GEORGE MARANGOS

# SPACE IN THOUGHT

1. Brevity being the prime vitue of style, I will try to keep the *length* of this paper within reasonable limits. I will do my best to restrict its *breadth* too. Modesty forbids to vaunt the *height* of the ideas about to be exposed. I suspect that *down deep*, thought and spatial intuition must be very tightly knit together, for spatial metaphors to carry our semantical intentions so effortlessly.

Be that as it may, everyday ideas about space and time and motion are fraught with confusions and perplexities. If you want to transcend those perplexities, internalize the relevant chapters of physical science! So a maxim that could very well belong to common sense, at least to the common sense of the educated layperson.

What would arguably be more important: referring the matter to science should suffice to solve or to dissolve philosophical worries, either metaphysical or epistemological, if any such persist. It is indeed a wide-spread view that the theory of relativity, special and general, has settled almost all questions concerning the nature of space and time, by structuring our knowledge of the world around a unified core conception of spacetime. To focus on a central issue, the theory of relativity along such lines would have settled the old dispute between the substantivalist and the relationist conceptions of space.

My aim here is to track this dispute in its various guises roughly from the 17th century. I do not approach my subject as an historian of philosophical and scientific ideas, but rather as a *bricoleur*: I attempt to devise narrative means to gain some leverage on problems that I find too difficult to attack head-on.

*Πρώτη μορφή του παρόντος κειμένου ήταν εισήγηση μου στο διεθνές συνέδριο Relativistic Physies and some of its Applications, Αθήνα, 25 - 28 Ιουνίου 1997. Και από τη θέση αυτή ευχαριστώ τον Ευτύχιο Μπιτσάκη, ομότιμο καθηγητή του Πανεπιστημίου Ιωαννίνων, και τον Franco Selleri, καθηγητή του Πανεπιστημίου του Bari, που μου έδωσαν την ευκαιρία να υποβάλω σε δημόσια δοκιμασία τις ιδέες μου.*

The point of contention between substantivalism and relationism might be stated thus: space and time or some combination thereof are they absolute substances, kinds of entities separate from and independent of physical bodies and their movements, or rather are they to be thought of as arising from or as being exhaustively definable in terms of relations among physical bodies?

2. Newton is commonly thought to be the archetypal representative of the absolute, substantivalist view[1]. Indeed in the well-known Scholium to the Definitions in Book 1 of the *Principia*[2], Newton insists that «absolute space, in its own nature, without relation to anything external, remains always similar and immovable» whereas «relative space is some moveble dimension or measure of the absolute space, which our senses determine by its position to bodies and which is commonly taken for immovable space»[3]. Further on Newton explains that «because the parts of space cannot be seen, or distinguished from one another by our senses, therefore in their stead we use sensible measures of them. For from the positions and distances of things from any body considered as immovable, we define all places; and then with respect to such places, we estimate all motions [...] And so instead of absolute places and motions, we use relative ones; and that without inconvenience in common affairs; but in philosophical disquistions, we ought to abstract from our senses, and consider things themselves, distinct from what are only sensible measures of them»[4]. And again «Relative quantities are not the quantities themselves, whose names they bear, but those sensible measures of them [...] which are used instead of the measured quantities themselves. And if the meaning of words is to be determined by their use, then by the names time, space, place, and motion, their measures are properly to be understood; [..] On this account, those violate the accuracy of language, which ought to be kept precise, who interpret these words for the measured quantities. Nor do those less defile the purity of mathematical and philosophical truths, who confound real quantities with their relations and sensible measures»[5].

1. Having said that I am not oblivious of the fact that for Descartes, in regard to material things, spatial extension is of the very essence.

2. I refer to the selection from *Sir Isac Newton's Mathematical Principles of Natural Philosophy and His System of the World*, Florian Cajori edition, as reprinted in J.J.C. Smart (ed.), *Problems of Space and Time*, N.Y, 1964, 81-8.

3. *ibid.*, 81.

4. *ibid.*, 83-4.

5. *ibid.*, 86-7. ..

