—like hammers, knives, forks—are REACTORs. A REACTOR can be abstractly represented by a non-empty set of ordered pairs, which is such that the first member of each pair in that set is a possible input-state, *determining*, if it occurs at a time t and the REACTOR functions well,[4] the occurrence of a certain output-state at time $t+\delta$; that output-state is the second member of the pair. If pairs in the set differ with respect to their first member, then they also differ with respect to their second. All the pairs in the set do not differ with regard to the reaction time, δ: δ is the same for all of them.[5] The possible input-states extractable from the set (that is, the possible inputs of the REACTOR) are exclusive of each other: they cannot co-occur; and the possible output-states extractable from the set (that is, the possible outputs of the REACTOR) are also exclusive of each other: they cannot co-occur. No output-state of a REACTOR is an input-state, and vice versa (of course). If a REACTOR has a finite number of possible input-states, then they can be named and listed completely: IP_1, ..., IP_N, and the corresponding possible output-states can also be named and listed completely (in the order of their correspondence to the already listed inputs): OP_1, ..., OP_N. This given, the REACTOR can simply be represented by a finite set of conditional statements (*which are true if the* REACTOR *functions well*), each of which has the following form:

If IP_k occurs at t, then OP_k occurs at $t+\delta$ (the index k is to be taken from 1, ..., N).

A *one-reaction* REACTOR is a REACTOR that can be represented by *one* such conditional. A *two-reactions* REACTOR is a REACTOR that can be represented by *two* such conditionals. A *finitely-many-reactions* REACTOR is a REACTOR that can be

3 "REACTOR" is not an acronym, but the word is nevertheless capitalized since it has a special sense here: the sense needed for describing DOMINDARs.

4 The well-functioning of a REACTOR requires the right inner *and* outer facts, the right "circumstances" (within and outside the REACTOR).

5 This is a restriction serving the restricted purposes of this paper. In a general theory of REACTORs one would also have to consider REACTORs with varying reaction times.

represented by N such conditionals (for some natural number N). An *infinitely-many-reactions* REACTOR is a REACTOR that cannot be represented by a finite set of conditionals of the above form. It is an interesting fact of our everyday life that we use infinitely-many-reactions REACTORs (complex ones, like cars, simple ones, like hammers) without giving it a moment's thought. In constructing *such* REACTORs, are we not envisaging infinitely many alternative possibilities in macroscopic physical reality, all open to us at one and the same moment of time, it being up to us which of the possibilities will be *the one* that is going to be *actual* (or *real*)?

Yes, the existence of infinitely-many-reactions REACTORs with macroscopic output-states *points in the direction* of *macro-indeterminism*. Indeed, already the existence of *any* more-than-one-reaction REACTOR with macroscopic output-states does so. But of course the existence of such REACTORs does not by itself *prove* macro-indeterminism. A well-functioning REACTOR is either idle or active. It is idle if none of its possible input-states occurs; it is active if one of its possible input-states occurs. It may be (completely) predetermined at what time the REACTOR is well-functioning and idle, and at what time it is well-functioning and active, and *in what way* it is active when it is well-functioning and active. Thus, the existence of any REACTOR with macroscopic output-states, no matter *what* is their number, is entirely compatible not only with macro-determinism, but also with *complete* determinism.[6]

The simplest REACTORs with more than one possible output are the *two-reactions* REACTORs. Their form of abstract representation is this:

If IP_1 occurs at t, then OP_1 occurs at $t+\delta$.
If IP_2 occurs at t, then OP_2 occurs at $t+\delta$.
(IP_1 and IP_2, OP_1 and OP_2 cannot co-occur.)

Note that the mechanism figuring in the thought-experiment which is known as "Schrödinger's Cat" is a two-reactions REACTOR. It is a two-reactions REACTOR of the following *special* type:

If IP_1 occurs at t, then OP_1 occurs at $t+\delta$.
If non-IP_1 occurs at t, then non-OP_1 occurs at $t+\delta$.

For a REACTOR of this type, the requirement that its input-states cannot co-occur and that its output-states cannot co-occur is automatically fulfilled. Moreover,

6 Consider also, in this context, that any REACTOR with more than one possible reaction can be regarded as a set of two or more *one-reaction* REACTORs.

for a REACTOR of this type, the input-states exhaust the space of possibilities at a given time, and so do the output-states. In addition to these features, the REACTOR figuring in *Schrödinger's Cat*—the SCREACTOR, for short—has further specialties. For one thing, its two input-states are microscopic, whereas its two output-states are macroscopic. The most important specialty of the SCREACTOR is, however, that it is not predetermined which of its two possible inputs will be realized at time *t*. And this is not just a supposition belonging to the set-up of the thought-experiment *Schrödinger's Cat*; for it is *an accepted scientific fact* that it is not predetermined whether this particular radium atom decays at *t* (which is one of the two possible inputs of the SCREACTOR), or not (which is the other possible input of the SCREACTOR).

