A Dualistic Theory of Consciousness

Dr. phil. Peter Flury-Kleubler

info@flury-kleubler.ch

Abstract: A dualistic theory of consciousness is presented which is compatible with the phenomena of conscious subjective experience and the findings of neurobiology. It is argued that qualitative phenomenal differences cannot be explained by differences in the underlying neural activity. Therefore, monistic models can never be sufficient for understanding consciousness. Arguments from phenomenology and functional neuroanatomy are presented to support the hypothesis that only brain events within a few selected brain areas have a subjective correlate. If any information processed in the brain shall be consciously accessible, it must build up a representation within those brain areas whose activity is accompanied by phenomenally concrete experience, that is by sensorymodal or emotional phenomena. In addition, it is argued that brain output cannot be fully explained physically.

Introduction

The term consciousness is used for a variety of processes within the individual (c.f. Chalmers, 1996). I use it in the narrow sense of *subjective phenomenal experience* and *not* for all the *cognitive processes* of which subjective experience is just a product. Nor do I use it for referring to intentional processes such as voluntarily or also unconsciously setting goals and pursuing them. Contemporary neurobiologists favour a monistic view of man which reduces human consciousness to brain activity (e.g. Edelman, 1989). The philosopher Daniel C. Dennett (1991) supports this view with a monistic theory of consciousness. For him, dualism is forlorn. Of course, a theory of consciousness has to be entirely compatible with both the phenomena of subjective conscious experience and the findings of neurobiology. In this paper, I shall suggest a dualistic alternative to Dennett's theory fulfilling these requirements. Like Dennett (p. 41), I will not be able to demonstrate the theory, but I will show that it is fully compatible with contemporary physics and neurobiology. In particular, I will contradict Dennett's view that there is no place in the brain where "it all comes together" (p. 135) and which is the physical substrate of subjective phenomenal experience, in other words the "Cartesian Theatre". Of course, if a theory of consciousness has to be compatible with current knowledge of functional neuroanatomy, this place in the brain cannot be just one nearly homogenous tiny structure such as the pineal gland, as Descartes (1966, p. 232) believed. I do not deny that different aspects of sensory input, but also of information processing which is involved in imagination, thinking and the generation of behaviour, are processed at different times and diffe-

rent places, as Dennett stresses in his Multiple Drafts model (1991, p. 134). This goes together well with Rumelhart and McClelland's ideas of Parallel Distributed Processing (Rumelhart & McClelland, 1986, and McClelland & Rumelhart, 1986) and, for instance, with the fact that different aspects such as motion, depth, and form are abstracted from visual information in different brain areas (Kandel, 1991). However, not all aspects of information processing in the brain are *conscious*, or in other words, directly experienced as subjective phenomena. So far, Dennett would still agree, since he speaks of the existence of *unconscious* information (1991, p. 326). But in addition, I claim that not all aspects of information processing *can* become conscious directly.

Let me now present and justify a few key theses forming the basis of my theory of consciousness. This theory is just one – but a fundamental – part of a larger, complex psychological and neurobiological theory of the human individual, which I cannot present here due to space limitations (publication of the theory is in preparation).

Dualism and the Quality of Subjective Phenomena

The term *consciousness* refers to *subjective experience*. Dennett probably agrees with me on this point, since, while dealing with consciousness, he tries to develop a method for phenomenology. To distinguish *subjective experience* from the *brain* as its physical basis already implies a dualistic view of human beings as *individuals*. – In spite of his claims to the contrary, Dennett is not really a monist. – The term individual refers to the indivisible unity of subjective experience and the organism connected to it. We have to assume that the death of the brain is the end of the subjective experience of every idiosyncratic, organism-based individual. At this point, I am talking about human individuals and do not discuss the question of whether non-human individuals exist or not. Nor do I discuss the question of the possibility of subjective experience without any physical basis.