Latter day realists and detractors of positivism and its verificationist/operationalist theory of cognitive meaning wouldn't have said it better.

Upsetting the temporal order of things, let me remind here that Einstein's critique of Newtonian absolute space and time may be thought to amount to a definition of congruence and simultaneity and a specification of experimental operations of measurement with rods and clocks. Beyond definitional stipulations and measurement the concepts 'space', 'time' and their kin would have no cognitive meaning. It is historically accurate and conceptually adequate to maintain that logical empiricists endorsed Einstein's proposal and elaborated on it[1].

3. Already Leibniz and Berkeley argued against Newtonian substantivalism, each from his own distinctive stand-point. Leibniz's relationist argument is stated in *The Leibniz-Clarke Correspondence*[2]. The impossibility to adjudicate between the assertion that space is an absolute being and the assertion that space is the order of bodies among themselves -*ordo coexistendi*- is not imputed to lack of adequate empirical evidence, or so it seems to me. The argument is mainly addressed at the lack of *conceptual* criteria concerning the identity of points in spase independently from the bodies occupying them. Leibniz relies on two quasi logical principles: the Principle of the Identity of Indiscernibles and the Principle of Sufficient Reason. Let us attend more closely to Leibniz's *reductio*: «If space was an absolute being, there would something happen for which it would be impossible there should be a sufficient reason[...] Space is

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1. Einstein's views are exposed in §§ 1 and 2 of his path breaking 1905 paper Zur Elektrodynamik bewegter Körper - English translation «On the Electrodynamics of Moving Bodies» *in The Principle of Relativity: A Collection of Original Memoirs on the Special and General Theory of Relativity,* 1923.

A classic exposition of the logical empiricist stance is to be found in Hans Reichanbach. *The Philosophy of Space and Time,* NY., 1958, where he argues for the conventional character of the definitions of congruence and simultaneity; cf. especially § 27 for the *construction* of the spacetime metric.

For a clear statement of how Einstein's 'shrewd analysis of previous concepts' not any novel experimental facts, influenced the gradual elaboration of the operationalist/verificationist theory of cognitive meaning, cf. P. Bridgman, *The Logic of Modern Physics,* London, 1927, Ch. 1.

2. I refer to the selection from the H.G. Alexander's edition of *The Leibniz-Clarke Correspondance,* as reprinted in J.J.C. Smart (ed.), *Problems of Space and Time,* N.Y., 1964, 89-98.

something absolutely uniform; [...] From hence it follows [...] that 'tis impossible there should be a reason, why God, preserving the same situations of bodies among themselves, should have placed them in space after one certain particular manner, and not otherwise; why every thing was not placed the quite contrary way [...] by changing East into West. [...] Those two states, the one such it now is, the other supposed to be the quite contrary way, would not at all differ from one another. [...] in truth the one would exactly be the same thing as the other, they being absolutely indiscernible». Barring reference to bodies placed in space, there is no criterion allowing the identification of points in space. But there is «no entity, without identity». To maintain as metaphysically sound an absolute distinction between spaces in the absence of any difference in the order of things is the consequence of the «chimerical supposition of the reality of space in itself»[1].

Berkeley's line is different. The non existence of absolute space would be a trivial consequence of the bishop's maxim *Esse est percipi* combined with the unperceivability of absolute space - about which Newton was adamant. Absolute, pure space, as distinct from that which is perceived by sense, says Berkeley in the *Treatise Concerning the Principles of Human Knowledge,* is an idea so abstract that it cannot be grasped in thought. Thinking of space as pure is an error due to linguistic confusion: we tend to think that substantive nouns refer to, or stand for, a distinct idea. Thus the noun space is mistakenly thought of as standing for an idea distinct from, or conceivable without body and motion. This demonstration of ordinary language analysis *avant la lettre* is preceded by Berkeley's attempt to refute Newtonian substantivalism by means of a relational analysis of motion and a corresponding reinterpretation of the well-known rotating bucket experiment[1].