It is provable for each well-functioning finitely-many-reactions REACTOR that if it is not predetermined which of its output-states occurs, that then it also not predetermined which of its input-states occurs.[7] But it is not provable for each well-functioning finitely-many-reactions REACTOR that if it is not predetermined which of its input-states occurs, that then it is also not predetermined which of its output-states occurs. In the special case of the SCREACTOR, however, provided it is well-functioning, it *is* provable: If it is not predetermined which of its input-states occurs, then it is also not predetermined which of its output-states occurs.[8]

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7 Suppose the occurrence at *t* of IP_k of a well-functioning finitely-many-reactions REACTOR is predetermined (and therefore, given the definition of a REACTOR, the *non-occurrence* at *t* of all other input-states of the REACTOR is also predetermined). Hence the occurrence at $t+\delta$ of OP_k is predetermined (as is the *non-occurrence* at $t+\delta$ of all other output-states of the REACTOR); this is so because of the truth of "If IP_k occurs at *t*, then OP_k occurs at $t+\delta$", in which "if A, then B" is to be taken in a sense that secures the transfer of predetermination from the *protasis* to the *apodosis*. Therefore: If it is predetermined *which* of the input-states of the REACTOR occurs at *t*, then it is also predetermined *which* of its output-states occurs at $t+\delta$. Therefore (via contraposition, since "if A, then B" is to be understood in such a sense that contraposition is valid for it): If it is not predetermined which of the REACTOR's output-states occurs at $t+\delta$, then it also not predetermined which of its input-states occurs at *t*.

8 Suppose it is not predetermined which of the input-states of the SCREACTOR—supposed to be well-functioning—occurs at *t*. Suppose, moreover, it is predetermined which of the output-states of the SCREACTOR occurs at $t+\delta$. There are two cases under this latter supposition. In case the occurrence at $t+\delta$ of OP_1 is predetermined (case 1), the non-occurrence at $t+\delta$ of non-OP_1 is predetermined, and therefore—because of the truth of "If non-IP_1 occurs at *t*, then non-OP_1 occurs at $t+\delta$", employing contraposition—the non-occurrence at *t* of non-IP_1 is predetermined. But this means that the occurrence at *t* of IP_1 is predetermined—*contradicting the initial supposition*. In case the occurrence at $t+\delta$ of non-OP_1 is predetermined (case 2), the non-occurrence at $t+\delta$ of OP_1 is predetermined, and therefore—because of the truth of "If IP_1 occurs at *t*, then OP_1 occurs at $t+\delta$", employing contraposition—the non-occurrence at *t* of IP_1 is predetermined. But this means that the occurrence at *t* of non-IP_1 is predetermined—*contradicting the initial supposition*. The

Thus, it is neither predetermined that the cat at the output-end of the well-functioning SCREACTOR is alive shortly after time *t* nor predetermined that it is not alive shortly after *t if* (and only if) it is neither predetermined that the radium atom at the input-end of the SCREACTOR decays at *t* nor predetermined that it does not decay at that time. And therefore the existence of the well-functioning SCREACTOR would prove the existence of physical macro-indetermination—if the existence of *micro*-indetermination in radioactivity is accepted (but the existence of micro-indetermination in radioactivity is quite uncontroversial).

The SCREACTOR is a remarkable REACTOR. But it is far from being a DOMINDAR. It is illuminating to consider what would be necessary for making a DOMINDAR out of the SCREACTOR. The cat at the output-end of the SCREACTOR is interested in continuing to live; this we can take for granted. *If* the cat knew, due to additional features of the set-up, that it is neither predetermined that she is alive at $t+\delta$ nor predetermined that she is not alive at $t+\delta$, and also knew how to restrict—in fact, *abolish*—this macro-indetermination by abolishing the correlated micro-indetermination (which is not only entailed by the macro-indetermination but is also the sufficient basis for it, *given* the well-functioning of the SCREACTOR, a well-functioning here presupposed), *then* the whole system would be a DOMINDAR, namely, an *instrumental*—though highly artificial—DOMINDAR *of the cat*. The cat would be—very artificially—in the role of a *natural soul*. If the cat in the system—*if* she had the knowledge just described—made it happen that the radium atom does not decay at *t*, then she would thereby guarantee her being alive at $t+\delta$; and if she made it happen that the radium atom decays at *t*, then she would thereby guarantee her being dead at $t+\delta$. It would be up to her whether she is dead or alive at $t+\delta$. But, given her interest in survival, she would of course choose the *first* of the indicated two alternative ways of restricting the macro-indetermination in question *by* restricting the correlated micro-indetermination. Unfortunately, there is no way known to cats, or to humans, of how to determine a radium atom's decay, or non-decay, at a given time. It is, therefore, impossible to make a DOMINDAR out of the SCREACTOR.

In abstract terms: A device X is a well-functioning *two-ways* DOMINDAR if, and only if, the following conditions are fulfilled:

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conclusion on the basis of the initial supposition must therefore be this: it is (after all) *not* predetermined which of the output-states of the SCREACTOR occurs at $t+\delta$. And therefore we have: If it is not predetermined which of the SCREACTOR's input-states occurs at *t*, then it is also not predetermined which of its output-states occurs at $t+\delta$.

