

# Mind, Space and Objectivity in non-human animals

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► **To cite this version:**

Joëlle Proust. Mind, Space and Objectivity in non-human animals. *Erkenntnis*, Springer Verlag, 1999, 51 (1), pp.41-58. <ijn\_00139217>

**HAL Id: ijn\_00139217**

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Submitted on 29 Mar 2007

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**Mind, space and objectivity  
in non-human animals**

published in *Erkenntnis*, 51, 1, 1999, 41-58.

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There are many diverse, and sometimes conflicting motives for studying animal minds. Ethology aims at describing and explaining animal behavior. Evolutionary biology is focussing on the functions that appear in phylogeny, such as cognitive perception, learning and social communication. Popular essays want to entertain the readers with moving stories. Moralists explore animal rights. Animal trainers try to increase learning efficiency. Philosophy looks for an explanation of mind in general, i.e. mentality as it appears in all animals, human or non-human. One of the primary intuitions on which the present contribution draws is that an explanation of the human mind that ignores the conditions in which minds appeared earlier in phylogeny in non-linguistic animals tends to emphasize non-necessary features while forgetting crucial ones.

If one choses to study minds "in general" through the notion of a linguistic representation, as does Davidson among others, one begs a variety of important questions : what are the early forms of representation that deserve to be called mental? What makes a representation a representation of an object, as contrasted, for example, with a representation of a feature of an individual's experience ? How constitutive are the capacities of exchanging information, of

using tools or of solving problems in possessing minds ? What is the difference between mentality and intelligence ?

If one looks at animal minds from above, so to speak, one tends to consider language, as Descartes did, as a necessary condition for developing a thought having the characteristics of creativity and of systematicity that underly human thought. (Creativity is the property of linguistic systems to allow the construction of ever new sentences ; systematicity is the feature in virtue of which grasping one sentence involves grasping all the sentences with the same structure, for an invariant lexicon). True, language entails the capacity of forming and of understanding any among an infinity of sentences. But is that a necessary component for mentality ? And if so, is that capacity restricted to external-language users ?

As ethologists know well, it is nearly inevitable to project human categories and preferred metaphysics onto an animal's world. This latter worry does not refer only to the popular subjectivist claim that animals, having no words and probably only rudimentary concepts, and often intriguingly exotic sensory mechanisms, do not in fact "look at" their world in the way we describe it, and that, therefore, we shall never really understand "how it feels" to be them. It articulates the more interesting issue that an animal may entertain representational states that are in no way mental states. Using a language of independent things and events may lead us to mistake the human, mentalistic, way of representing, with early biological representational functions that do not involve possessing a mind. The present essay attempts at formulating general constraints for a representation to be mental. Such constraints should allow characterizing the differences between, say, an aplysia instantiating internal - but non-mental - representations of an external condition, and a rat entertaining an internal and mental representation of food location.

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Kandel & Hawkins' work on a mollusc named Aplysia will help us introduce this

crucial distinction. This invertebrate possesses respiratory organs including a gill located in a mantle cavity recovered with a protective sheet, named the mantle shelf, whose extremity constitutes the siphon. Now when the latter is stimulated by touch, all the respiratory organs withdraw into the mantle cavity in virtue of a defensive reflex. Now what is important is that this reflex can indeed be modified by learning: in habituation, the animal will learn to ignore a repeated tactile stimulus, whereas in sensitization it will learn to strengthen its response and trigger it for weaker stimuli. Aplysiae can also be conditioned to withdraw their siphons when their tails receive shocks. Thus they present capacities for learning that were until recently considered as specific of vertebrates, in a process that presents a temporal pattern analogous to the vertebrates' conditioning pattern.

These authors suggest that elementary neuronal mechanisms, as found in an aplysia and responsible for sensitization and habituation in this animal's behavior, are also at work in higher-order features of learning, such as first- and second-order conditioning, blocking, latent inhibition etc. In their view, conditioning would thus rely on a combination of cellular mechanisms that are already present in very simple organisms. Now what is of interest for us is the notion of representation that is being used by Kandel & Hawkins, as well as by most neuroscientists: in their view, a particular change in neurotransmitter at a certain locus of sensory neurons ( $Ca^{++}$  channels) provides the animal with "an internal representation of the world". In what sense is it justified to consider the new state of the sensory neurons as representing the world? Should we take it that aplysiae already have mental representations?

