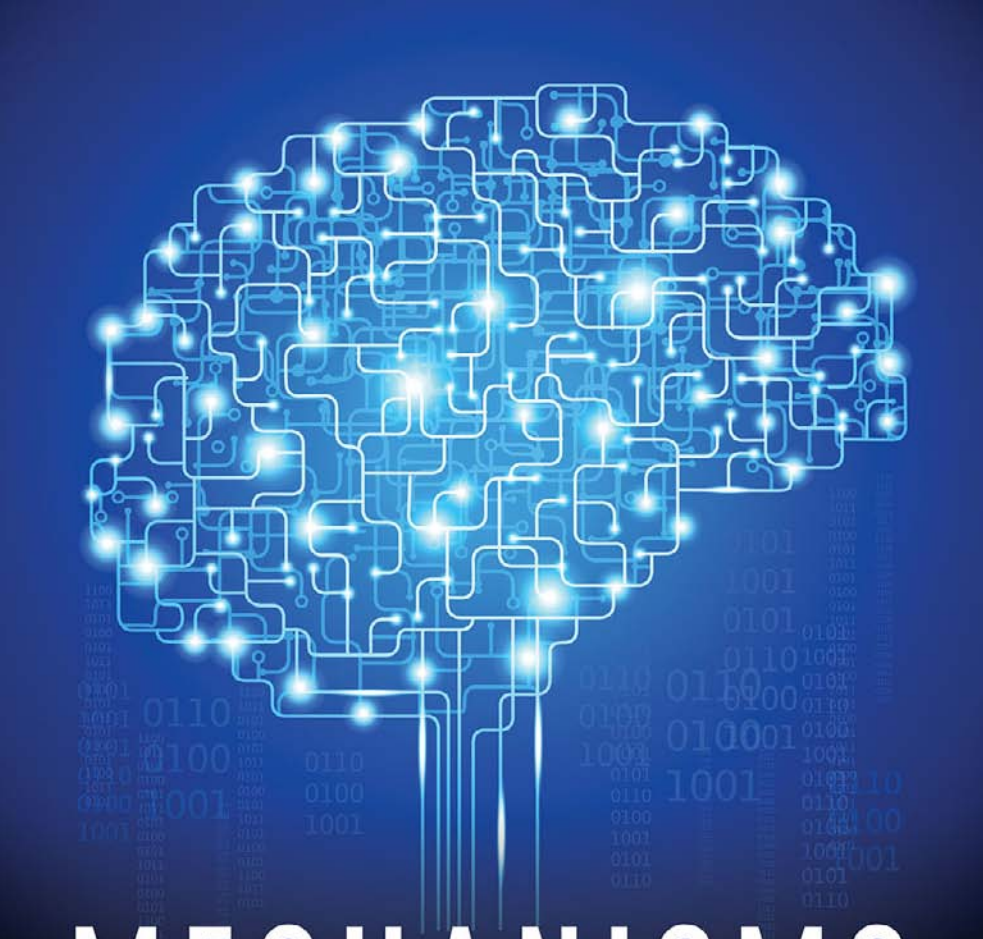

MECHANISMS IN WORLD AND MIND

Perspective Dualism, Systems Theory, Neuroscience, Reductive Physicalism

Bernd Lindemann

Contents

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1. Perspective

This text on philosophical aspects of neuroscience is centred on perspective dualism, distinguishing the mental or first-person view from the neuronal world, which is invisible to the first-person, the Self. The topic *reduction of apparent mental processes to real neuronal mechanisms* unfolds in the discussion of mechanisms in world and mind. Models of neuronal mechanisms of differing complexity are described in a general way, classified and assigned to levels of systems theory. Various strategies of reduction are delineated and their feasibility is tested using explananda such as life, mind or consciousness.