1. The central part of X is a well-functioning two-reactions REACTOR, represented by the following two (predetermination transferring) conditionals:

   If IP_1 occurs at t, then OP_1 occurs at $t+\delta$.
   If IP_2 occurs at t, then OP_2 occurs at $t+\delta$.
   (IP_1 and IP_2, OP_1 and OP_2 cannot co-occur.)

2. IP_1 and IP_2 are physical micro-states, and OP_1 and OP_2 are physical macro-states.
3. X is equipped with a well-functioning *detector* of occasions on which it is neither predetermined that OP_1 occurs nor predetermined that OP_2 occurs.
4. X is equipped with a well-functioning *determiner* for occasions on which it is neither predetermined that IP_1 occurs nor predetermined that IP_2 occurs.
5. The determiner of X determines either the occurrence at t of IP_1 or the occurrence at t of IP_2 *if* the detector of X detects that neither the occurrence at $t+\delta$ of OP_1 nor the occurrence at $t+\delta$ of OP_2 is predetermined and *if* X acts on the occasion.

Suppose now that X is a well-functioning two-ways DOMINDAR, and suppose that neither the occurrence at $t+\delta$ of OP_1 nor the occurrence at $t+\delta$ of OP_2 is predetermined. For this reason, and because the REACTOR of X is well-functioning, it follows that it is neither predetermined that IP_1 occurs at t nor predetermined that IP_2 occurs at t (see the proof in footnote 7). Suppose X is doing the job it is well-equipped for. Then its detector will detect the OP_1/OP_2 macro-indetermination at $t+\delta$, and its determiner will restrict—in fact, abolish—this OP_1/OP_2 macro-indetermination *by* determining either that IP_1 occurs at t, or that IP_2 occurs at t. For it is guaranteed—given the well-functioning of the REACTOR of X—that if IP_1 occurs at t, then OP_1 occurs at $t+\delta$, and if IP_2 occurs at t, then OP_2 occurs at $t+\delta$.

Several things are important to note here, which are already quite apparent in the simple case of a two-ways DOMINDAR: (i) A DOMINDAR restricts—in the special case: abolishes—(an instance of) *macro*-indetermination *via* restricting (an instance of) *micro*-indetermination. (ii) It does not need to detect this micro-indetermination; rather, it may be the case that the micro-indetermination is not only instrumental in restricting the macro-indetermination but also in detecting it (see below). (iii) The determiner of the DOMINDAR acts, if it acts, at the time at which the actual (but not predetermined) input-state of the REACTOR of the DOMINDAR occurs; the detector of the DOMINDAR acts, if it acts, *not later* than that time. (iv) A DOMINDAR is not per se *rationality-guided*; in order to be rationality-guided, a DOMINDAR must restrict the macro-indetermination it detects in accordance with the *interests* of a being that does have interests in the macroscopic physical world—for example, the interest to continue to exist. This interested entity may, of course, be the DOMINDAR itself; or the interested entity

may be an entity of which the DOMINDAR is an organ; or the interested entity may be an entity that knows (but need not be articulate about it) that its own existence depends completely and utterly on the existence of the organism of which the DOMINDAR is an organ—an entity which is not the incarnation but, so to speak, the *empsychization* of the life-interests of the organism.

The three central questions concerning DOMINDARs are these: (A) How does the detector of a DOMINDAR work? (B) How does the determiner (or *restrictor*: see footnote 13) of a DOMINDAR work? (C) Are there any DOMINDARs? The first two questions are utterly difficult to answer. I will make some suggestions, but perhaps questions (A) and (B) are impossible for us to answer. This may give one the idea that there are no DOMINDARs—along the lines of a very familiar, but hardly ever explicitly avowed pattern of anthropocentric thinking, according to which something that *we* just cannot understand must be assumed to be simply non-existent. This pattern of thinking is difficult to defend even in cases that are favorable to its application; in the case of DOMINDARs, however, the pattern is just about indefensible. *Consider*:

In a room with no easy way out, an evil person has left me alone with a bomb that is set to explode in ten seconds, at 12 o'clock. But I can run to the bomb and touch it. The evil person was confident that I do not know how to prevent the bomb from exploding. Fortunately, I happen to know. If I turn this particular little switch on the casing of the bomb to the left, the bomb will inevitably not explode; if I don't, it will inevitably explode. This I know. Not wishing to die, I therefore run to the bomb and turn the switch to the left. The bomb does not explode, and I survive.