Obviously, there is some nomological covariation between the application on the siphon of a sequence of stimuli in a certain temporal pattern and a specific change in the sensory neurons that affect themselves gill and siphon motor neurons. Using the definition for a representation suggested by Fred Dretske (1986), this internal state seems to qualify as a representation because:

- 1) There is a nomological covariation between that state and some other external condition, in virtue of which the former indicates the latter (i.e. carries information on the presence of the latter).

2) The internal indicator has further the function to indicate the external condition ; in other words, evolution selected the neuronal mechanism causally responsible for habituation and sensitization because such a mechanism helped the organisms to react in a more flexible way to changes in the environment that simpler mechanisms such as tropisms, i.e. orientation mechanisms could afford.

Yet we may be reluctant to attribute to the animal something like the belief that "there is in the outer world a non-threatening object in contact with my siphon", or some equivalent expression for it. For one thing, it seems odd to say that aplysiae entertain representations about the world that could be mistaken. Now as was rightly stressed by Dretske (1988), the ability to misrepresent is part and parcel of the capacity of representing. For a representation has the essential feature that it is semantically evaluable ; it can be true or false. Naturally, as is the case for every function, the function which is performed by the  $Ca^{++}$  channels can be misperformed, if, for example, the animal suffers from a lack of calcium. In such a case, the animal could fail to habituate or sensitize. But there is a good reason why we are not tempted to say, in that case, that the animal misrepresented the world. The very idea of a contrast between an inner representing state and an external, represented condition seems superimposed on the description of the learning process by the human interpreter, rather than intrinsic to the animal's internal indicators function. Such a contrast requires as its precondition that the animal be able to semantically evaluate its own representational states, in other words that it should be able to correct them adequately when faced with contrary evidence. Speaking of a 'semantical evaluation' should not suggest that the animal is able, so to speak, to exercise a logical competence and inter alia, apply the concept of truth. It is only meant to suggest that a representational skill involves aiming at veridicality, and using when necessary corrective procedures to achieve veridicality.

One might try to capture the distinction between the kind of crude, "proto-representation" that the aplysia instantiates and representation understood as a contentful, true-or-false, picture of the world, by using Fred Dretske's contrast between what he calls a "phylogenetic" representation and an "ontogenetic" one.

In the former case, a neuronal state has a representational value in virtue of the history of the species to which the individual organism belongs ; in the second case, it acquires its representational value in virtue of the particular history of the individual. As Dretske (1988) shows at length, a representation can influence the animal's behavior in virtue of its content in the ontogenetic variety only. For only then is the representational content meaningful for the individual organism. Only then is the corresponding representation specifically mental.

But even if this distinction can work in the way suggested, we see immediately that this distinction will not do the job we expect from it in our present case. For the aplysia that habituates is the individual aplysia, confronted with its own individual perceptual history. It is through its previous encounters with the stimulus that it reaches the point of habituation (or of sensitization). Replacing this aplysia with another, we would not get the same connection between a given stimulus and a particular motor output : the internal state triggered by the stimulus would have a different representational content. Still, one is not prepared to accept the view that either of the aplysiae (the "learned" and the "naive" ones) represent the world. Accordingly, we are not ready to say that they form mental representations. It seems that conditioning is a function that can involve, or fail to involve, representations, in virtue of the cognitive capacities that are, or fail to be, present in the type of organism under investigation. Therefore we cannot conclude from learning to any involvement of mental function.

It is clear that our philosophical account of intentionality, i.e. of the property of some internal states to be about external conditions, still lacks an explanation of what the difference is between a representation that covaries with some external state and a representation that is about that state. In traditional philosophy, objectivity names the property of a representation that distinguishes in some principled way what belongs to a subject's experience, from what belongs to the object of her experience. Using the term "experience" in the case of an aplysia is obviously problematic: we don't know whether that animal receives information from its receptors in any qualitative format, i.e. whether its perceptual states include any phenomenological content. But we can rephrase the problem of

objectivity in more general terms in order to accommodate this case: is it possible to specify in a non-question begging way the conditions in which a representation refers to an external object (a distal stimulus) and those in which it refers to some sensory input at the level of its own receptors ( a proximal stimulus) ?