4. Here I would like to change the focus of my exposition and move from considerations on the global character of space to a *local* aspect of spatial thought as documented in the dispute opposing Berkeley the relationist empiricist and Descartes the substantivalist rationalist[2]. The issue between Berkeley and Descartes is: how do we

1. *ibid.*, 89-90.

2. Cf. George Berkeley, *Philosophical Works,* M.R. Ayers (ed.), London, 1975, Part I, §§ 112-116.

3. Making Descartes the target of Berkeley's critique is convenient but not entirely accurate: Berkeley argues *contra* those he collectively calls 'optic writers';

come to know the relative positions of physical objects, and their relative distance from us? How do we form perceptual judgements about the depth of our visual field? Or again, how do we perceive objects as three-dimensional, when their retinal image is two-dimensional; what is it in our perceptual faculty that adds a 3rd dimension to the data of early vision? Descartes in *La Dioptrique* contends that we form such judgements by performing mental computations on the triangles having as basis the line joining the eyes and as sides lines projected from the eyes and converging on the object. Upon completion of the computation, we perceive the object as placed at such or such a distance from ourselves. These computations are performed according to a kind of geometry *innate* to all men - as the diagrams in Descartes' text show, this geometry is Euclidean[1].

Berkeley in the *Essay towards a New Theory of Vision* protests: «in vain shall any man tell me that I perceive certain lines and angles which introduce into my mind the various ideas of distance, so long as I myself am conscious of no such thing»[2]. According to Berkeley judgements of distance do not rest directly on sense data, but are mediate products of inference from a stock of generalisations and abstractions over sets of successive experiences and of empirically learned associations. These associations coordinate visual and 'tangible' sensations with each other[3]. Berkeley agrees with the optic writers that perception of distance, and thus of volume and shape, is mediate. They disagree about the mental workings, the 'psychological' *mechanism* of mediation: computation vs. association[4].

5. The tale of the origins of spatial thought as articulated in the Berkeley-Descartes controversy carries with it the possibility to trans-

for a most illuminating presentation of the specific issue of spatial thought, as well as of Berkeley's position in the general movement of philosophical and scientific ideas up to present day concerns about and treatment of visual perception and thought, cf. Robert Schwartz, *Vision: Variations on Some Berkeleian Themes,* Oxford (1994), especially Ch. 1.

1. Cf. Descartes, *Oeuvres et Lettres: La Dioptrique,* Discours Sixième: De la vision, 217-24, Paris, 1953, Éd. Gallimard.

2. Cf. *An Essay towards a New Theory of Vision,* §§ 10-14, in Berkeley, *op. cit.* 10-11.

3. *ibid.,* §§ 44-59, 20-2.

4. Aware though I am of the danger of anachronistic overinterpretation, I find tempting to see in the Berkeley-Descartes controversy a premonition of current debates in cognitive science, to wit the dispute on the rules-and-symbols and the connectionist approaches in modelling the architecture and function of the mind /brain.

form what in the Leibniz-Newton controversy is an abstract, free-floating so to speak, commentary on conceptual constructs into an issue between anthropologically, and why not say it, psychologically grounded hypotheses. This transformation seems to me to be of primary importance, cutting as it does across the rationalist-empiricist and the substantivalist-relationist divides. This transformation enriches these philosophical styles with new conceptual and argumentative ends and means. Although, I must hasten to add, the possibility of a naturalized epistemology that would take into serious consideration the cognitive activities of actual and not merely of possible or ideal knowing subjects remained unactualized until quite recently. As a matter of fact, 'psychologism' has been a derogatory term among philosophers, even among those who were not shy of speculating about mental faculties[1]. Psychology, whether *psychologia rationalis* or empirical psychology presented as natural science, was deemed irrelevant to the concerns of metaphysics, or else methologically messy, empirically unreliable and unmathematisable.

6. In this perspect I find Kant's case very telling: with some trepidation I risk the hypothesis that Kant devised his transcendental method so as to explore the link between epistemology and the operation of cognitive faculties, without committing the sin of psychologism.