Obviously, the bomb was not predetermined to explode, for it did not explode. Was it predetermined *not* to explode? Hardly, for it would inevitably have exploded if I had not intervened at the very last moment, a split second before the blast. But if the bomb was neither predetermined to explode nor not to, then I myself was neither predetermined to turn the switch to the left nor not to (for—given the nature and well-functioning of the mechanism of the bomb—if there had been the latter predetermination, for the one behavioral outcome or the other, then there would certainly have been also the former predetermination, for the one or the other of the corresponding "pyrotechnical" outcomes). If so, did not my brain—either in its own right, or as an instrument of my soul[9]—detect *this latter* macro-indetermination, and did it not restrict—in fact, abolish—it in the way favorable to my survival by abolishing, in the depth of my brain, a micro-indetermination that corresponds to that macro-indetermination in the manner previously described, the descrip-

9 I am my soul, in a certain sense of "I". In another sense of "I", I am this entire human being, this unity of body and soul, and in this sense, I am *not* my soul.

tion being in terms of input-output conditionals and their logical consequences? In short, did not my brain act as a well-functioning two-ways DOMINDAR? I, for my part, am very much tempted to concur. The only hitch is that I do not know *how* the brain, or any other candidate for being a DOMINDAR, detects macro-indetermination—this is *the detection-problem*—, and how it restricts, even abolishes, micro-indetermination—this is *the determination-problem*.

The center of the detection-problem is that a state of indetermination—whether *macro* or *micro*—is a state of pure possibility, not a state of actuality. How does the brain detect that there are alternative, hence incompatible, unactualized possibilities relative to the same future moment of time? Only something that is actual can be detected. It seems, therefore, that the detection of indetermination is impossible.

At this point quantum physics comes to the rescue: it suggests a way out of the difficulty. States of indetermination are, in themselves, states of pure possibility; but fortunately for the DOMINDAR-project they are also, so to speak, *incarnated* in certain states of actuality—namely, in states of quantum-physical superposition. A state of indetermination may be detected via detecting the state of quantum-physical superposition which *incarnates* that state of indetermination.

Superposition states are notoriously hard to describe as soon as one moves beyond the mathematical formalism. The cat in Schrödinger's thought-experiment is taken to be in a macroscopic superposition state—and in popular books on quantum physics the reader is told that the cat in that state is dead and alive, and/or neither dead nor alive. Inadequate as such descriptions certainly are,[10] they nevertheless show that states of quantum-physical superposition are fit to *incarnate* states of indetermination. The incompatible, alternative possibilities of a state of indetermination are *superposed* in the *incarnating* superposition state—which is a state of actuality; the *incarnated* state of indetermination, a state of pure alternative possibilities, is "decided on"—is in one way or another replaced by a classical state of actuality—if, and only if, the incarnating superposition state mutates into a *definite* state of actuality: in selection-actualization of precisely one of the alternative (and precise) possibilities of the state of indetermination it incarnates (by superposition of those alternative possibilities).

So far, so good. But there are further difficulties, further aspects of the detection-problem. Would not the very detection of a superposition state automatically make it mutate into definiteness, and make it mutate into definiteness in an uncontrollable way (that is, make it "collapse")? And are there *macroscopic* superposition states? Even if there are, this, by itself, is not enough for the feasi-

10 The best ordinary-language description of superposition states is this: they are *actual, but ontologically vague* states.

bility of the central part of the DOMINDAR-project: In order to support the interpretation of *brains* as DOMINDARs, macroscopic superposition states must be naturally given, in great numbers, within the natural environment of animals; it is not enough if they are here and there artificially produced in the lab. Judging from our human position, there *do seem* to be uncountably many naturally given states of macroscopic indetermination within the natural range of animals (especially humans), but there do not seem to be within the natural range of animals many naturally given macroscopic superposition states. This suggests that the connection between macroscopic states of indetermination and superposition states is not as close as initially hoped for. In the life-world, in the world in which animals have to make their decisions, the number of superposition states that are available for *incarnating* macroscopic states of indetermination appears to be just too small. Thus, it is far from obvious that quantum physical states of superposition contribute significantly to a solution of the detection-problem.

Perhaps the detecting of macroscopic indetermination by DOMINDARs is not literally a detecting; perhaps it is, properly speaking, an inferring, or even a postulating. If what is inferred or postulated turns out to be really there, at least in a great number of cases, then the inferring, respectively postulating, serves the purpose of obtaining reliable information not significantly worse than it would be served by *detection* in the literal sense. Taking this idea seriously, I propose that any state of *micro*-indetermination for a DOMINDAR—any occasion on which it is not predetermined which of its input-states occurs—is, in fact, *incarnated* by a state of quantum-physical superposition, a certain non-classical state of actuality; *whereas* any state of macro-indetermination for a DOMINDAR is, indeed, *merely* a state of pure possibility (*not* incarnated by a superposition state, a certain non-classical state of actuality). There is, after all, no problem in this, because under the presently considered hypothesis the states of macro-indetermination for a DOMINDAR do not need to be literally *detected* by it. It is true of the *usual* DOMINDAR that a state of micro-indetermination for it does not betoken with logical certainty that there is also, corresponding to that state, a state of *macro*-indetermination for the DOMINDAR[11] (that is, an occasion—in a certain temporal distance—on which it is not predetermined which of its output-states occurs); that the DOMINDAR's states of micro-indetermination are *incarnated* by states of quantum-physical superposition does not change this (usual) fact. But given the truth of the DOMINDAR-conditionals—each with an input-state of the DOMINDAR on the *protasis*-side and the corresponding out-

11 But we have seen what an exception to the *usual* DOMINDAR would look like: the SCREACTOR (if it were a DOMINDAR).

put-state on the *apodosis*-side, and taken together completely describing the determination relation between the DOMINDAR's input- and output-states—a state of micro-indetermination for the DOMINDAR is *an indication* of a state of macro-indetermination for it. Micro-indetermination for the DOMINDAR justifies *assuming* the corresponding macro-indetermination.