As we saw earlier, a mental representation must be such that it can represent (and fail to represent) adequately the world. This strange capacity seems to involve in some sense the ability to "reach out to the world", i.e. to respond to conditions in the world and not simply to some "proximal" state in the organism's receptors. The difference between proximal and distal information is indeed a crucial one, in that it characterizes the way knowledge is being organized in this system. Habituation, sensitization and learning are produced at the neuronal level, by chemical changes in the synapses. This is true whether the information that is extracted is proximal or distal. The difference is not to be looked for in the brain chemistry, but in the type and use of the information available to that particular organism. In a system that relies on proximal information pick up, the world plays no particular role, besides causing some perturbations in the receptors. Only the dynamics in the inputs is relevant to determine the next state in the organism. By contrast, an organism that can pick up distal information, is also able to store its knowledge not only in the form of its own dynamics, but also by relying on the organization of the world itself. Distal representations allow the organism to identify stable objects and changing properties, and to predict events in the world, and not only to adjust its internal states by way of feedback.

Common sense deals with the problem of objectivity in a metaphoric way, where spatial and functional considerations are mingled : one simply contrasts what happens "in the head" and "outside it", or, what belongs to "the system" and what belongs to its surroundings. But commonsense begs the question, by relying on a form of representation - spatial concepts, in particular the opposition within/without - to explain representational skills in non-human minds. As we saw, experimental psychology also presupposes space to distinguish proximal and distal stimuli. Now, spatial concepts fail to offer a solution, when what is at stake is an explanation of this very usage of spatial relations to distinguish different sources of

incoming information. Therefore a naturalistic explanation of animal minds must offer a non-question begging account for how space comes to be, so to speak, internalized by a system ; and for how the internal/external distinction, in some sense, orients the whole process of forming mental representations.

A philosopher who has to solve the problem of objectivity in the context of explaining what mental representations are in non-linguistic animals is loaded with two further constraints : he has to tackle the problem in the most austere way, by relying only on the kind of information which a non-linguistic animal can extract, and by avoiding considerations that would involve the preliminary mastery of mental representations ( the notion to be defined).

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The first, and main, difficulty, is to understand why space offers a privileged way of capturing objectivity. Fortunately, work by Peter Strawson (Strawson, 1959) and Gareth Evans (Evans, 1985) can offer us significant help in this intricate question. They show that all that is required for someone to be able to distinguish what one's own representation from the independent entity that is being represented, is the capacity of forming a particular scheme where the existence of perceptual elements is independent of the existence of one's own states. In other words, this capacity involves the capacity of reidentifying a particular in a reference frame. Your experience is not confused with its object when the disappearance of the object from sight, say, does not prevent you from having the representation of its continued existence. From this observation, Strawson tries to establish whether space as such is a necessary ingredient for reidentifying a particular : would a purely auditory world - a world in which we suppose that no spatial information is available, only a succession of auditory events - would allow one to recognize, when certain regularity conditions obtain, some reidentifiable particulars ? Strawson claims that indeed, all that is required is the existence of a specific order constraining the sequence of instantaneous experiences, an order

that applies over and above the type of relations that derive from the particular nature of each element. In the exclusively auditory world imagined by Strawson for his thought experiment, the kind of formal order required to achieve objectivity could consist in the presence of a master sound, accompanying the individual sounds, and changing pitch level in some systematic fashion.

To this, Evans, in a nutshell, objects that Strawson's auditory particulars would not offer the features of strong numerical discernability that one needs to reidentify a particular thing as distinct from another. Such a world would provide at best the conditions for qualitative identity, but not for numerical identity, which is needed for reidentifying particulars. Evans seems right to insist that something more than pure sequential regularity is needed for a subject to have the sense of an external world, independent from its experience. But Evans adds that only a substantial notion of causation can indeed account for that "independent from" relationship (between my experience and its object, or between my representation and what it is about). According to him, only an organism able to understand that the features of his experience are indeed caused by the things that are at the informational source of the experience can identify independent particulars. If this was true, then we would have to conclude that most non-linguistic animals fail to achieve objectivity, insofar as they fail to possess and use causal concepts. Another consequence of Evans' point is that we could not "naturalize" both intentionality and objectivity, each having in the other its own foundation.