With respect to space it is amply documented that Kant moved from Leibnizian relationism to a position close to the Newtonian conception of absolute space[2]. But it would be hasty to conclude that

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1. The story of antipsychologism, especially as a central tenet of logical empiricism originating in Frege and Husserl, is well-known, so I will not insist on it here - for a recent assessment, cf. Martin Kusch, *Psychologism: A Case Study in the Sociology of Philosophical Knowledge*, London, 1995. Let me only point out that mistrust vis à vis a psychology of cognition is to be found also among opponents of logical empiricism, many of whom invest Language and/or Social Practice with a regulatory authority on knowledge.

2. It is in the essay *Vom Ersten Grunde des Unterschiedes der Gegenden in Raume* Ak. b. II, 375-83, Berlin, 1912, that Kant draws the inference from the existence of incongruous counterparts, for example, of left and right hands, to the independent, substantival character of space. The argument might be summarized as follows: space itself must be real, because a) there are objects which cannot be made to overlap with one another-although they possess the same geometrical structure, they are differently oriented; b) so, there is a spatial property, orientability, which is differently possessed by otherwise spatially identical objects; c) such a property is not derivable from the relative position of the parts of the objects; d) so, such a property must derive from the relation of the objects to space

Kant's views just converged on the Newtonian idea of absolute space in itself. For space «is nothing as soon as we lay aside the condition upon which the possibility of all experience depends, and look upon space as something that underlies things in themselves». Kant's exposition of his theory of space in the first *Critique* is, in letter and in spirit, anthropological: «It is...solely from the standpoint of man that we can speak of space, of extended things, etc. If we depart from the subjective condition under which alone we can have outer intuition, or, in other words, by means of which we are affected by objects, the representation of space has no meaning whatsoever» The exposition teaches «the *reality* (that is the objective validity) of space»... [only with] «reference to the constitution of our sensibility»[1].

The mandatory character of the spatial constraint on our perceptual capacity is due to the fact that it is constitutive of our experience: try as we might, we cannot dream of pink elephants non spatially. The fact that the spatial constraint is *a priori* stops short a regress that would postpone *ad infinitum* the acquisition of knowledge from experience, if the spatial constraint on experience were itself acquired through experience. In 1790, three years after the publication of the second edition of the *Ctitique of Pure Reason,* in his polemic with Eberhard, Kant concedes that the foundation of the possibility of experience, for example the foundation of the possibility of spatial intuition is innate[2]. Innateness is the anthropological ground of the *a priori.* Innateness pertains to the form of our experience; it does not constrain its contents, in our case spatial representations. The determination of contents, that is the determination of spatial representations, is effected by means of the conceptual apparatus of geometry. Analogously, the transition from the possibility of experience of external things to determinate experience, from the

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itself. The best place to get the story of Kant's turning away from Leibniz would be Chapter 7 John Earman's, *World Enough and Space-Time: Absolute vs Relational Theories of Space and Time,* Cambridge MA, 1989; cf. also Ned Block, Why Do Mirrors Reverse Right/Left but not Up/Down?, *Journal of Philosophy,* XLXI, 1974, 259-76.

1. I refer to the selection from «The Transcendental Aesthetic», Section I: Space, § 3, The transcendental exposition of the Concept of Space, from the *Critique of Pure Reason,* translated by Norman Kemp Smith, as reprinted in J.C. Smart, *op. cit.,* 106-10.

2. *Kants gesammelte Schriften,* Ak. VIII, 221-23.

formal conditions of knowledge to knowledge of determinate natural objects, is effected by means of the conceptual apparatus of mathematical natural science.

Thus the mandatory character of the form of spatial intuition, strengthened with the necessarily Euclidean character of the determinate contents of spatial represwntations, would confer to Kantian space anthropologically grounded universal validity but not the status of a Newtonian free-floating absolute substance.