So far, when speaking of subjective experience, we need not yet specify if we are talking about the experience of a unified subject, of the two subjects of a split-brain patient, or of amorphous subjectivity. Results from split-brain patients suggest (Springer & Deutsch, 1995) that the unity of subjective experience depends on the functional unity of its physical basis, that is, on the functional integrity of the brain.

I contradict Dennett's conviction that "dualism is forlorn" (1991, pp. 33f.), because subjective reality cannot be reduced to physical reality. More precisely: phenomenal *qualities* cannot be explained by physical differences in the underly-

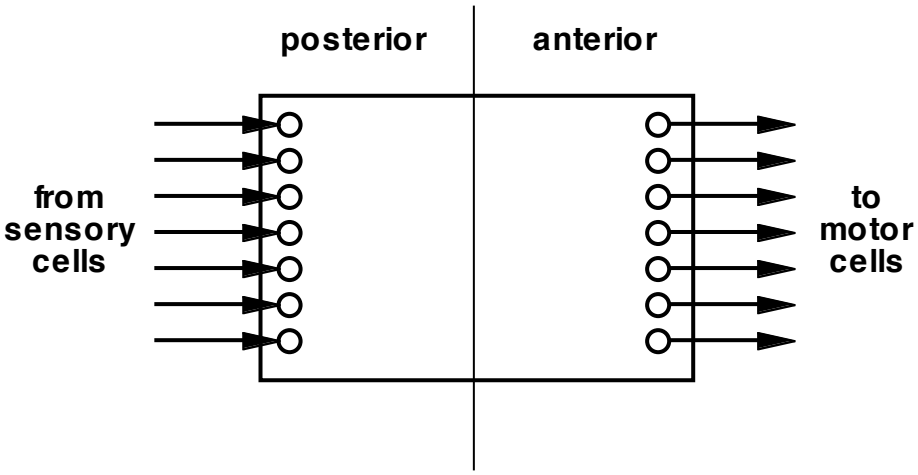
ing neural activity. Dennett, nevertheless, tries to disqualify qualia. He denies that there are any "phenomenal qualities" or "qualia" (p. 372). Instead, he believes "that there seem to be qualia". What can this mean? To whom or what does it seem so? Phenomenal qualities do not exist in physical reality. However, I would not call them "additional properties" as Dennett does, because within physical reality, *properties* simply do not exist. Properties are something that *subjects attribute to objective reality*. Of course, this does not mean that there is nothing behind these attributions. Colours do indeed refer to certain aspects of physical reality. But this does not imply that they *are* those aspects. If phenomenal qualities could be fully explained by the underlying neural activity, the neural activity which is experienced subjectively as "red" would have to be physically different from the neural activity which is subjectively experienced as "green". Yet, this in not the case. Within physical reality, the only difference between the red-information processing neurons and the green-information processing neurons consists in the different *origins* of the information processed. In the simplest case, the information originates in two different types of sensory cells. Of course, the relation between physical stimuli and subjective colour experience is in many cases more complex than this. The physical stimuli need not consist of one single wave length, and they need not have a wave length which corresponds exactly to the sensitivity maximum of one type of cone photoreceptors of the retina. Phenomenal qualities are not just phenomenal properties within a certain sensory modality, such as the visual modality. Equally important is the fact that to the subject visual phenomena are – in their quality – different from auditory phenomena, somatosensory phenomena and so on. But also here, the activity of neurons that process visual information is not different physically from the activity of neurons that process auditory information. The only physical difference is found in the afferent and efferent *pathways*.

The reality of an individual can only be understood with a dualistic theory which distinguishes physical and subjective reality, since using physical terms, one can neither describe nor understand subjective reality, and on the other hand, using phenomenological terms, one cannot describe or understand physical reality.