But we are not stuck by Evans' objection to Strawson, for there is another way of showing what gives space a special role in the acquisition of objectivity. The step that Evans misses is that there is another kind of constraints that holds in ordinary physical space, besides the causal organization of facts, and that explains why space is a privileged medium for discerning entities in a numerical way. This other kind of constraints are linked to the way multisensory perceptual inputs are put together in each instantaneous perceptual manifold. Space as intuitively conceived is a kind of empty setting for possible perceptual contents. But it can also be understood as a set of formal properties characterising necessarily the relations between possible inputs. While a perceptual system that processes only

one kind of sensory input cannot establish any kind of relations between kinds of inputs, a more complex perceptual system, harnessed to a more sophisticated set of cognitive functions, may extract formal relations between inputs and exploit them for the purposes of categorizing input spatially. Let us call perceptual conditions of correction such a set of constraints. The point I will make in this paper is that the ability of applying perceptual conditions of correction on the sensory inputs is an essential dimension in the capacity for forming and using mental representations, i.e. representations meeting the criterion of objectivity in the sense indicated above.

Let us take stock. From the case of aplysia, we inferred intuitively that this animal fails to form mental representations. We argued that such a capacity would have implied the capacity of objectivity ; the latter in turn was shown to presuppose a spatial constraint ; but this constraint can be articulated as a set of conditions of correction at the level of perceptual input. Competence in applying these conditions involves in an animal a capacity of correcting its perceptual inputs. Now one important supplementary condition has to be made explicit, before we articulate more finely in what perceptual conditions of correction might consist.

While exploring the role of correction in objectivity, it should be emphasized that the relevant corrections must be effected quite generally, and not as a matter of chance, motivation, or as a consequence of a particular circumstance. This condition is called by philosophers "the generality principle". This principle is quite important for determining the scope of mental capacities, as distinct from other functional capacities. The simple fact that an organism can act in the world and direct responses to external objects and events in a spatially adequate way, or even that it displays an aptitude at correcting its trajectory in the relevant manner, is not enough to attribute to it a capacity for representing objectively the world. Let us use here a parallel with linguistic competence. Every animal owner knows that an animal can "understand" an utterance without understanding the language to which this utterance belongs. When you call your dog with the words "Come here", he may come to you and thus display in some modest way an understanding of your utterance. But you don't want to say that your dog understands English. He

only has a partial, so to speak atomic, capacity, or in other words his linguistic capacity is not structured.

In an analogous way, an organism may have a partial, atomic capacity to control its motions towards or away from a specific location, without having a structured capacity to use spatial information in any systematic way. For example, a coastal snail can rely on geotaxis and phototaxis to reach the point under water that is most adequate for its survival, without having any kind of access to spatial information as such. Just as only a structured capacity can explain language production, only such a capacity can account for the spatial competence relevant for objectivity.

The notion of a structured competence is linked to the constraint of generality, in virtue of which a mental or cognitive competence should be able to deal with any kind of circumstance in its domain; for example a speaker who knows the meaning of "here" must be able to apply the word at any point of space where himself is located. Some philosophers defend the view that the very capacity to move in and act on the world is a sufficient condition for exercising spatial concepts. Having done it elsewhere at length, I will not discuss here the relevance of action to spatial concept acquisition. Let me only say this. It is certainly not enough to say that every being that interacts with objects displays a structured capacity for representing the world objectively. It is clear that the motor program that governs a response can be interpreted in proximal informational terms or in distal ones. A fixed action pattern, for example, boils down to activating some stereotyped motor response in response to predetermined sensory inputs. The success of a movement does not prove that distal information was used, nor that any kind of concept or protoconcept was used, and was causally efficacious in the performance of the movement.

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The idea that there are formal links in the perceptual layout that can be extracted in a tacit, quick and entirely subpersonal way is not new. It brings us at least back to an unjustly neglected era of philosophical enquiry named logical positivism. Whereas Carnap, an eminent member of the Vienna Circle project, defended a view of the possibility of logically deriving knowledge from sense-data that is no longer defensible, he devoted considerable care to extracting the logical relations that hold between perceptual constituents, and made pioneering work in an area known today as multidimensional scaling in the psychology of perception (Clark, 1993). Let me quickly give you some idea of what Carnap (1928) attempted to do in his effort to provide a logical reconstruction of the world. Let us suppose with Carnap that a subject - or some subpersonal system in an organism - can memorize relations of similarity between the sensory elements of his various instantaneous experiences. For example, the green of the thuja appears to him to be like the green of the cypress, the fragrance of the rose similar to the lilac's and different from the hellebore's. With the corresponding extensions of the relation of what Carnap calls "memory resemblance" (in that it contains both information on earlier/later and on more or less similar), the subject builds classes of phenomenal qualities.