The necessary character of Eucliden geometry as the determinate form of space derives from the supposition that an alternative geometry is inconceivable: concerning Euclidean geometry, one may indeed impute to Kant the inference from the inconceivability of the opposite to necessary existence-from the *Nichtandersdenkenkönnen* to the *Nichtandersseinkönnen*. The advent, in the decades following Kant's death, of logically consistent and thus conceptually possible non-euclidean geometries, if it were not to shatter the categorial unity of geometrical representations which guarantees their objectivity, called for a profound revision of the epistemological and metaphysical status of the conceptual framework of geometry.

7. One can hardly exaggerate the extent to which the philosophy of science, and philosophy at large, during the second half of the 19th and much of the 20th century was shaped by the effort to come to terms with the complex knot of problems prompted by the discovery of non-euclidean geometries. Of course I am exaggerating a little, but not very much: we all know how set-theory, relativity theory and quantum mechanics, between them, contributed to our expulsion from the paradise Aristotle, Newton and Kant had invented for us.

Reducing a protracted effort to its barest essentials, I single out: first, the truly radical move to bring into the focus of philosophical inquiry not the things theories talk about but the very medium of articulate thought, language itself. Second, the rise and gradual domination of the nominalist - instrumentalist - conventionalist interpretation of scientific theories, whereby theories are viewed as convenient systematisations and as means to easier calculations. On the other hand, and in equal measure waned the realist conception of theories as capturing essential features of their objects. Finally, I should mention the rejection of metaphysics in so far as it was tied to the notion of synthetic *a priori* forms of knowledge. Sole bearers of *cognitive* meaning, that is meaning pertaining to objects, were

those linguistic forms that could be rephrased either as analytic, that is as logico-linguistic explications of meanings, or as synthetic a posteriori, that is as reports of actual or possible experiences and observations. The retention of kantian terminology, however partial and re(de)fined, is not accidental.

Of course I am not gonig to dwell on the carreer of logical empiricism which the foregoing remarks serve to adumbrate. I simply try to suggest that it is within the historical and argumentative context of logical empiricism that adequate sense can be made of the claim that the theory of relativity has settled the dispute between the substantivalist and the relational conception of space in favour of relationism[1].

8. And yet even in this context things are more complicated. Take for example so called Mach's Principle. In its original (1883) formulation by Mach, it amounts to the inertial properties of space being determined by the distribution of matter in the universe. The reinterpreation of Mach's principle within the General Theory of Relativity proceeds in 3 steps: identification of inertia with gravitation; identification of gravitation with the metric of the space-time manifold; determination of the metric field by the energy-momentum tensor which expresses the distribution of mass-energy in the universe. But the metric and the energy-momentum tensor are connected by non-linear second order partial differential equations. Their solution requires the imposition of boundary conditions determining the metric at inifinity. The boundary conditions then under reasonable assumptions which warrant the solubility of the differential equations, act as Newton's absolute space, since it is not the distribution of matter determines the metric at infinity, but the boundary conditions themselves. As Adolf Grünbaum stressed in 1957, this fact makes clear that, «far from having been exorcised by the GTR, the ghost of Newton's absolute space is nothing less than a haunting incubus»[2]. I rely here on the authority of this distinguished

1. One might remark that with the theory of relativity a shift of focus has occurred from space and time to space-time. The possibility to reformulate the Newtonian theory within the framework of generally covariant theories used for special and general relativity cautions a smooth widening of perspective in our commentary.

2. A. Grünbaum, The Philosophical Retention of Absolute Space in Einstein's General Theory of Relativity, *The Philosophical Review,* LXVI, 1957, 525-34, as excerpted in Smart, *op. cit.,* 314.

continuator of Hans Reichenbach's program in the foundations of the Theory of Relativity in an updated logical empiricist perspective.