Cognition vs. Intention

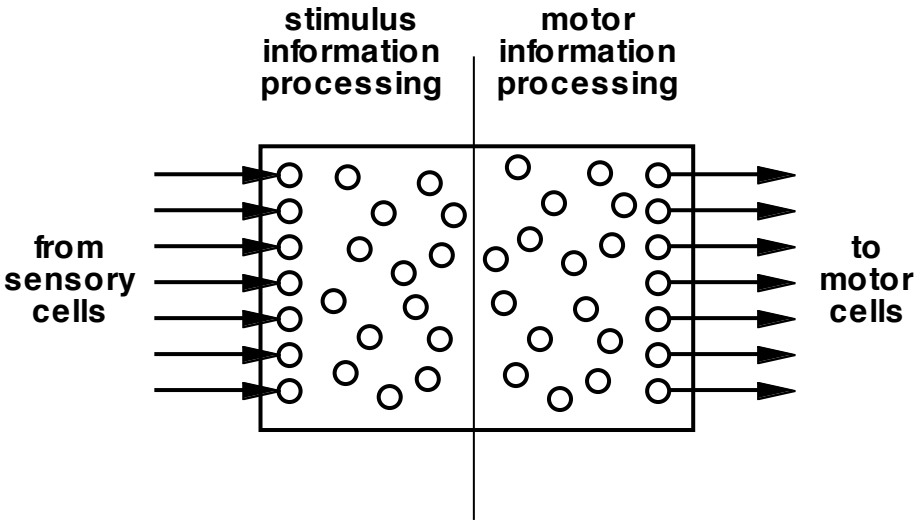
Dennett is convinced that "there is no motivated way to draw a line dividing events that are definitely 'in' consciousness from events that stay forever 'outside' or 'beneath' consciousness." (1991, p. 275) If we speak of *brain* events, I hypothesize that he is wrong. In order to support this hypothesis, I would like to show that the brain consists roughly of two functional parts. The distinction I speak of

is *not* the distinction between the two neocortical hemispheres. They are specialized to some extent; functional considerations suggest that in most brains, the left hemisphere contains a larger proportion of sequential connections while the right hemisphere contains a larger proportion of parallel connections. This has important effects on the contents that are processed in each hemisphere (Springer & Deutsch, 1995). However, how these connections are realized remains unclear, since neurophysiological comparisons have shown no visible differences in the microstructure of cortical tissue. As mentioned above, I do not want to talk about distinguishing between the two hemispheres, but rather about the fact that – as a rule of thumb – brain structures which receive direct sensory input have an anatomically posterior position, while brain structures which produce direct motor output have an anterior position. In the neocortex, the *central sulcus*, which separates the primary somatosensory cortex from the primary motor cortex, forms the border between posterior and anterior. An analogous distinction can be made within the spinal cord.



If we suppose that between the neurons that process afferent information and those that process efferent information no miracle occurs (Dennett, 1991, figures 2.4 and 5.4), then there must be a network of intermediary *interneurons* which determines brain output as a function of brain input. As we shall see, this function is not a hundred percent deterministic. There is some stochastic variance. However, let us suppose that among the numerous interneurons there is a fundamental functional division. Suppose that one can determine whether a certain brain area is either involved in processing sensory information or in processing motor information (c.f. Kupfermann's, 1991, functional analysis of the association cortices). The processing of sensory information takes place at a large number of different levels, at low levels which are very close to information of a specific sensory modality coming from receptor cells and at high levels which are far from the original receptor information and which are no longer sensory-modality-specific.

In a similar way, motor information processing also occurs at different levels: at high levels which are not directly related to specific muscles and at low levels which refer directly to defined muscles.



If we suppose that this functional division can indeed be found in the brain, it makes sense to give names to those parts. I define the brain structures processing stimulus information *cognitive* structures. The motor information processing structures will be called *intentional* structures.

Behind this functional division is the idea that every organism – in order to survive – must act upon its environment in a manner conducive to its own existence. This requires first that it record *stimuli* containing *information relevant to its survival*. Second, the organism must be able to suitably modify its *behaviour* in accordance with the *meaning of these stimuli with regard to survival*. So far, this does not yet imply that subjective experience be involved. In contrast to zombies (Dennett, 1991, pp. 72f.) and computers, we human beings do experience some aspects of this information processing subjectively [c.f. Stoerig & Cowey's (p. 260-261) discussion of the question "who has consciousness?"]. The issue of conscious experience in other species will not be discussed in this paper. On the basis of the functional division mentioned above, two types of processes will be distinguished: cognition and intention. Cognitive processes have to do with the processing of stimulus information and intentional processes with the processing of motor information. As simple as the distinction may seem, there are some complications.

