The visual Brain in Context:

Comments on William Bechtel's "Looking Down, Around and Up: Mechanistic Explanation in Psychology"

William Bechtel has developed in recent years a thorough philosophical analysis of many aspects of contemporary trends in cognitive science. His broader perspective is philosophy of science, rather than philosophy of mind. From the point of view of philosophy of science, the question of the explanation of mental phenomena should not be divorced from the general understanding of scientific explanation. When we say that in many cases, to explain a phenomenon is to describe the mechanism responsible for its existence and characteristics, we do not make any reference to the properties (physical or psychological) of the phenomenon itself. We only sketch a model of explanation that may be relevant for mental phenomena just as well. And a further reason to consider the idea of mechanistic explanation in psychology is that it fits nicely well-known parts of natural science. What has been called "neurology" in the XIXth century is not concerned first of all with the neuron as a nerve cell and a component of the nervous system, but with the causal explanation of phenomena like language, perception, action and memory. Neurology draws inferences from the consequences of pathological states and electrical stimulation of the brain to its functional architecture and normal functioning. *If* patients with lesions in V2 area fail to experience illusory contours when they look at Kanizsa triangles, *then* V2 area has a chance to play a role in the definition of such contours (as we may have already reasons to believe)[1]. Neurology distinguishes structures and pathways within the brain in terms of their contribution to observable (clinical) normal and pathological phenomena. From its very birth, identifying the causal relations between the pattern of activity of one's brain and one's mental states is what neurology has been about. Consequently, by any standard definition of what a mechanism is[2], neuropsychology, or more recently cognitive neuroscience, are in the business of looking for brain mechanisms that could explain psychological processes, typically by "looking down" and paying attention to brain parts, their operations and interactions. And the scientific practice of both neurospsychology and of cognitive neuroscience certainly deserves some attention from the philosopher of science focusing on the logic of explanation. When successful, cognitive neuroscience shows clearly that we should not overemphasize the autonomy of

Rédigé en 2007. Première présentation : atelier « La réduction de la psychologie aux neurosciences », Paris, 2006, organisé par Max Kistler.

[1] Zeki, 1993.
[2] Craver and Bechtel, 2006.

psychology: neuropsychological knowledge is brain knowledge, and it is clearly relevant to psychology itself. But on the other side, it is far from obvious that the development of cognitive neuroscience leads to its reduction, in a strong sense, to another discipline like molecular neuroscience. This lack of equivalence (to put it mildly) between mechanistic explanation and reduction is probably a reason to reflect on the concept of organization (which refers to what is considered when we are "looking around" and take into account, not only the components themselves, but how they are mutually related).

In this theoretical context, the example of visual perception chosen by Bechtel is not surprising. First, instead of taking a purely normative stance about what psychological explanation should (or shoudn't be) be in general, a philosopher may be tempted to take a more descriptive stance, putting emphasis on what existing explanations consist in and how they are refined. And there is for sure a large body of vision-related neuroscientific knowledge that has been expanded from the days of Ferrier and Munk[3] till current speculations related to the respective functions of the ventral and dorsal streams of visual information[4]. The development from classical neurology to cognitive neuroscience eloquently shows that the discovery of pathways, the assessment of the consequences of lesions, the recording of brain cells activity, may lead to a better understanding of cognitive operations and psychological processes. Discovering what kind of information is processed by inferotemporal or posterior parietal cortex neurons is not simply discovering neural *correlates* of visual activity. It is understanding visual perception itself. Developing the physiology of the "visual brain" is proposing a mechanistic explanation of vision as a psychological phenomenon.

The second reason to focus on visual perception is that in earlier days of cognitivism, visual perception has elicited different, and even conflicting theories[5]. Now the idea is not only that we could reconcile these different kinds of explanations. It is that taking mechanistic explanation seriously does not mean to conceive visual mechanisms as self-sufficient, as it could have been the case in the tradition of methodological solipsism. The idea of looking for explanatory factors in the environment itself ("looking up") has recently attracted a lot of attention, but it needs a careful analysis if we want to go beyond mere ecumenism.

[3] Gross, 1998.
[4] Milner and Goodale, 1995.
[5] Fodor & Pylyshyn, 1981.

I.