On the level of the logical bare bones: Though the following form of inference is not *logically* valid,

If A, then B. Not necessarily A → Not necessarily B,[12]

particular instances of this inference-form are, nevertheless, rationally useful, namely, as bases of *Peircean abductions* of a peculiar kind: *non-necessity abductions*. Consider Peter. If he wins in the lottery, he will buy a BMW. But of course it is not a necessity that he will win in the lottery. We infer (not in a logically valid way, but still quite justifiedly): It is (therefore) not a necessity that Peter will buy a BMW. Or consider the Geiger-counter. If this particular atom decays at t, then the Geiger-counter will click at $t+\delta$. But it is not a necessity that the atom decays at t. We infer: It is (therefore) not a necessity that the Geiger-counter will click at $t+\delta$. The inferential quality of a non-necessity abduction depends, of course, on the availability (more precisely speaking: the *extent* of the availability) of routes of necessitation that are viable *alternatives* to the route of necessitation presented by the first of the abductive inference's two premises, the premise with the form "If A, then B"—routes that might lead to the necessity of B *even in the absence* of the necessity of A. In the two examples of non-necessity abductions just adduced, the inferential quality is rather high (under normal circumstances, which we—quite automatically—assume to obtain), and in the second abduction still higher than in the first.

It seems to me that what I called "the detection of macro-indetermination" by a DOMINDAR is in fact the performance, by the DOMINDAR, of a non-necessity abduction, on the basis of its input-output conditionals and on the basis of a state of micro-indetermination for it. The abduction is fallible, but that does not mean that it is not reasonable. Having called it "reasonable", I immediately add that a DOMINDAR need not have any idea of *how* it arrives at postulating macro-inde-

12 This inference form and the inference form "If A, then B. Necessarily B → Necessarily A" are not logically valid (but are here understood in such a way as to be logically equivalent). In contrast, "If A, then B. Necessarily A → Necessarily B" and "If A, then B. Not necessarily B → Not necessarily A" are (understood in such a way as to be logically equivalent and) logically valid. In this paper, I have, in effect, made use of the latter two inference forms: cf. footnotes 7 and 8.

termination, let alone of how reasonable the procedure is. The DOMINDAR which is the human brain certainly has no idea of how it comes to conclude that there is macro-indetermination for it (in fact, it is entirely unaware of the inference); *a fortiori*, it has no idea of how reasonable, under the circumstances, are the non-necessity abductions it performs. It just implements the procedure. And it presents *us*—the human subjects of consciousness—*in the mode of consciousness* with the *conclusions* (*merely* with the conclusions, and those *not as* conclusions) of its automatically performed, objectively reasonable inferences: We have, normally, the consciousness of macro-indetermination *for us*—the feeling that we might do *this*, or alternatively *that*, the feeling of many possibilities open to us *now*; this consciousness steadily accompanies our waking hours of normal life. If this consciousness of freedom were always or usually untrue, *its insistent occurrence* would be quite unexplainable from the biological point of view.

Having spoken at some length about the detection-problem for DOMINDARs, I finally come to the determination-problem. Whereas the detection-problem concerns the states of macro-indetermination for a DOMINDAR, the determination-problem concerns the states of micro-indetermination for it. There is, obviously, no independent determination-problem concerning the states of *macro*-indetermination for a DOMINDAR, since a DOMINDAR restricts macro-indetermination *via*—only *via*—restricting micro-indetermination. Likewise, there is no independent detection-problem concerning the states of *micro*-indetermination for a DOMINDAR: a DOMINDAR does not detect these states, it is simply *in* these states (or rather, some microscopic part of it), and on their basis it "detects"—that is: implements an abductive inference of the existence of—the corresponding states of macro-indetermination. I propose (see above) that the states of micro-indetermination for a DOMINDAR—in themselves states of pure possibility—are *incarnated* in states of actuality: *in states of quantum-physical superposition*. If so, a DOMINDAR's abolishing of micro-indetermination is not a sort of *creatio ex nihilo*, not even a *creatio* out of the moderate *nihilum* of pure possibility. Rather, that abolishing is *like* the making-clear, the making-precise of a vague term, of a term that can be made clear or precise in more than one way; in other words, it is more like a decision than a creation. Clearly, quantum physics contributes crucially to avoiding the appearance that the work of a DOMINDAR must be something like the creative work of God.