First, not all cognitive activity is based on *present* sensory stimuli. Human beings of more than about 16 to 24 months of age and at least some other primates (Köhler, 1973, Bischof-Köhler, 1991, p.171, and Piaget & Inhelder, 1986, p. 62) are able to create the subjective experience of virtual sensory information

in their *imaginations*. The building blocks of imagined phenomena are sensory phenomena that were once perceived and then stored in memory. (This does not mean that we can only imagine objects in waking or dreaming that are exactly like objects perceived at an earlier time. The building blocks need not be on a concrete phenomenal level, but rather, they can also be phenomenally abstract. We can imagine a new object or situation with properties that originally stem from many different objects or situations.) Second, not all cognitive activity is on the level of concrete sensory modal phenomena. This will be discussed in more detail later in the paper. Third, not all intentional activity is directed to the immediate generation of motor activity. Rather, some intentional activity is directed to internal evaluation of and preparation for future and possible motor activity. Therefore, human beings are able to control cognitive processes that serve these purposes, namely, imagination and thinking.

Definitions of cognition and intention thus have to take this into account: *cognition* refers to all processes through which *stimuli* from the objective world are transformed for the individual into *perceived phenomena* connected to *subjective meaning* and through which *fictitious* objects, states and processes can be experienced as *imagined phenomena* connected to *subjective meaning*. *Intention* refers to all the processes through which an individual – depending on the cognitive contents present and his or her free will – can *produce behaviour* and transform cognitive contents through *attention processes*, *imagination processes* and *thinking*.

You may ask if there really is a sharp boundary between cognitive and intentional brain structures. One argument in favour of a strict cognition-intention distinction is the fact that although the primary somatosensory cortex and the primary motor cortex (that is one of the hierarchically lowest sensory information processing structures and one of the hierarchically lowest motor information processing structures) are direct neighbours within the neocortex, information on its way from the primary somatosensory cortex to the primary motor cortex (if we disregard reflex connections) first has to go to brain areas which are further and further away from the destination. Then, via deeper brain structures, the information has to jump over from posterior brain areas to anterior ones. If the pathway from primary sensory cortex areas to the primary motor cortex were a continuous succession of processing stations without any fundamental functional leap, it would be hard to explain why the primary somatosensory cortex is not located at some distance from the primary motor cortex. Yet, this anatomic argument is not the only reason supporting a sharp cognition-intention distinction. Further support comes from the detailed analysis of brain functions that I will present in the

framework of my psychological and neurobiological theory of the human individual mentioned above.

Let us return to Dennett's conviction that there is no motivated way to distinguish between brain events that *can* become conscious and others that *cannot*. In order to decide if all contents processed in any brain structure can have a *direct* subjective correlate, we have to analyze the contents processed in each brain structure. Let us begin with intentional brain structures. The hierarchically low motor structures process information that is related to specific muscle fibres. However, if we want to perform a certain behaviour, such as taking a cup from the table and bringing it to our mouths, our experience is related to a phenomenally three-dimensional space within which we will move our hand and within which a number of objects are represented subjectively. Yet, in order to seize the cup and move it to the intended position successfully, we have to produce motor signals for a large number of muscle fibres, well-tuned to the spatial arrangement of our bones and joints. These muscle fibre commands themselves are unconscious. If we want to perform a certain movement deliberately, we experience the present shape and position of our limbs, but no motor commands. If we had direct phenomenal access to muscle commands, the learning of new movements would not be as difficult as we experience it to be when learning to ski, to play the flute or to pronounce new phonemes in a foreign language.

The activity of hierarchically high intentional structures does not refer to specific motor commands, but rather to setting goals of behaviour and cognition. This type of brain activity also has no direct subjective correlate.