Are mechanistic explanations in psychology truly reductionistic, and if not, why exactly? On this topic, the best place to start may be the paper of Bechtel and Mundale[6]. According to the Multiple Realization Thesis (MRT)[7], the same psychological state can be realized by different brain states. To challenge this thesis, Bechtel and Mundale claim that the characterization of brain states offered by MRT (brain states are physical, or chemical states) is inadequate. They observe that in common scientific practice, brain parts are identified in relation to their functional roles and the functional architecture of the brain:

> […] the scientifically operative notion of a "brain state" differs from the sort of fine-grained conception of brain-states employed in philosophy; it is more coarse-grained […]"[8].

So instead of being understood as a reason to divorce neuroscience from psychology, "functional equivalence" between brain parts (the result of the comparison between the brains of different biological species, for instance) would be a reason to link closely these disciplines. In a sense, this could be read as: as far as psychology is concerned, we do not have to go *too far* down. Instead of a one-to-many relation between psychological states and brain states, we may have to deal, in fact, with a one-to-many relation between (1) brain states, characterized by their physical properties and (2) brain states, functionally characterized. And the consequence seems to be, there is *in principle* a close link between cognitive neuroscience and psychology, but a weak link (for instance) between cognitive neuroscience and molecular neuroscience. Instead of accepting the "gloomy implications"[9] of the multiple realization of mental states ("gloomy", because of the lack of psychological significance of the current development of our knowledge of the brain), we should consider that distinct brain maps, in fact, may be only representing different implementations of a similar functional organization. The psychologically significant part of brain science would be, then, the one that focuses on such a functional organization[10].

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[6] Bechtel and Mundale, 1999.

[7] Putnam, 1967/ 1975.

[8] Bechtel and Mundale, p. 177.

[9] Ibid., p. 178.

[10] In this paper I will not elaborate on the concept of function. I assume that a systemic concept of function is fundamentally what is needed in neuroscience (see Craver, 2001). But it is always possible to ask ourselves where does the brain's present functional architecture comes from, and to reintroduce evolutionary considerations. See below, II and III.

On the other hand, functional role ascriptions are linked to a mechanistic perspective, and it is a defining feature of mechanistic explanations that component parts or more exactly their operations can be treated, in turn, as explainable phenomena. As Bechtel says in a recent paper, "the process of decomposition is iterative –the operation of a component part can itself be explained by another round of decomposition and localization"[11]. So in principle, one could think there is no reason to limit the analysis to high-level functional characterisations of brain states in their relation to mental phenomena.

The interest and the difficulty of Bechtel's position is that he does not think, as I understand him, that we have to *choose* between a psychologically relevant functional characterization of brain states (interested only in high-level descriptions of brain activity), and an iterative process of decomposition (concerned mainly with lower-level processes and components).

First, a distinctive feature of the explanatory program of neuroscientific research must be kept in mind. Questions that cognitive neuroscience usually tries to answer are not of the type: what is (…)? True, some philosophers quarrel about the identity of pain with C-fiber firing, but the purpose of neuroscientific investigation is not strictly or mainly definitional. Questions it typically addresses are of a different type: for instance, what is responsible for the occurrence of a certain phenomenon (a distinctive capacity, like the perception of contours, the recognition of familiar faces, or visually guided behaviour) or its absence in an anomalous condition. Two features of the neuropsychological explanation will be that a) complex phenomena must be the result of the interaction of several components that can be functionally identified, and b) that the reference to these components is parsimonious, since a different combination of some of them will contribute to the explanation of different but related phenomena. Questions, then, will be answered when we know which structures are involved, and what is the nature of their distinctive contribution. Trying to find out what their contribution is will be trying to find out which function they perform, which higher-level ability they contribute to (like the sensitivity to simple patterns of some neurons, that may contribute to the identification of biological forms). In consequence, breaking brain mechanisms into components would not be fruitful if we had to lose entirely from view psychological analysis itself. A reference to brain parts will only have an explanatory value in cognitive neuroscience if these parts may be considered to perform cognitive operations. Decomposition, then, will be "horizontal" rather than vertical.

For instance, in his pioneering study on visual recognition, Lissauer made a distinction between two kind of disorders, "apperceptive" agnosia and

[11] Bechtel, *in press*.