9. More recently, in his 1989 *World Enough and Space-Time: Absolute versus Relational Theories of Space and Time,* John Earman details the insuperable difficulties that seem to plague the relationist attempts to excise all absolute concepts from the theory of relativity in its usual generally covariant formulation. Yet in chapters 9 and 10 by which he concludes his book, Earman shows that the price of substantivalism is no less than the renunciation of determinism. This conclusion is reached by means of the so-called «Hole Argument», presented by John Earman and John Norton in 1987[1]. The troubling dilemma facing substantivalists: either repudiate substantivalism or else opt for indeterminism, emerges as a consequence of a corollary of the very definition of general covariance. Passing over essential tecnical details, I would like to present here the three premises that bear the force of the argument:

> *Gauge Theorem* (General Covariance): Let M: ‹M, g, O› be a model of a spacetime theory. M is a differentiable manifold, that is a continuum of points; g is the metric which defines the geometry of the spacetime - in a newtonian theory g defines a flat euclidean space; O is a set of objects. Let h be a transformation from M onto M - a diffeomorphism. Then M′: ‹M, h*g, h*O›- the image of ‹ M, g, O› under h- is also a model of the theory.

There are infinitely many diffeomorphisms that satisfy this condition. In general, with respect to g, h*g effects a non trivial rearrangement of metrical properties on M, but such that the relative relations between objects are preserved. Hence, strictly or rather substantivally speaking, diffeomorphic models do not represent the same world, even though the relative properties which are within our compass are the same. *Nota bene*: talk here is about possible worlds being the same up to diffeomorphism, not up to a more or less definite empirical approximation to the actual world.

Earman and Norton point out that the diffeomorphic transformation is an analogon of the reversal between East and West in Lei-

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1. John Earman & John Norton, What Price Substantivalism? The Hole Story, *Brit. J. Phil.* Sci., 38, 1987, 515-25; the argument is referred back to Einstein himself. For an accessible exposition, cf. also John Norton, Philosophy of Space and Time, in Salmon, M.H. *et al., Philosophy of Science,* N.J., 1992, 179-231; esp. 227-30.

bniz's refutation of newtonian absolutism. So they cast the decision facing the substantivalist as a rejection of the

> *Leibniz equivalence*: Two models of a spacetime theory related by a difemorphic transformation represent the same possible world.

For the substantivalist, empirical equivalence does not imply ontological identity.

But then imagine an arbitrary neighbourhood H of the manifold M. Imagine also a transformation h on M - one among an infinite family of transformations-such that g=h*g outside H but g=/=h*g inside H.

> *Hole corollary*: Let M be a model of a spacetime theory with manifold M and a neighbourhood H of M. Then there exist arbitrarily many distinct models of the theory on M which differ from one another *only* within H.

In what respect do such models differ within H? Being diffeomorphic, they have different metrical properties. What does this amount to? Given that the metric determines *inter alia* trajectories traversible by objects not subject to any force (inertial trajectories), a manifold's having different metrical properties would mean that there are different possible inertial trajectories within H. Even if the theory determines completely the trajectory of, let's say, a neutrino in its intergalactic course, it would be impossible to determine the trajectory of the neutrino within the hole. This is how the threat of indeterminism arises. The form of indeterminism is radical in the sense that it is not a consequence of empirical indeterminacy but stems from the basic theoretical assumptions of any generally covariant spacetime theory.

Of course the threat arises on a realist reading of spacetime theories. In the wake of the demise of logical empiricist agnosticism such a reading is not uncommon, on the contrary. And to dismiss the issue, from an instrumentalist, or a neo-empiricist standpoint - *à la* van Fraasen, Hacking, and Cartright - would be judged by many contrary to good taste: a very unheroic flight in the face of a profound result forcing us to reflect physical science in the mirror of metaphysics.

Let me draw rather bathetically the moral: far from being a ghost story, research on such foundational notions as space, time,

movement, is a lively enterprise[1].

10. No less actively pursued is the matter of the anthropological grounding of spatial thought in the domain of cognitive studies. The volume of empirical findings and the theoretical models under elaboration command the attention not only of naturalistically minded epistemologists but also of metaphysically inclined philosophers sensitive to the noble ancestry of such speculations. So to conclude, I would like to survey some issues high on the agenda of cognitive researchers in the area of spatial representation. I will not flesh out my cursory indications by citing significant results- what follows, as it is stated, is but a promissory note, for work to be presented on another occasion. To keep my enumeration of significant themes in norrow compass here, I operate an arbitrary selection among topics detailed in the 1993 volume *Spatial Representation,* edited by Naomi Eilan, Rosaleen McCarthy and Bill Brewer (Oxford, Blackwell, 1993).