The aim is to explore if and how the mental may be understood in terms of neuroscience, in terms of biophysical mechanisms. According to a common intuition, such understanding is not possible because humans have design, agency – they have feelings, emotions, consciousness – and intention, concepts, knowledge, reason, believes, values, dignity – they are in many ways 'more' than what is explainable by physics. Nevertheless, such understanding in neuroscience terms will be found feasible for a variety of one-level reductions, including reductions of agency and dignity. Multi-level reductions are combinations of one-level-reductions. Their explanations, unfortunately, are less comprehensible, for comprehension tends to fail as intermediate explanations are skipped.

1a. The mind-neuron problem

When viewing living beings from a distance, in the third-person perspective, we find them to be similar to physical objects in a general way. For they can be located in space and time (are not abstract) and events within them, like those outside of them, follow gap-less chains of physical interactions. Thus the living objects, or their bodily aspects, are part of the physical world. As such they

can be analysed objectively by physics and its branches biophysics, biochemistry, genetics, molecular biology, neurobiology, biology. This third-person view is the *physical perspective*.

But there is something else. Living beings, unlike physical objects generally, have design, a construction plan generated and changed by evolution. Further, they have needs and initiative by design. For instance, when their composition deviates too much from optimal values, living beings take measures of self-preservation, counteracting the unfavourable trend.[1] Then they will fold or unfold their leaves or tentacles, expand or shrink, search for food, leave their environment or manipulate it, in short, make use of mechanisms of control to exercise autonomy, agency.[2] This property of agency draws a line between them and their environment, it establishes a subjective *agent-world polarity*.

Further, those living beings which live with peers *report* about themselves by their behaviour and those gifted with speech *report* about themselves explicitly, using a system of symbols.[3] Their story reveals an inner dimension which seems fundamentally different from the physical world. Using the first-person or mental perspective, the reports are about experiences, thoughts, desires, about feelings of a conscious Self-agent. The reports are about mind-phenomena which are not locatable in space (and, arguably, time). Where in space is a thought, a belief? Being not locatable, mind-phenomena are abstracta. As such they cannot interact with physical things, even though they are 'about' them

[1] This behaviour may be shared by automata designed by humans.

[2] An agent is an at least partially autonomous unit which is or appears to be in control: it can decide and act upon its decisions. This definition applies, for instance, to every living cell.

[3] The report is an objective fact while its content is only subjectively accessible.

[21]. Yet such thought → world interaction is reported by the Self-agent, a logical contradiction.[4]

Mental and physical perspective, first- and third-person perspective, these are the two sides of 'perspective dualism'[5]. The perspectives may be equally relevant but they are contradictory and irritating: Why two points of view? Below I shall try to answer this vexing question.

It comes almost as a relief that there is a clear relation between the mental and the material world. The mental has a support system, the body. In detail, experience shows the mind's objective existence to depend on many organs but in particular on the action of the body's neurons.[6] When influencing the neurons physically, the mind is strongly affected. For instance, when, due to a physical effect on neurons, consciousness is lost, the mental stops to be noticeable. When the neurons cease to interact entirely and life ends, any report from this mind ceases too. Whether the mind continues to exist is a matter of belief. But the familiar report, which was an objective fact, ends with the life.

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[4] 'An object is abstract if and only if it is non-spatial and causally inefficacious.' http://plato.stanford.edu/entries/abstract-objects/, see also the *fallacy of mistaken concreteness* [139:51].

[5] I use the term *'perspective dualism'* to designate 'first-versus third-person perspective'. The concept is also known as epistemic dualism [57, 58]. Contrary to J. Habermas I do not imply that the mental perspective necessarily cannot be reduced to the physical. For roots of perspective dualism and the mind-body problem, see René Descartes, quoted in [112:142], Franz Brentano [21:124], Ludwig Bertalanffy [16:95ff] and Thomas Nagel's 'dual aspect theory' [101:28].

[6] Arguably the mental 'supervenes' over the neuronal, meaning that it exists 'in virtue of', is necessitated by the neuronal system. Supervenience [35] is an asymmetric relation: the supervenient cannot change without a change in the subvenient. According to John Heil, the relation may be identitiv, constitutive or causal [60:67]).