"associative" agnosia[12]. According to his proposition, people suffering from apperceptive agnosia do not unite the distinct parts and attributes of a seen object in a recognizable whole, while people suffering from associative agnosia are unable to access what we would call semantic knowledge about the objects they are nonetheless visually aware of. Whatever its defects, Lissauer's distinction is a powerful heuristic tool which has contributed to a more complete understanding of visual agnosia[13]. Moreover, its basic idea can be reconciled to a certain extent with the contemporary framework of the dorsal/ventral distinction: compared with the apperceptive type, the associative type can be understood as the manifestation of a problem at a higher level of (ventral) visual processing; and people suffering from visual form agnosia (a typical subform of the apperceptive type) are still able, for instance, to orient themselves successfully through corridors. Lissauer's proposition is typical of neuropsychological explanation: a) it is the product of a psychological analysis about what object recognition consists in; b) it offers the interpretation of contrasting deficits in terms of selective impairment of subpersonal cognitive operations; c) in explanations of core symptoms of visual agnosia, just as in the explanation of related neuropsychological syndromes, no special reference has to be made to brain cell metabolism or synaptic transmission; d) the complex symptomatology of agnosias and the detailed analysis of visual recognition lead to a decomposition of the brain in functionally-characterized components: among them, some will be more involved than others in a specific task. Decomposition in component parts and operations, then, even iterated, is still *functional*, that is, *psychologically relevant* decomposition[14].

Second, to say that mechanisms are organized[15] is to insist on the fact that organization is an important source of *divergence* between explanatory purposes at different levels. For instance, to identify functionally brain regions and to understand what they do, connectivity (as related to spatial organization) is important: we have to know if a part is connected to input systems, or to motor output, if there are feedback loops that link it to other parts, and so on[16]. This

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[12] Lissauer, 1890.
[13] Milner and Goodale, 1995, Humphreys, 1999.
[14] A similar point could be made about pain. We can refine the psychological analysis of what pain is as an already complex psychological phenomenon, and we can correlate aspects of the phenomenon of pain with component parts and operations of the relevant system. It seems that, roughly speaking, distinct mechanisms are responsible for the sensory-discriminative dimension of pain (the lateral nociceptive system) and for its affective-motivational dimension (the medial system) – see Treede, Kenshalo, Gracely & Jones, 1999. To iterate the analysis would be, for instance, to see how different aspects of the discriminative ability can be distinguished (as localisation of pain, intensity of pain, and so on) and to look for the corresponding sub-systems and activities.
[15] Craver & Bechtel, 2006.
[16] Bechtel and Mundale 1999.

means that according to their location and connections, similar low level mechanisms with *aspecific* properties may contribute to distinct and very specific higher-level operations. For a given operation we may have to distinguish:

1. A Low-level explanation of *how* the operation is performed
2. A description of *what* the nature of the operation is
3. A high level (contextual or systemic) characterization of which *contribution* it makes to one or another higher-level mechanism[17].

Concerning for instance infero-temporal neurons, we can distinguish between a) questions concerning their role (their activity has been shown to be selective for shape, or texture, or a combination of both); questions about how the selectivity of responses is achieved (selectivity may involve inhibitory mechanisms in which the neuromediator GABA play a role[18]); c) questions about how the information is further exploited during recognition tasks involving complex stimuli, as when the coactivation of several cells with overlapping properties codes for one of such stimuli[19]. Clearly, diverging questions do not call for answers that could be substituted one to the other. Knowing what is responsible for elementary shape selectivity in the inferotemporal cortex is not knowing how assemblies of shape-sensitive cells give us the ability to categorize natural objects in the outer world. Accordingly, what I have called horizontal decomposition is not the only reason why mechanistic, neuropsychological explanation do not necessarily lead to 'ruthless' reduction (as John Bickle would call it). The other reason is that explanatory purposes in neuroscience are linked together for sure, but that we may have to admit that there are several kinds of them, now and in the future.

II.

In the beginning of the second part of his paper, Bechtel draws a parallel between a) the *simple localizationist* assumption and b) the *aggregative* view of organization. Direct instantiation of functions dictates claims about which structure is responsible for some phenomenon, without usually being able to specify, *how* the function is performed, nor *why* the structure responsible for it is this one (and no other). The aggregative view of organization is nothing but a simplistic view of the division of labour within a given system. According to this view, in particular, early processing of information is independent from what happens at higher levels of the internal hierarchy. It becomes easy, then, to conflate obvious functional *differences* between components with ill-grounded

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17 Craver, 2001.
18 Wang, Fujita and Murayama, 2000.
19 Tanaka K., Saito H., Saito Y., and Moriya M., 1991; Jacob and Jeannerod, 2003.

functional *autonomy* of such parts. And just as the failure of simple localization has often led to propose explanations that rely on interacting sub-parts (looking down)[20], the flaws of the aggregative view may oblige us to reconsider the decomposition of systems in quasi-autonomous units (looking around). Limits of a strict interpretation of functional decomposition are obvious for instance in the case of the ventral and dorsal streams of visual information, as there is evidence of functionally significant interactions between them[21]. But what concerns specifically the limits of the aggregative model of organization may be even more accurately illustrated with multisensory integration.