But those various classes are distinguishable not only through their phenomenal properties, but also through their formal ones. (In fact, a theorist only has the formal properties, and not the phenomenal ones, and is supposed to reconstruct classes of classes of inputs - like color, visual modality, or pitch, and auditory modality - only using the relations between perceptual events). Among them is the class of properties that constitute the conditions of correction of a perceptual field. Indeed the apparent locations in the perceptual field associated to each sensory quality do entertain a specific relation: each one belongs to an equilocality class.

For example, being located at the center of the subject's visual field can be true of various qualitative properties, such as color, smell, sound. But each of them has to be instantiated by only one token of the same class at that location. Whereas a given fragrance can belong to various locations of that visual field, both inside and across experiences, being at a particular location is a property that holds uniquely

for one of each set of properties at a particular time. An element located at P can have only one color, say red, (and not any other color) ; it has one olfactory property, one texture, one auditory property. All the non-red, (etc.) elements have to be in some other location. This formal property has been called antitypy : it means "either exclusive or identical", and is applied to classes of sensory qualities formed from complex sensory events (using a similarity relation).

Now this apparently complicated property can be grasped in a practical way if

1) there is the corresponding information in the animal's perceptual field, and 2) the organism is equipped with a mechanism able to extract it.

1) The information that an animal uses to extract conditions of correction of his perceptual layout is in part made possible by the world being what it is : objects have stable properties until something changes them, and when some quick change happens, it takes place at a time at a certain location (except in quantum physics, but this should not bother us at the macrolevel where the animal's world is located). If one assume, as I think safe to do, that an animal's environment contains objects and properties as well as individual events involving them, we have the source of the information that the animal can use, if he is equipped to extract it, even in the absence of a capacity for causal reasoning. The information in question is of the kind described above in formal terms : an event has definite spatio-temporal coordinates ; a thing is or is not in front of me ; it has or does not have a particular color, as well as other qualitative properties (audition, smell, touch, etc.). What I touch should be located at the same spot as what I see, if the two share some other invariants (like the spatio-temporal dynamics, or the shape, etc.).

2) Now what kind of capacity can meet all the requirements for a structured competence for checking the conditions of correction of the perceptual inputs ? I want to defend the view that an animal equipped with a perceptual set of mechanisms called "calibration-recalibration" has ipso facto fulfilled one of the crucial conditions for having representations of the world. Such a mechanism in effect is a device for correcting modal-specific inputs when they fail to be spatially coherent with each others. It is obviously a practical skill (or tacit competence), in

the sense that the animal does not need to know that he has those mechanisms to actually use them. This skill is not the result of any learning. It develops very early in the animal's life, as a result of evolutionary pressures for achieving a more reliable perceptual system, i.e. more efficient in action. Concrete case analyses will help me to make this point clearer. In the aplysiae, there is no general mechanism for correcting sensory inputs that would allow them to conform to the formal equilocality constraints. In many invertebrates, the only procedure for integrating sensory inputs is an additive mechanism. Intensities of sensory events in different modalities are summed, and potentiating and depotentiating effects result directly from the inputs being summed.

Now in other animals, such as birds, reptiles, mammals, there is such a general mechanism, allowing the animal to correct its own modal-specific sensory receptors in order to respect equilocality constraints in its perceptual layout. Work by Knudsen (1982) reported in Gallistel (1990) shows for example how a young owl whose correspondence between visual and auditory stimulus representation (in the tectum) has been experimentally distorted (through a plug in one ear) will restore spatial congruence : "the projection of the auditory stimulus onto the tectum gradually changes so as to bring the effect of a sound back in register with the effect of a visual stimulus originating at the same angular deviation" (Gallistel, 1990, p. 481). This calibration process is important for us because it exemplifies one feature that, as we saw, a representational system *must* have in order to be able to form "objective" representations. This mechanism allows the animal to correct its sensory inputs in order to put them into one single spatially coherent perceptual frame. It seems that such a capacity of extracting crossmodal spatially coherent information results in part from the existence of multisensory neurons. Calibration is the operation through which a perceiving subject modifies the reception of one or several matching sensory inputs to exploit coherently the spatial information they contain. Crossmodal adaptation does more than introducing coherence to the content of any particular experience ; it also thereby makes possible an objective perception of the world.

Now let us check whether calibrations does fulfill the conditions that need to be

fulfilled for the representing system to achieve representational objectivity.