I hypothesize that contents of intentional brain structures are *not directly* accessible to conscious experience. Not directly means that we have limited *indirect* access to intentional activity, because intentional brain structures are connected to cognitive brain structures whose activity is – in part – directly experienced as subjective phenomena. I assume that only events within cognitive brain structures can become conscious. And of all cognitive brain structure activity, only some of it has a conscious correlate, as we will now see.

Phenomenal Concreteness and the Cartesian Theatre

In order to explain why not all cognitive activities have a direct phenomenal correspondence, we have to analyze carefully how human phenomenal experience is structured. But I will not use Dennett's heterophenomonological method (1991, pp. 66f.), since it originates from false assumptions. Like every phenomenal reality, even supposed heterophenomonological worlds are only accessible via one's

own phenomenal experience and on the basis of the presupposition that others experience phenomena in a similar way than we do. In our conscious experience, there is no objectivity, only subjectively experienced intersubjective correspondence. I do not deny the existence of a subject-independent, objective reality, but it is accessible as subjective phenomena only in part and indirectly. The relation of these subjective phenomena to objective reality is a matter of epistemological theory (c.f. Kant, 1956, Lorenz, 1977).

I suggest that phenomenal reality consists of two types of phenomena, *sensory-modal* phenomena on the one hand and *emotional* phenomena on the other. In the case of perception, sensory-modal phenomena refer to physical reality as it really *is*, and in the case of imagination, as it could be, should be, was or will be. Emotional phenomena are the subjective quality of interpretations of the meaning of certain aspects of reality in reference to one's goals. This distinction between sensory-modal and emotional experience will be explained in full detail in my publication of the psychological and neurobiological theory of the human individual. Sensory-modal experience consists of *visual* phenomena, *auditory* phenomena, and *somatosensory* phenomena (namely mechanical, thermal, and nociceptive) – all within a phenomenally spatial reference system – and of *gustatory* and *olfactory* phenomena – which both are phenomenally non-spatial. Emotional experience consists of a *pleasant* or *unpleasant* basic quality and of *specific* interpretative and motivational contents. Apart from a few basic emotions, most emotions are composed of emotional and sensory-modal phenomena, since they contain linguistic aspects. As will be shown below, language is always experienced sensory-modally.

Sensory-modal experience is composed of different phenomenal qualities at different phenomenal locations. In the case of the visual modality, for instance, it is made up of points in phenomenal space with a certain (phenomenal) brightness, colour, and colour saturation. So far, we are talking about phenomenal elements which have nothing to do with each other. In general, groups of phenomenal elements belong together, since they originate from the same *object*. For the recognition of objects, however, a number of analyses have to be performed which are abstracted from the level of immediate phenomenal elements. In an abstract analysis, aspects such as motion, depth, and form are extracted from visual information, and this happens in a number of brain areas (Kandel, 1991). At an even higher level of abstraction, specific objects can be identified, such as a particular person's face. And yet, object recognition is not only a bottom-up process, since categorizing a certain visual pattern as a certain object has an impact on the phenomenally concrete level of single elements in phenomenal space. As soon as

we identify an object in the fog, be this identification correct or not, we *see* this object more clearly. The more ambiguous a phenomenal pattern is, the more dramatic this effect can be. In principle, this is not only true for the visual modality but also for the other sensory modalities. This statement is commonplace enough in cognitive psychology (e.g. Anderson, 1996, Posner & Raichle, 1997).

But I want to emphasize that from a phenomenal perspective, all the steps of *abstract* analysis are *not directly* accessible to phenomenal experience. What I experience when I have categorized a certain visual pattern as "my wife's face", or an auditory pattern as a certain spoken word, is still a phenomenal spatial brightness and colour pattern or a phenomenal volume and pitch pattern. When I have identified a visual pattern as "my wife's face", my concrete object-experience will be accompanied by the experience of visual or auditory linguistic *expressions*, such as "my wife". This means, for example, that I experience in my imagination the phonetic sound pattern "maɪ waɪf". I can formulate my hypothesis as follows: we experience phenomenally abstract aspects as phenomenally concrete linguistic expressions, either auditorily as imagined loud thinking or visually as imagined written language.