It may be worth remembering that since the beginning of modern neuroscience, feedforward convergence has been the only available representation of sensory integration based on brain architecture and physiology (see in the XIXth Century the distinction between projection areas and association areas[22]). Today, unisensory informational streams are still thought to be combined at a later stage in higher-order 'multisensory' regions of the brain, like the superior colliculus in the brain of the cat[23] or areas PZ and VIP in the cortex of primates[24]. Two things may be worth mentioning in this context. First, this organization mirrors the naïve *phenomenal decomposition* of our perceptual faculty into several sensory modalities, which are thought to be fundamentally independent from each other. Second, in this aggregative conception of organization, sensory modalities are cognitive modules, in the standard fodorian sense[25]; such modules are domain-specific; they are informationally encapsulated; they are hard-wired in brain circuitry, and they are subject to specific types of deficiencies (as for instance in cortically-blind patients). Multisensory integration would only occur at a higher level, without being able to modify or influence sensory inputs themselves. However, intriguing cross-modal effects have been experimentally demonstrated, like the well-known Mc Gurk effect where the non-congruent visual perception of speech articulation may distort the auditory perception of syllables[26]. Another striking example is the parchment-skin illusion where subjects rubbing their hands are exposed to a modified auditory feedback. In this latter case, enhanced high-frequencies in the auditory feedback are enough to modify the corresponding tactile sensation[27]. Such crossmodal effects clearly invite to a reappraisal of the theory of sensory information encapsulation within each

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[20] Bechtel and Richardson, 1993.
[21] Gross, 1998 ; Jacob and Jeannerod, 2003.
[22] Meynert, 1867-1868.
[23] Stein and Meredith, 1993.
[24] Graziano, Gross, Talylor & Moore, 2004.
[25] Fodor, 1983.
[26] Mc Gurk and Mac Donald, 1974.
[27] Jousmäki and Hari, 1998.

sensory modality. Like the parchment-skin illusion clearly shows, the modulation of the output of one sensory modality under the influence of another may extend to a radical revision of the content of one's sensory experience. Sound may be relevant to what we feel.

Instead of focusing only on additive or super-additive effects in associative, plurimodal areas, recent neurocognitive studies have shown that seemingly unimodal areas can also be directly sensitive to crossmodal interactions. When a flash of light is combined with an unexpected tactile stimulus in the same area (e. g., the unseen vibration of one's hand), the (spatially congruent) tactile stimulus increases occipital activity contralateral to the flash [28]. What gives its importance to such a phenomenon is that first, the occipital region has been traditionally understood as unimodal (so the false prediction would have been that it is insensitive to tactile influence); and second, the crossmodal influence is spatially constrained, as it has also proven to be in otherwise quite different cases of extinction [29]. Other studies have also demonstrated that unimodal sensory areas (visual and auditive) are affected by congruent and synchronous speech signals [30]. Such multisensory effects found in unimodal areas long thought to be devoted exclusively to lower levels of processing clearly challenge the simplistic idea of integration through convergence and the classical modular view.

In consequence, neurocognitive research has been led to hypothesize new integrative mechanisms like vertical feedback (from heteromodal to unimodal cortex) and direct crossmodal interactions[31]. Pathways linking primary auditory cortex and visual area V1[32], and somatosensory and auditory association cortex[33], have recently been discovered. This new picture of sensory integration is still open to discussion: for instance, exclusive feedback interpretations of crossmodal effects have been challenged because of the timing of some kinds of multisensory integration effects, that seem to happen too early to depend on the influence of higher-level mechanisms[34]. The more likely solution seems to be that feedback, feedforward and lateral connections have to be simultaneously taken in consideration in the explanation of cross-modal effects.

We may conclude that :

[28] Macaluso, 2000; Macaluso and Driver, 2005.
[29] Ladavas and Farne, 2004.
[30] Macaluso E., George N., Dolan R., Spence C., Driver J., 2004.
[31] Macaluso and Driver, 2005.
[32] Falchier (A.), Clavagnier (S.), Barone (P.), Kennedy (H.), 2002
[33] Schroeder C., Lindsley R. W., Specht C., Marcovici A., Smiley J. F., Javitt D. C., 2001.
[34] Foxe J.J., Schroeder C. E., 2005.