What is the connection between the capacity for spatial thought and grasp of the idea of an external world we inhabit? If there is more to spatial thought than the ability to work on or with abstract mathematical geometry, then we must investigate the way we mentally represent the world we inhabit. Antipsychologism (*vide supra*, p. 22, nt 1), common to friends and foes of logical empiricism, led, epistemologists and philosophers of science to focus on 'mature' science expressible in languages or language-like formalisms conceived as external artefacts. Scientific activity was viewed as manipulation of those artefacts. Their cognitive meaning, their worldly bearings, were taken as *somehow* antecedently 'given' - either by pragmatically rational conventions or else by 'irrational' intuitions. Their conditions, perhaps with the exception of equally external social determinations, should not or could not be investigated any further. Which raises the legitimate question whether the alleged understanding - over and above pragmatic success - offered by the abstract theoretical framework is but an artefact of the representational medium, a transcendental illusion of sorts. In this light, taking sides in the dispute between realists and anti-realists in favour of the former, might be thought of as assuming something like a preestablished harmony of mind and world.

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1. For an extensive and subtle presentation of the Hole Argument together with an incisive realist reply, cf. Jeremy Butterfield, The Hole Truth, *Brit. J. Phil. Sci.*, 40, 1989, 1-28.

Externalist strategies rest on the assumption that linguistic symbols as vehicles of mental representation are transparent, so that we can focus our attention on their external correlatives. Opting for an internalist strategy is predicated on the opacity of representations and the need to theorize on exactly how representations - if that concept is an apt analytical tool at all- are endowed with their object and content. Thus Brentano's thesis - the mind as stuff secreting intentionality - is seen not as an intractable mystery, *wovon man schweigen muss*, but as a spring-board for research.

If we choose to look into the cognizer's innards, then some interrelated problem-areas emerge: 1) What makes spatial thought thought about the physical world? An essential ingredient of the idea of physical space is that physical space, in contrast to abstract mathematical space, is a space in which causal processes and events, movement and change, can occur. What then is our 'intuitive' or 'native' physics- the physical principles that we employ in everyday perception, thought and action? 2) The external world is external in that it is not tied to any particular point of view or frame of reference. The claim that spatial thought does provide with the framework for thinking in a disengaged, objective way about the world, is being tested with research into the formation and function of egocentric -body-centred- and allocentric frames of reference and their interrelations. 3) Perception of bodies and action on bodies, how do they rete to spatial representations having the topological and metrical properties they do? 4) To what extend does language sustain spatial intuition?[1] What is the relation between linguistically coded representations and mental imagery? Research into how to screen out the linguistic factor in spatial thought focuses on the performance of preverbal infants and of animals in spatial tasks. 5) Which dynamic learning processes allow to reset and update the values of parameters of the cognitive system, starting from possibly innate initial or default values? How is one to account for cognitive development and

1. A major contribution to the problem of the relations between spatial thoght and language is that of Ray Jackendoff. In a series of books where he spells out his theory of conceptual structure - a theory broadly of chomskian inspiration - Jackendoff explores this theme, cf., for example, Ray Jackendoff, *Semantics and Cognition,* Cambridge MA, MIT Press, 1993, esp. chapter 9: Semantics of Spatial Expressions and chapter 10: Nonspatial Semantic Fields and the Thematic Relations Hypothesis - in the latter he tries to explicate the metaphorical use of spatial categories in a variety of semantic fields.

For a thorough coverage of current research ou the relations between language and srcpe, cf. Bloom, P., Peterson, M.A., Nadel, L., Garrett, M.F., *Language* and *Space,* MIT Press, 1996.

the dynamics of conceptual change, the mental dynamics of scientific revolutions? These, and many others, are areas of intense empirical and theoretical work in cognitive science.