Of course, phenomenally abstract cognitive contents are also processed in the brain, but I hypothesize that this happens in areas whose activity is not experienced subjectively in a direct way. If we want to localize anatomically those brain areas whose activity has a direct phenomenal correlate, we face a considerable methodological problem. In the normal functioning of cognitive processes, all hierarchical levels are involved. Neural structures are active which are connected with one another both bottom-up and top-down. It is not possible to examine the function of any of these structures in isolation. Brain stimulation as performed by Penfield (c.f. Penfield & Jasper, 1954, Kolb & Whishaw, 1990, pp. 80-82) shows effects which need not be based on the brain structure which is stimulated specifically by electrodes. Rather, they can be based on structures that are neurally connected to the stimulated structure. This imposes problems on empirical testing of the hypothesis that the activity of certain brain structures is consciously experienced while the activity of certain other brain structures is not. Therefore, I think that the justification of the hypothesis that our phenomenal experience is based on the activity of only few cognitive brain structures must come mainly from a comparison of subjective phenomenal experience with the contents processed in each brain structure.

On the basis of such analysis, I suggest, first, that hierarchically low sensory cortex areas are the physical basis of sensory-modal experience. One empirical indication that this low level of information representation is necessary for senso-

ry-modal experience can be found in the fact that while we are dreaming (especially during REM-sleep), the optic radiation between the lateral geniculate body of the thalamus and the primary visual cortex is highly active although the eyes are closed and there is no visual sensory information coming in at all (Buchsbaum et al., 1989). Dreaming is an imagination process, that is, a top-down process in which sensory-modal phenomena are generated which do not come from actual sensory input but from memory.

In the case of the visual modality, localizing the physical substrate of phenomenal experience proves to be difficult for the following reason: When we are turning our *head*, our visual phenomenal world is moving as well, provided that the eyes do not change their position with regard to the head. So far, this is no problem. But when we are moving our *eyes*, both by voluntary looking around or by involuntary saccades, our visual world is not moving! This means that somewhere in the brain, the visual representation has to be shifted to *compensate* for eye movements. So, if the primary visual cortex represents a perfectly retinotopical image, that is, if every point of the primary visual cortex corresponds to exactly one point of the retina, keeping the image in place in spite of eye movements is not possible. This implies that the visual part of the substrate of sensory-modal experience must lie in a cortex area of higher order than the primary visual cortex. Additional complications have to do with the translation of two-dimensional retina images into three-dimensional phenomenal space.

I hypothesize that, within the brain, there is a cognitive psychophysical level, or in other words, a number of brain structures whose activity is the physical basis or correlate of our subjective experience. This goes not only for sensory-modal experience. Our emotional experience has this neural basis as well. Candidate structures are, in my view, the amygdala and perhaps some limbic cortex areas. I suppose that most of the other brain structures that are usually related to the emotions are not actually connected to *experiencing* emotional phenomena, but rather to the memory processes (hippocampus), motivational processes, cognitive processes, endocrine and motor reactions that are triggered by emotions (LeDoux, 1992). Also Berridge (1996) and Lane et al. (1997) attempted to localize the neuroanatomical substrates of emotional experience. However, both studies are examples of a tradition of neuropsychological research that lacks a sophisticated model of psychological functions which could allow us to interpret empirical findings; not every brain area that is active in situations in which emotions are experienced is related to the emotions themselves).

Within the brain, there is insofar a Cartesian Theatre as subjective phenomenal experience corresponds to the activity of well-defined brain structures. Some

brain events correspond directly to subjective phenomena, whereas others are *abstracted from phenomena* and can therefore only be inferred *by means of sensory-modal or emotional phenomena*. Language is phenomenally only accessible in the form of sensory-modal phenomena, whereas most aspects of language are abstracted from phenomenal experience.