Thus there is a dependence of mind on neurons. Whether there is in addition a dependence of neurons on mind is the other question of the mind-neuron problem. It will be taken up.

A mere dependence of mind on neurons would not prove that neuronal activity *alone* 'gives rise to' and explains the mind. Yet it opens this possibility. Already the 17th century 'philosophical materialism'[7] claimed dependence, that "all that exists is matter in motion and mental states are ontologically dependent on states of bodies" [64]. Around 1820, *"organ physics"* was the inspiration of a group of influential physiologists. Opposing vitalism and nativism, Helmholtz, together with du Bois Reymond and others, aimed to reduce the phenomena of the living body to mechanisms based on chemical and physical laws, cast in mathematical form [e.g. 23]. This third-person approach, still largely excluding the 'mind-body' problem, was a resounding success.

Physicalism,[8] which pointedly deals with the mind-body or mind-neuron problem, is still a controversial branch of philosophy. A defender of *reductive physicalism* (RP for short) expects that mental activity can or will be explained by biophysical neuronal processes. Indeed, according to Jaegwon Kim almost all mental states, excepting only the qualia, are reducible to neuronal (in the end, physical) processes [74]. In contradistinction, a defender of *post-reductionism* maintains that such reduction is not possible as the reduction base is incomplete and the mental more than a physical system.

The promise of reductive physicalism is a unity of science. One world, one science, including the expectation that the mental first-person perspective will be explained by neuronal phenomena. RP claims that even psychology or sociology or ethics will, though indirectly, have a physical basis. I add that such multi-level

[7] also known as 'ontological physicalism' or 'physical monism'.

[8] *Physicalism:* All is physical or supervenes on the physical. All phenomena can be explained physically.

reduction to physical base is, where possible, of little practical use. For the weakness of RP becomes apparent when many system levels are included in the reduction. Then the explanatory appeal decreases for reasons to be explained. As reduction progresses, comprehension fails.

1b. Three concepts

World, mind and mechanisms are key concepts of this treatise. The *physical world*, of course, is first of all our environment, a system of objects of matter,[9] composed largely of atoms. These, in turn, are composed of subatomic particles, which are composed of elementary particles and/or waves. Every change in this physical world is due to interaction of matter and its constituents, their energy and fields (Section 2b). The world includes ourselves as physical entities, our neuronal mechanisms are mechanisms of the world.

The human *mind* is a bundle of *experienced mental processes*, tentatively taken to be a result of neuronal (physical) mechanisms in our brain. These mechanisms arguably generate the *first-person perspective* as the experience of an interior view. The view shows our conscious Self positioned in the world in past, presence and future. The first-person or Self views itself to exist apart from the world in an agent-world polarity. Further, it is not aware of its own neuronal system. This because we perceive only what our senses tell us, and we have no sensory organ to notice our own neuronal activity.

In a way the Self is a *separation by perspective*, an agent experiencing independence from the world and from its organism's machinery.

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[9] 'Matter': what has mass and other classical physical properties (Extensive: energy, mass, charge, volume. Intensive: speed, temperature, pressure, density and others). Photons, being without mass, are not part of matter (e.g. http://en.wikipedia.org/wiki/Matter). They, of course, are part of the world, too.

The separation is of great conceptual consequence. Of course it would be illusionary to conclude that Self and mind actually have this self-perceived independent existence. Indeed, the objective third-person perspective shows Self and mind to depend on the action of neurons in the physical world.

A *mechanism* is a physical device or system (made of physical components) optimized to alter its environment in a characteristic and quantitatively more or less predictable way.[10] Mechanisms are designed by man or have evolved in nature. They are modelled with physical cause-effect chains (causal chains or causal loops), defining the sequence of component interactions giving rise to state transitions. The design appears to be *optimized* to yield a distinct system behaviour (SB) ranging from random to almost fully predictable. The study of neuronal mechanisms, ordered by systems theory, may open the way for an understanding of the mental in neuronal terms.