Let me remind the 3-tiered strategy of cognitive studies. First, specification of the cognitive task under research both at the level of phenomenological description and at the level of functional explanation, with postulation of causally linked mental processes. This is the domain of experimental and cognitive psychology. Second, elaboration of computational models of mental processes- the domain of AI research. Third, exploration of neural structures and mechanisms that might implement those computations. This is the task of neuroscience. Whether and under what conditions the integration of the 3 levels is practicable is itself a question under close scrutiny, both in its conceptual and its methodological aspects. If it were possible, what would such an integration amount to? To no less than a deep understanding of human thought, an understanding which, however partial, could indeed be presented as a natural science.

This much might be necessary in order to come to grips with spatial thought. As Kant had clearly sensed, the thought of external objects as existing without us, in time and space is at the same time conscious thought of our own existence.

# ΧΩΡΟΣ ΚΑΙ ΝΟΗΣΗ

## Π Ε Ρ Ι Λ Η Ψ Η

Στον προβληματισμό περί του χώρου και του χρόνου δεσπόζουν δύο αντιτιθέμενες θεωρητικές απόψεις, η ουσιοκρατική και η σχετικοκρατική: ο χώρος και ο χρόνος ή κάποιος συνδυασμός τους είναι απόλυτες ουσίες, χωριστές και ανεξάρτητες από τα φυσικά σώματα και τις κινήσεις τους ή μήπως ανακύπτουν από τις σχέσεις ανάμεσα στα φυσικά σώματα και / ή ορίζονται πλήρως με αναφορά στις σχέσεις αυτές; Εστιακό σημείο εδώ είναι ο χώρος.

Τυπικός εκφραστής της απόλυτης ουσιοκρατικής άποψης θεωρείται κατά παράδοση ο Newton, ενώ κλασικός εκπρόσωπος της σχετικοκρατικής, ο Leibniz. Η διαφωνία μεταξύ Descartes και Berkeley σχετικά με το πώς αντιλαμβανόμαστε το βάθος του οπτικού πεδίου θέτει το πρόβλημα της χωρικής νόησης σε ανθρωπολογική βάση. Η ανθρωπολογική θεμελίωση της χωρικής νόησης είναι μείζων συνιστώσα της Καντιανής φιλοσοφίας.

Κατὰ τον 20ο αιώνα, το ζήτημα της φύσης του χώρου και της χωρικής νόησης έμοιαζε να βρίσκει λύση στο πλαίσιο της φυσικής και μάλιστα σε σχετικοκρατικό πλαίσιο, σύμφωνα με τη λογικοεμπειριστική ερμηνεία της θεωρίας της Σχετικότητας - ειδικής και γενικής. Ωστόσο, το ζήτημα της φύσης του χώρου και της χωρικής νόησης μοιάζει να μην έχει κριθεί οριστικά. Αφενός, όπως έχει τονίσει ο A. Grünbaum, φαίνεται να μην εξαλείφονται πλήρως απολυτοκρατικά στοιχεία από τη συνήθη covariant διατύπωση της γενικής θεωρίας της σχετικότητας. Αφετέρου, όπως έχουν δείξει οι Earman και Norton, με το επιχείρημα της αιτιακής «οπής», το κόστος της ουσιοκρατικής επιλογής είναι μεγάλο: η εγκατάλειψη της αρχής της αιτιοκρατίας. Η σχετική συζήτηση συνεχίζεται έντονη στους κύκλους των φιλοσόφων της φυσικής.

Στις μέρες μας, η χωρική νόηση και οι όροι δυνατότητάς της γίνονται αντικείμενο διεπιστημονικής έρευνας στο πλαίσιο του γνωσιοεπιστημονικού εγχειρήματος, με συνδυασμό θεωρητικών υποδειγμάτων και εμπειρικών μελετών στα πεδία της γνωσιακής ψυχολογίας, της θεωρίας της γλώσσας, της νευροεπιστήμης, της τεχνητής νοημοσύνης.

ΓΕΩΡΓΙΟΣ ΜΑΡΑΓΚΟΣ