1. Strictly hierarchical, aggregative models do not account for all kinds of sensory integration, and this is true for multisensory phenomena, as it has been already demonstrated for visual cognition itself[35].

2. The so-called unimodal areas are rather *domain-dominant* than *domain-specific*[36]. In Bechtel's terms[37], the explanation of cross-modal effects requires a *mechanistic decomposition* of our perceptive ability that its *phenomenal decomposition* in separate sensory modalities could not predict. To understand the processing of visual information, we may have to look around (to other modalities and to some kind of feedback, attention-related influence), and not only to look down to specific brain components and circuits.

3. In such a renewed context, it is not only the modular view that should be re-examined, but its teleological justification. In his defense of modular architecture, Fodor has suggested that a modular design allows fast computation[38] and involves "dedicated" mechanisms that are able to draw inferences from proximal stimulations to distal objects[39]. In the context of language perception, this last point involves the idea of a trade-off between transparency (canonical inference from sound to meaning) and superficiality (as the result achieved concerns only the literal content). The case of visual perception is not significantly different: from a certain pattern of proximal excitation of the retina, my visual system can infer the presence, not of a barn, but of something that looks very much like a barn. In Fodor's view, just as figuring out the further intentions of the speaker is a supplementary cognitive task, deciding if what looks like a barn (an example now famous in the epistemological literature) is really what it seems to be would go beyond mere sensory experience.

My point is not simply that we have now some empirical evidence that challenge the modular view. Multisensory integration, in some cases at least, not only enhances the sensory responses of neurons, but shortens their response latencies, possibly to the effect of speeding behavioural responses[40]. And as we have already seen, crossmodal effects make unisensory responses to proximal stimuli far less "canonical", or law-based, than we could expect. My point is rather, on a more theoretical level, that these phenomena make perfectly sense and may serve to achieve important biological goals. To quote Macaluso and Driver, "it might be functionally useful for the modality-specific 'expert

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[35] Bullier, 2001.
[36] I borrow this distinction to Buller, 2005.
[37] Bechtel, 2002.
[38] Fodor, 1983.
[39] Fodor, 1990.
[40] Rowland, Quessy, Stanford & Stein, 2007.

systems' of one sense (…) to prioritize processing signals originating from a location that becomes salient in another sense"[41]. Physical objects (differing in this from visual chimera) are usually accessible through different modalities; preys and predators are not only visible; for instance, they make noise while moving. The fact that for a given neuron the response to a cross-modal stimulus combination may exceed the arithmetic sum of unisensory responses may be understandable if the question: "how is sensory integration achieved?" gives way to the further question: "why does it take the form it does?". If the processing of spatially and temporally congruent signals makes perceptually or attentionnally salient those objects whose properties are typically detected by more than one sensory modality, then there is a high probability that what will be perceptually privileged will turn out to be what is also biologically meaningful. Cross-modal illusory effects would be the price to pay for an efficient, adaptive, fast and all-important crossmodal integration. In consequence, we may have a chance to reconcile the understanding of the internal mechanisms of sensory integration and the 'teleological' definition of their biological significance.

III.

Current reflection and research on visual cognition may often seem to move simultaneouly in two opposite directions. On the one hand, notions that were traditionally foreign to neurocognitive explanation, like the gibsonian notion of affordance, have been reconciled with the mechanistic framework: there is new evidence that some brain areas may indeed be sensitive to relational properties of objects (being graspable, for instance) and not only to their intrinsic properties, like shape[42]. On the other hand, some approaches of visual perception have recently challenged the view that we should conceive visual perception in terms of internal processing of visual representations[43]. Intriguing phenomena, like *change blindness*, suggest that to perceive visually is not to take detailed pictures of the external world[44]. Some researchers have proposed that the world could be conceived as an external memory store which content is accessed when we perform exploratory movements[45]. This alternative view has some obvious connections with broader issues in the philosophy of cognition. According to what is sometimes called "active externalism", cognitive processes do not take place exclusively within the head; they suppose the extensive use of

[41] Macaluso & Driver, 2005, p. 266-7.
[42] Grèzes and Decety, 2002.
[43] Noë, 2006.
[44] Ibid.
[45] O'Regan, 1992.

instruments or devices situated in the external environment[46]. If we adopt active externalism, the environment does not only define the broader content of one's thought as in Twin Earth thought experiments. As it is the case when we manipulate written symbols, the environment may be part of the vehicle of thought, thus conditioning the exercise of our mental abilities. What we could ask to ourselves, then, is if this still holds in the case of perceptual processes. Active externalism does not have to reject entirely the idea of internal, individualistic processing of information. Its distinctive claim is rather that such processing is only part of the story. [47]. But if an externalist approach of visual cognition is legitimate, the current development of mechanistic explanation of visual phenomena should not prevent us from thinking of what Bechtel calls the "situatedness" of mechanisms.