1c. Preview

(1) Neuronal mechanisms, though built of molecules with stochastic behaviour, are often modelled deterministically. One thread of this text concerns the *idealizations* which lead to such deterministic models. The (usually macroscopic) models describe only the mean values of fluctuating ensemble sums. However, full deterministic reliability is not possible for neuronal mechanisms, as probabilistic fluctuations, which even increase with ensemble size, are ubiquitous.

In models of neuronal mechanisms a *causal chain* and a *causal loop* is a characteristic sequence of physical interactions. These are more or less optimized, raising the efficiency of the system behaviour SB. Even probabilistic models are causal and there is no evidence for 'causality-gaps' in the so-called 'causal closure of the physical world'. Thoughts, if understood as immaterial,

[10] For further definitions, see [10:13ff].

cannot influence material neurons. And there is no need for this influence, because thoughts necessarily have a neuronal basis, and this interacts causally.

(2) Universal system levels. Another major theme is the nature of system levels and their linkage. A novel concept is suggested: that each level is *universal*, housing all basal objects and events (which are physical by axiom). These are grouped differently and symbols are assigned to the groups, populating higher-order levels. Events involving basal items occur synchronic on all levels. Linkage of levels is given by identity of the basal items. There is no need for an additional vertical linkage of levels, be it causal or constitutive. The levels importantly differ in the elements' grouping, representation with symbols, thematization of features and in level-specific idiom.

(3) Reductive physicalism. Reduction, the attempt to explain by fundamental laws, is a recursive process for which several examples are given. The reductions of life, of mind and of consciousness to physical processes without remainder are such attempts. Who stops his reductions abstains from any explanation.

Reductive physicalism brings the expectation that the mental will be understood in neuronal and thus in physical terms. This seemingly daunting task may be aided by systems theory. It is common to place a mental level above the neuronal. But the nature of those levels is important. With *universal* levels basal events are physical per axiom, the physical basis of all complex phenomena is implied. This arguably includes the phenomena of the mind.

Reductive physicalism cannot be proven, it is a hypothesis. As yet, the hypothesis was not falsified, though often rejected. It rests on the causal closure hypothesis of physics. Mental functions like thoughts, if immaterial, must be causally powerless. For they are *'about'*, are language, abstracta, they cannot encounter for physical interaction. The causal relevance, which the mental nevertheless

appears to have, may be due to its neuronal roots which, as part of the physical world, have causal power.

Generally mental (immaterial) phenomena have an objective physical reduction base over which they supervene. That, in short, is the RP hypothesis. However such reduction, if it includes multiple levels, explains little in a 1st-person perspective, it tends to over-tax our comprehension. That is the devil's hoof. The mental, which is 'more' than physics, may be reducible to physical base by objective scientific proof. Yet subjectively it will not be convincingly explained by physics because such explanation exceeds our cognitive abilities. Proof is objective, comprehension subjective.

'More' than physics: yes.

Objective reduction to physical base: yes.

Subjective comprehension: limited.

2. Mechanisms

Mechanisms are defined and examples are given for their probabilistic and deterministic models. When based on the behaviour of molecules, probabilistic models are more realistic and deterministic models (on the macroscopic level) are their idealisations. Mechanisms operating continuously have cyclic state-transition diagrams and show the over-sum effect. All models of mechanisms are causal. Those of neuroscience are based on molecules, often in small numbers. They show ubiquitous fluctuations and cannot perform ideally deterministic.

A mechanism is a physical device made of interacting components, optimized to alter its environment in a characteristic and quantitatively more or less predictable way by its system behaviour SB. Mechanisms were designed by man or have evolved in nature. In designed mechanisms SB is the construction goal. A machine is constituted of mechanisms. The optimization with respect to SB improves the reliability of mechanisms and machines.

An *ideal* mechanism is a deterministic system of components and their interactions. Its behaviour is fully predictable by appropriate differential equations. In a wider scope the behaviour of mechanisms ranges from probabilistic to deterministic. Typically, molecular models involving few units behave probabilistic, models of large ensembles of molecules behave quasi-deterministic and macroscopic models may behave deterministic.