But the center of the determination-problem is that superpositions seem to mutate into definite states by pure chance. If there is, on a certain occasion, a state of micro-indetermination for a DOMINDAR and it is not predetermined which of the several input-states of the DOMINDAR occurs at time t, then each of these input-states has, on the given occasion and as an ingredient in a quantum-physical superposition state, a certain objective probability of occurrence at

t. Suppose it is predetermined that one of the DOMINDAR's input-states occurs at *t*—although it is not predetermined *which* of the DOMINDAR's input-states occurs at *t*. Then the mentioned probabilities add up to 1, for occurrence at *t*—though none of them *is* 1 for occurrence at *t*. *Later*, the probabilities of the input-states still add up to 1, for occurrence at *t*, but now *one* of the probabilities *is* 1 for occurrence at *t* (and all the other ones are, therefore, 0). The superposition state has mutated into definiteness, in other words, *one* of the microscopic input-states of the DOMINDAR has now been *determined* to occur at *t* (and accordingly, given that the DOMINDAR is well-functioning, one of its macroscopic output-states has been determined to occur at $t+\delta$). The problem is that saying "this input-state has now been determined to occur" seems a purely metaphorical way of speaking; for there appears to have been *no one and nothing* that did the determining. The DOMINDAR, certainly, appears to have nothing to do, causally, with the mutations into definiteness of the superposition states that incarnate its states of micro-indetermination. These mutations appear to occur by pure chance, the DOMINDAR having no control whatsoever over them.

If this turned out to be the true general state of the matter, then there would be no DOMINDARs *in the strict sense*, all DOMINDARs (i.e., the things that one nevertheless calls "DOMINDARs", perhaps out of habit) would be DOMINDARs *only in an attenuated sense*. For they would have no *determiner* in the true sense of the word; [13] their so-called "determiner" with respect to microscopic indetermination (and hence also macroscopic indetermination) would be *pure chance*. DOMINDARs have already been found to have no *detector* in the true sense of the word; their so-called "detector" of macroscopic indetermination is not really a detector but, so to speak, an *inferential postulator*. Already for this reason alone, all DOMINDARs are DOMINDARs only in an attenuated sense (keeping in mind what "DOMINDAR" is an acronym for). But the *second* extension (or thinning) of the meaning of the term "DOMINDAR", now threatening, would be considerably more problematic than the first. Recall that I asserted that it is impossible to make a DOMINDAR out of the SCREACTOR because there is no known way to *determine* that a radium atom decays, or does not decay, at time *t*. Clearly, in asserting this, I implicitly excluded pure (objective) chance from being a way of *determining* that a radium atom decays, or does not decay, at a given time. I had good reason for

13 I am here using terminology that I introduced only for two-ways DOMINDARs for formulating conclusions that concern all DOMINDARs. Note that for more-than-two-ways DOMINDARs, "restrictor" is more appropriate than "determiner"; for in their case, *restriction*—i.e., excluding a possibility or some possibilities from actualization—is not automatically *determination*, that is, picking precisely one possibility for actualization.

this exclusion: pure chance ought not to be considered a selective agent, and it ought not to be considered a causal agent. But now it seems that pure chance has to be *included* among the possible *determiners* and that the notion of a *determiner* has to be stretched in this manner, so that at least *in an attenuated sense of the term* "DOMINDAR" there can be DOMINDARs. And pure chance may well be the only determiner—"determiner" (in scare quotes)—that *can be* "put to work" in a prospective DOMINDAR. *Chance*-DOMINDARs may well be, by natural necessity, the only DOMINDARs there can be.

That *chance*-DOMINDARs are necessarily the only DOMINDARs—this is what many would accept as the ultimate verdict of physics. But, so far, I refuse to concur; for from the biological point of view *such* an ultimate verdict of physics would be highly unsatisfactory. For it seems undeniable: If the human brain—a product of biological evolution—is a DOMINDAR, then it is not a chance-DOMINDAR but a *rational* DOMINDAR, a DOMINDAR that restricts macro-indetermination *not blindly* but so as to fit means to ends. If DOMINDARs are favored by biological evolution, as they certainly seem to be, evolution leading to ever higher developments and sophistications of the basic DOMINDAR-model (the present apex is, as far as we know, the human brain, which even produces reflexive consciousness), then it can hardly be true that all DOMINDARs are—let alone: must be—*chance*-DOMINDARs. For the biological usefulness of a chance-DOMINDAR—that is, its contribution to the survival capacity of the organism that is equipped with it—is severely limited. A chance-DOMINDAR can serve as a tie-breaker in situations where it is not important what (among the given alternatives) is done—where it is only important that something (among the given alternatives) *be* done. A chance-DOMINDAR will certainly save Buridan's Ass from dying of starvation. But it will only accidentally—only by chance—help the poor animal to escape from the lion's maw.