Let's take the example of motion perception. Gibson used to point out[48] that when we move forward and look straight ahead, there is a centrifugal flow of the optic texture around a point of focus on the line of locomotion. This optic flow specifies both the direction and the speed of our movement, providing useful information for the monitoring and control of one's behaviour. Vision in this case is proprioceptive, in Gibson's sense[49]: visual signals may be considered as reafferent signals bearing information about our own, self-generated movement. And just as in the case of affordances, mechanistic explanations of visual processes may be combined with the ecological notion of optic flow, since it is known[50] that neurons in the dorsal part of the medial superior temporal area (MSTd) are sensitive to differences of pattern in optic flow. This kind of discovery, however, does not lead to reject what Mark Rowlands has called the 'epistemological' claim:

> It is not possible to understand the nature of cognitive processes by focusing exclusively on what is occurring inside the skin of cognizing organisms[51].

We do not have to deny, as orthodox ecological optics is often supposed to deny, that some kind of complex internal processing of visual information is needed for the brain to become sensitive to optic flow patterns. But if these patterns specify movement properties, then we do not have to postulate unnecessary complex internal processing either. Whatever internal processes are needed for the visual perception of our movements (through the visual

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[46] Bechtel, 1996, develops an externalist, interactive conception of scientific practice : to understand the construction of scientific explanation, we (also) have to « look up » – that is, to take into account external representational systems.
[47] Rowlands, 1999.
[48] Gibson, 1954.
[49] Gibson, 1972.
[50] Duffy and Wurtz, 1997.
[51] Rowlands, 1999, p. 22.

perception of their normal consequences), visual processing may be conceived as taking advantage of optic flow patterns, as they bear crucial information relative to direction and speed. Seeing, then, is like using available natural resources. Sensory mechanisms only work when they are embedded in environments that yield the proper kind of input.

At this point, opponents of the active externalist (or as Rowlands puts it, environmentalist) view, may want to recall that while optic flow signals specify modifications that usually take place in the outer world, the corresponding processing still takes place within the head. They would challenge the idea that visual perception is truly a matter of interaction, in an interesting sense, between internal structures and external environment. But for my present purpose, the strength of active externalism matters less than the relations of neuroscientific explanation with other kinds of knowledge. My point is that even if active externalism could not be vindicated against internalist views in the context of the understanding of vision, we would *still* have to look up to the environment when we want to explain visual phenomena. To echo what has been said before concerning sensory integration, the question is not only where cognitive processes are situated, but it is also to find out why they are what they are. Without an informational relation between optic flow patterns and movement properties, it would be useless to have neural structures that are able to answer selectively to the former. The informational value of optic flow patterns and their possible role in the monitoring of one's locomotion in the outer world may in particular explain why structures like MSTd have evolved (even if is may prove to be extremely difficult to reconstruct the corresponding evolutionary story). Likewise, the responses of neurons of the posterior parietal cortex to identical retinal stimulation are known to be sensitive to gaze orientation, a testimony of their implication in the transformation of spatial coding of visual information from retinal coordinates to head-centered coordinates[52]. But such a function of posterior parietal neurons only makes sense because of the existence of oculo-motor movements, that is, because of the existence of a certain kind of body architecture with specific anatomical and physiological characteristics. In this case, as in others, the range of one's behavioural repertoire defines the corresponding informational needs. Understanding what neural mechanisms do has often a high explanatory value, but we may also want to specify because of what kind of informational needs and resources (see optic flow patterns), or in connexion with what kind of bodily structure (see oculomotor movements), neural mechanisms are operative. And clearly, we are, then, in both cases, *looking around* to discover constraints on visual cognition.

[52] Andersen (Richard A.), Essick (Greg K.), Siegel (Ralph M.), 1985.

Denis Forest, University of Lyon & IHPST, Paris

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