2a. Examples and basic features

The interaction of components of ideal mechanisms may be modelled kinetically, e.g. with a set of ordinary differential equations with continuous variables [e.g. 17, 91]. The differential equations are deterministic.

The equations of finite state models define system states and specify the rate of change of their occupation, which may be probabilistic. The states are exclusive and, together with their transitions, form a structure given by a *state-transition diagram (STD)*. This structure describes the organisation which makes a concerted action of components possible.

Examples for macroscopic single-shot mechanisms are the ignition and burning of a match or the firing of a rocket. The energy set free in such events is limited by an inherent chemical reservoir and there is no recovery of the initial state, a steady state is impossible. In contrast, macroscopic mechanisms and machines which are capable of repetitive (steady-state) performance have cyclic STDs and must tap environmental energy gradients (Figure 2.1A).

Similarly, a cyclic *molecular mechanism* allows repetitive (steady-state) performance, modelled with a cyclic STD [e.g. 63:5]. The cycle assures recovery of the initial state, tapping an environmental energy source (Figure 2.1C). Examples are many: metabolic cycles in cells, molecular ion pumps and ion channels in cell membranes, drug receptors, etc.[11] In molecular models the continuous variables are occupational probabilities: the equations specify these system state probabilities and their rate of change (finite state Markov-chain models). Typical of molecular mechanisms is the probabilistic system behaviour.

Constituted of molecular devices we find a variety of *neuronal mechanisms* of higher organisation like synapses, neurons, reflex circuits, further neuronal feedback circuits and regulators, analysers of sensory data, memory devices, conscious-executive

[11] Usually unconsidered in such models remains the fact that repeated action leads to ageing of components and thus to a slow change of the mechanism itself. Then real recovery is an idealisation. In biological cells there is continuous replacement of ageing components by newly synthesized ones.

cortical mechanisms etc. Their output is largely driven by the input. Details are provided by a wealth of deterministic and stochastic models in neuroscience [e.g. 78, 80].

The *brain* is an organ devoted to the control of body function, analysis of sensory input, coordination of muscle activity, generation of emotions and wishes, conscious thinking, conscious experiencing of past (memory), present and predicted future and many other tasks. These complex functions are all due to interaction of neurons, which are built of stochastic elements, molecules. The complex functions combine in various ways, generating internal states and behaviour performed in the environment. The brain's neuronal activity may be described as ideally deterministic only if its result is fully predictable. While, strictly speaking, this will never be the case,[12] the measured performance may still be impressively predictable in selected cases.

Every mechanism has its specifications and, therefore, limitations. Regarding the human brain as an assembly of neuronal mechanisms, several limitations are apparent. The restricted capacity of working memory [96] is certainly one of them (see PLC, Sections 4j, 5c).

In conclusion, there is a hierarchy of organisation concerning mechanisms in neuroscience, with models spanning from molecules to neuronal networks and brain modules. On the molecular level the model performance is probabilistic or, in large ensembles, quasi-deterministic. At higher levels of organisation it may be nearly but not fully deterministic. For, based on molecular components, a residual lack of certainty cannot be excluded.

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[12] if based on a level-2 formalism (mesoscopic physical level, see Section 2b).

Term	Meaning
Mechanism	Optimized physical system with typical, ideally with predictable behaviour
Component	Of a mechanism. Distinct physical entity capable of interaction and energy transfer
State	Of component or system. One of several mutually exclusive combinations of component properties as defined in the STD
STD	State-transition-diagram. Defines all states and transitions
Transition	Event of changing state. Due to time-consuming interaction of components
OCA	Organized component activity. Transitions as defined in the STD
Cycle-rate	Cycle-turnover. Rate of repetitive cycle-completion
SB, EB	System behaviour. Cycle-rate or its direct consequence, the environmental behaviour
MaW	'Mechanism-as-a-whole' [30]
Dor P-model	Deterministic or probabilistic model
1B2S	1-barrier 2-site ion channel

Table 2.1. Key terms: Abbreviations and meaning.