Chance-DOMINDARs are DOMINDARs in a broadened sense of the term, but they simply do not have enough of DOMINDAR-hood to fit all the facts of evolutionary biology. However, at this point I must confess my ignorance. I do not know how a DOMINDAR that is *more than* a chance-DOMINDAR is physically realized or realizable. Here we have the truly hard problem for the DOMINDAR-project. It is not enough that evolutionary biology has, quite plausibly, a place for DOMINDARs that are more than chance-DOMINDARs; it would seem that the physical implementation of such devices must also be described in a true and convincing way. The wherewithal for a solution of the problem, assuming that it has a solution, may be expected to be found in certain, not yet clearly ascertainable quantum-physical features of the brain. (Where else might it be found?) Along with others, I *surmise* that those features are closely connected to, perhaps identical with, certain hypothesized quantum-physical features of the brain which, supposedly, enable it to bring forth consciousness. But this—not very precise—*surmise* is all I have.

In order to dispel an impression that my ignorance is merely personal, consider the quantum-theoretical model of human action proposed by Henry Stapp. It is quite sufficient to consider Stapp's approach in its most general terms.[14] According to Stapp (utilizing quantum-theoretical ideas of John von Neumann's), a human action—say, raising one's arm—has two aspects, the conscious intention and the physical action linked to it, and it is determined by four processes (some of which, in their turn, deserve the name "action", some of which don't): process 0, process 1, process 2, process 3. Following von Neumann's terminology, process 2 is the undisturbed evolution of the physical system, in accordance with the Schrödinger equation, and process 1 "the basic probing action that partitions a potential continuum of physically described possibilities into a (countable) set of empirically recognizable alternative possibilities" (Stapp 2011, 24). Process 1 is an *intervention* in process 2, an intervention inexplicable by the formalism of quantum theory, but nonetheless necessary if quantum theory is to have empirical import.[15] Process 0 (Stapp's terminology) is the partly conscious selection process, inexplicable by the formalism of quantum theory, which determines the "process 1 action", the "basic probing action" just described. Process 3 (Stapp's terminology), finally, "*selects the outcome*, 'Yes' or 'No', of the probing action. Dirac calls this intervention a 'choice on the part of nature', and it is subject, according to quantum theory, to statistical rules specified by the theory" (24; the emphasis is Stapp's). This account is likely to leave the reader with the impression that the ultimate and decisive agent of a human action is, according to Stapp, *not* the human being to whom the action is ascribed, and *not* the soul or subject of consciousness of that human being—and Stapp could hardly disagree, given his claim "I introduce no ghosts" and his endorsement of William James's dictum "The thought itself is the thinker" (133),[16] not to speak of Stapp's favoring of Whitehead's anti-substance process ontology (see Stapp 2011, 85–98). However, Stapp's account is also likely to leave the reader with another impression, an impression that is certainly contrary to Stapp's best intentions: the impression

14 For what follows, see Stapp 2011, 23–24.

15 "[T]he orthodox formulation of quantum theory [...] asserts that, in order to connect adequately the mathematically described state of a physical system to human experience, there must be an abrupt *intervention* in the otherwise smoothly evolving mathematically described state of that system" (Stapp 2011, 22; the emphasis is Stapp's).

16 Stapp's "No mental substance!" position is also apparent in Stapp 2009, 21–22. For Stapp, the thought is the *thinker*—and the actualization, Stapp seems to suggest, is the *actualizer*: "Suppose the actualized state of the brain is really *actualized*. What can this mean? One possibility is that some characteristic feature of this state becomes an actual 'experience'" (165; the emphasis is Stapp's).

that the ultimate and decisive agent of a human action is even *not* the mental process of the human being to whom the action is ascribed, but *physical nature*, which (in process 3) certainly acts to some extent *by pure chance* (non-statistical single-case physical necessity being out of the question in the orthodox quantum theory adhered to by Stapp). Stapp's analysis strongly suggests that all a human being's mental process *really does* (in constituting process 0 and in determining process 1) is "to set the stage" for *the action* (i.e., the human act) by putting in place, preliminary to the action, a range of distinct alternative possibilities (paradigmatically, two of them). The all-important rest is up to (physical) *nature*, in other words, up to (physical, objective) *chance*—which means that, in the end, the *intention of the agent* is quite irrelevant.

In the terminology of the present paper, Stapp's account of human action can be soberly summed up as follows: The intending agent determines a particular state of (physical) indetermination for itself, a particular set of alternative possibilities; but the action itself, in which precisely one of these alternatives is actualized, is *not* up to the intending agent; it just happens (with no explanation possible that goes beyond a merely statistical explanation, assigning probabilities). Now, a man, or his soul, or his mental process would not grudge *nature* the privilege of actualization if he, or his soul, or his mental process retained the right to *select* before actualization (or perhaps simultaneous with it) *the possibility that is to be actualized*. But according to Stapp's account, the intending agent—which is for Stapp the mental process of the human being—does certainly *not* retain that right. For according to Stapp *nature* not only actualizes but also *selects* the outcome, i.e., *the action*, the human act. The selection of the outcome is, according to Stapp, using Dirac's words (see above), a "choice on the part of nature", in other words: a "choice" on the part of *chance*—and the scare quotes around "choice" are quite justified (for *chance* is not only *causeless* but also *blind*).