As discussed above, the anatomical localization of the cognitive psychophysical level has its difficulties. Since brain structures are connected extensively with one another, one can hardly find a functional state in which a certain brain structure is active, but its functional neighbours are not. Therefore, whenever primary sensory cortex areas are active, higher order cortex areas are active as well. But we may wonder what would happen, if – within a certain sensory modality – the primary sensory cortex were intact but the adjacent higher order cortex were destroyed.

So far, we have tried to localize the cognitive psychophysical level, that is, the brain areas that are the physical substrate of subjective phenomenal experience. But a dualistic position raises additional questions. Let us look at the question of whether and how brain activity can be subjectively influenced, and what parts of brain activity these might be.

Physical Underdeterminedness of Brain Activity

Dennett is convinced that subjective influence on brain activity would violate physical laws (1991, p. 35). But Dennett ignores the fact that neural activity is not completely determined physically. We must recognize that synaptic transmission is not entirely determined by the signals arriving at the end of the axon (c.f. Eccles, 1994). Therefore, the output signals of the brain are not completely defined by former or current input signals or by genetic determination. There is a lack of physical determination. This physically unexplained variance or – in other words – this underdeterminedness might be explained by chance. Eccles instead suggests a different possible explanation. He views this *physical underdeterminedness* as the *field of influence of the self's free will*, or in my own words, the subject's free will. Eccles has even hypothesized the location in the brain of this underdeterminedness. According to his hypothesis, wanting has a neural effect by causing a momentary increase of the probability of exocytosis in the neurons of the supplementary motor cortex (Eccles, 1994). Wilson (1995) criticized that Eccles' hypothesis violated the requirement of randomness in the quantum mechanical event of synaptic-vesicles exocytosis, because human intentions were nonrandom. Wilson's criticism, however, is based on the false assumption that within a purely

physical variance analysis not only physical variables, but also subjective variables are considered.

Whether Eccles's hypothesis refers to the correct brain areas or not, that is in other words, whether he has localized the intentional psychophysical level correctly, is not the most important question. More important is rather the insight that the assumption of subjective influence on physical events does not necessarily lead to a violation of physical laws. On the contrary, modern physics is entirely compatible with a dualistic view of man as an individual who – to a limited extent – has an impact on his experience and behaviour and is therefore – to a limited extent – free and responsible for his behaviour.

References

Anderson, J. R. (1995). *Cognitive Psychology and its Implications*. 4th edition. New York: Freeman.

Berridge, K. C. (1996). Food reward. Brain substrates of wanting and liking. *Neuroscience and Biobehavioral Reviews 20*, 1-25.

Bischof-Köhler, D. (1991). Jenseits des Rubikon. Die Entstehung spezifisch menschlicher Erkenntnisformen und ihre Auswirkung auf das Sozialverhalten. In: Fischer, E. P. (Hrsg.). *Mannheimer Forum 90/91: Ein Panorama der Naturwissenschaften*. München: Piper.

Buchsbaum, M. S., Gillin, J. Ch., Wu, J., Hazlett, E., Sicotte, N., Dupont, R. M. & Bunney, W. E., Jr. (1989). Regional cerebral glucose metabolic rate in human sleep. Assessed by positron emission tomography. *Life Sciences 45*, 1349-1356.

Chalmers, D. J. (1996). Facing up to the problem of consciousness. In: Hameroff, S. R., Kaszniak, A. W. & Scott, A. C. (Eds.). Toward a Science of Consciousness: The First Tucson Discussions and Debates (pp. 5-28). Cambridge, Massachusetts: Massachusetts Institute of Technology.

Dennett, D. D. (1991). Consciousness Explained. London: Penguin.

Descartes, R. (1966). *Discours de la méthode*. Suivi d'extraits de la *dioptrique*, des *météores*, de la *vie de Descartes* par Baillet, du *monde*, de *l'homme* et de *lettres*. Chronologie et préface par Geneviève Rodis-Lewis, professeur à la Faculté des Lettres et Sciences humaines de Lyon. Paris: Garnier-Flammarion. [First edition of the *Discours de la méthode* published in 1636]

Eccles, J. C. (1994). *How the Self Controls its Brain*. Berlin: Springer.