Thus, Stapp's quantum-theoretical approach to human action offers no perspective to solve the determination-problem for DOMINDARs in such a way as to give DOMINDARs that are *more than* chance-DOMINDARs a substantial chance. The so-called *quantum Zeno effect*, invoked by Stapp in an attempt to get from mere "probing actions" and "choices on the part of nature" to *intentional actions*,[17] is of no considerable help. The quantum Zeno effect consists in

17 Stapp *is* sensing a problem for his account: "But the only dynamical freedom offered by the quantum formalism in this situation is the freedom to perform at a selected time some process 1 action. Whether or not the 'Yes' component is actualized is determined by 'nature' on the basis of a statistical law. So the effectiveness of the 'free choice' of this process 1 in achieving the desired end would generally be quite limited. The net effect of this 'free choice' would tend to be nullified

the following phenomenon (see Stapp 2011, 35–36): If a process 1 action X, with a particular process 3 outcome, is the first element in a very rapid sequence of process 1 actions very similar to X, then all the process 1 actions in that sequence will, with high probability, have the same kind of process 3 outcome as X had. Stapp believes that the rapidity of a sequence of "essentially identical" process 1 actions—and therefore the likelihood of the Zeno effect—can be increased by a mental effort of attention (36–37). Therefore, according to Stapp, the intending agent of a human action (which agent is for Stapp—to repeat—the human being's mental process) has *some* power to hold nature, or chance, to *its word*, i.e., to its original choice—at a time when the word has already been spoken, the choice already been made! One may well ask: Is *this*—just *this*—supposed to be what the *intendedness* of a human action consists in? The mere mental insistence on an outcome *chosen by nature* (but is it even that?, or is it merely the mental insistence on a certain kind of "essentially identical" probing actions?), even if causally effective, seems altogether insufficient for *intending* that outcome. If *nature's choice* is not to the intending agent's liking, what then?—Then presumably the intending agent may by a mental effort of non-attention contribute to rendering nature's choice ineffective in the end? (But Stapp, as far as I can see, is silent on this issue.)

Given the central (but in its centrality not quite acknowledged) role that objective c*hance, randomness*, plays in Stapp's account of human action[18]—even *with* the quantum Zeno effect in place—it is clear that one cannot profit from that account if one wishes to recognize DOMINDARs that are, truly, *more than* chance-DOMINDARs. The existence of DOMINDARs—indeed, the existence of *non-idle*, *active* DOMINDARs—is called for by our self-experience and by evolutionary biology, and it is consistent with quantum physics (though not with classical physics). The existence of active DOMINDARs is even consistent with the causal closure of the physical—*if* chance-DOMINDARs are all the DOMIN-

by the randomness in nature's choice between 'Yes' and its negation 'No'" (Stapp 2011, 35).

18 At one point Stapp touches on the problem: "The advance to quantum theory appears at first to offer no basis for any significant improvement: choice is now distributed over time, [...] but is asserted to be controlled exclusively by 'pure chance'" (Stapp 2009, 169). Choice *would* be controlled by pure chance if nature were the ultimate chooser. And that nature *is* the ultimate chooser seems to be what Stapp's view ultimately comes down to. It does not help to *call* nature's choices (for no good reason) "*intrinsically meaningful*: each quantum choice injects meaning, in the form of enduring structure, into the physical universe" (169; the emphasis is Stapp's). Enduring structure is certainly not *per se* a form of intrinsic meaning: there can be plenty of enduring structure in a physical universe that is absolutely meaningless. What is true, however, is that enduring structure is a *necessary condition* of whatever meaning there is in a physical universe.

DARs there are.[19] But in fact our self-experience and evolutionary biology demand active DOMINDARs that are *more than* chance-DOMINDARs: they demand active DOMINDARs that are *rational* (which as such, it seems, have to be *instrumental* DOMINDARs—instruments for *conscious souls*).[20] The existence of active rational DOMINDARs is still consistent with quantum physics (though hardly with materialism); it is, however, an open question whether quantum physics can significantly help us with the determination-problem for *such* DOMINDARs. They are, as *rational* DOMINDARs, DOMINDARs not only in the broad—the attenuated—sense but also DOMINDARs *in sensu stricto*, since they require *determiners* in the true sense. Chance—which is blind and, properly speaking, not a causal agent at all—is certainly not "determiner" enough for *such* DOMINDARs. But how would their determiners *work*? Will we ever know?

19 The mere admission of physical chance-events—physical events without sufficient cause—does not hurt the causal closure of the physical; it only hurts physical determinism.

20 Stapp, not a friend of substantial souls, at least quotes and endorses William James, who in his *Principles of Psychology* forcefully argued on biological grounds for the causal efficaciousness of consciousness (though not for the causal efficaciousness of its *enduring subject*). (See Stapp 2011, 3–4; Stapp 2009, 10–11.)

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