Edelman, G. M. (1989). *The Remembered Present: A Biological Theory of Consciousness*. New York: Basic Books.

Kandel, E. R. (1991). Perception of motion, depth, and form. In: Kandel, E. R., Schwartz, J. H. & Jessell, T. M (Eds.). *Principles of Neural Science* (pp. 440-466). New York: Elsevier.

Kant, I. (1956). *Kritik der reinen Vernunft*. Hamburg: Meiner. [Original editions published in 1781 and 1787]

Kant, I. (1956). *Kritik der reinen Vernunft*. Nach der ersten und zweiten Original-Ausgabe neu herausgegeben von Raymund Schmidt. Hamburg: Meiner. (1. Originalausgabe 1781, 2. Originalausgabe 1787)

Köhler, W. (1973). *Intelligenzprüfungen an Menschenaffen*. Mit einem Anhang zur Psychologie des Schimpansen. Dritte, unveränderte Auflage. Berlin / Heidelberg: Springer. [Original edition published in 1917]

Kolb, B. & Whishaw, I. Q. (1990). *Fundamentals of Human Neuropsychology*. Third edition. New York: Freeman.

Kupfermann, I. (1991). Localization of higher cognitive and affective functions. The association cortices. In: Kandel, E. R., Schwartz, J. H. & Jessell, Th. M. (Eds.). *Principles of Neural Science*. Third edition. New York: Elsevier. 823-838.

Lane, R. D., Reiman, E. M., Bradley, M. M., Lang, P. J., Ahern, G. L., Davidson, R. J. & Schwartz, G. E. (1997). Neuroanatomical correlates of pleasant and unpleasant emotion. *Neuropsychologia 35 (11)*, 1437-1444.

LeDoux, J. E. (1992). Emotion and the amygdala. In: Aggleton, J. P. (Ed.). *The Amygdala: Neurobiological Aspects of Emotion, Memory, and Mental Dysfunction* (pp. 339-351). New York: Wiley-Liss.

Lorenz, K. (1977). *Die Rückseite des Spiegels*. Versuch einer Naturgeschichte menschlichen Erkennens. München: Deutscher Taschenbuch-Verlag.

McClelland, J. L., Rumelhart, D. E. & the PDP Research Group (1986). *Parallel Distributed Processing: Explorations in the Microstructure of Cognition*. Volume 2: Psychological and Biological Models. Cambridge, Massachusetts: MIT Press.

Penfield, W. & Jasper, H. (1954). *Epilepsy and the Functional Anatomy of the Human Brain*. Boston: Little, Brown.

Piaget, J. & Inhelder, B. (1986). *Die Psychologie des Kindes*. Aus dem Französischen von Lorenz Häfliger. München: Deutscher Taschenbuch-Verlag. [Original

edition: Piaget, J. & Inhelder, B. (1966). *La psychologie de l'enfant*. Paris: Presses Universitaires de France.]

Posner, M. I. & Raichle, M. E. (1997). *Images of Mind*. New York: Scientific American Library.

Rumelhart, D. E., McClelland, J. L. & the PDP Research Group (1986). *Parallel Distributed Processing: Explorations in the Microstructure of Cognition*. Volume 1: Foundations. Cambridge, Massachusetts: MIT Press.

Springer, S. P. & Deutsch, G. (1993). *Left Brain, Right Brain*. Fourth Edition. New York: Freeman.

Stoerig, P. & Cowey, A. (1996). Visual perception and phenomenal consciousness. In: Hameroff, S. R., Kaszniak, A. W. & Scott, A. C. (Eds.). *Toward a Science of Consciousness: The First Tucson Discussions and Debates* (pp. 259-278). Cambridge, Massachusetts: Massachusetts Institute of Technology.

Wilson, D. L. (1995). Book review: seeking the neural correlate of consciousness. *American Scientist 83*, 269-270.