### 1 - Calibration as a structured capacity.

Calibration does respect the constraint of generality. Spatial calibration for sensory inputs can be effected from any point, and will apply to any point of the perceptual field. It is also general in the sense that it can be effected from any modality to any other, (when certain conditions obtain, see 3 below). Moreover, the generalisation of the effect of calibration is linear, in the sense that its effects do not depend on their distance from the point where non-matching inputs occurred.

### 2 - Calibration organizes the perceptual field in a way that respects equilocality constraints.

Calibration checks on the equilocality conditions in the sensory content, in order to identify and distinguish from one another possible external events. The rules of correction for local identification are

- a) that there is not more than one spatially coherent sensory event in one point of space at one time, and
- b) that if there are two simultaneous spatially coherent sensory events, they fail to be equilocal.

### 3- Calibration is the capacity of correcting if necessary the inputs when they violate the equilocality constraints.

What are the characteristics of the information that dominates the others ? The dominance of a signal of a certain modality depends less on the intrinsic properties of a sensory channel than on the quality of the spatial information that it conveys. Ordinarily, in man and in most mammals, vision dominates audition. But in particular circumstances, a subject can recalibrate his vision on his audition. The conditions that favor one modality over another have to do with the intensity of the signal and with the quality of the spatial information it conveys. For example, vision fails to dominate audition if the visual field is weakly structured.

The same kind of flexibility according to context is found in the width of the temporal window that is used to fuse together two sensory events as a signal for one single external event. Stein and Meredith, in their book The Merging of the senses, (1993) claim that most intersensory interactions last 100 msec and are optimal for most neurons at this interval. But interaction vision-audition may last up to 1500 msec. This allows identifying as a single external event sensory events issued by distant referents, distance aggravating the temporal gap between visual and auditory stimuli.

These empirical facts illustrate a philosophically important point, that is that veridicality in perception does not depend on any permanent feature in the world being extracted in some fixed way. It depends each time crucially on a gradient of reliability of the various sources of information. That this gradient of reliability is centered on spatial location is not surprising if we think of the requirements of survival related to spotting a predator, a nutrient, or a mate.

#### 4 - Calibration operates in a principled way.

When equilateral stimuli fall inside the receptor field of a multisensory neuron, their combined effect is multiplicative, whereas non equilateral stimuli will fall inside the receptor field of an inhibitory multisensory neuron, which will allow more sensory disparity to be experienced. This effect allows a predator or a prey to be sensitive to food or danger even in low intensities of plurimodal signals. But all that needs to concern the philosopher is that the capacity for (re)calibration is structured in a reliable way. Calibration is the one tiny mechanism that fits all the intentional pieces together, and allows an animal to maintain a coherent representation of a world of independent objects and events.

Whatever their fine-tuning for habituation, sensitization and conditioning, Aplysiae do not have the proper means for identifying spatially incoherent incoming signals. If for example, we fiddle the proximal stimuli in an aplysia or in a coastal snail, the poor animal will have to go with the evidence it has; it will be

steering its way using simple rules such as : " go away from the light when crawling upon a horizontal surface ; go to the light when crawling hanging down from the underside of a horizontal surface" (Gallistel, 1980, 158). But a bird whose one ear is plugged can overwrite the proximal stimuli in order to maintain its access to distal stimuli. As we saw, he does it by using perceptual recalibration. This device changes the very nature of representational capacity : the information being used is not any more centered on the perceiving subject that uses it ; it is centered on the distal source that provides it. This device brings about representational objectivity : thanks to it, a mind can think about the world in a detached way. Now such a model has to make clear that it does not fall prey to circularity : the burden on us is to show that recalibration does not involve any use of a mental representation.

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The threat of circularity is, as we saw, one of the main difficulties that one faces when trying to explain intentionality. If it was the case that perceptual conditions of correction presuppose conceptual ability, then we would be caught in a vicious circle : in order to be able to recalibrate a sensory event, an animal should already have categorized that object or event. If this was the case, calibration would suppose that representations are already at work, and could not without circularity contribute to forming a representational capacity.

Specialists in the alignment of sensory maps now consider that the spatial matching effected between crossmodal data is innate. Blind babies orient their eyes in a way that is spatially coherent with the sounds they hear. It is now hypothesized that the mechanism of crossmodal adaptation used in recalibration was selected because it "lends coherence to, but is independent of, the content of any particular experience" (Butterworth, quoted in Stein and Meredith, 1993, p. 14). In the case of spatial information, independence is grounded in the

separation of neural pathways for processing spatial and semantic information : dorsal cortical neurons deal with location of events, and ventral ones deal with the semantic properties of those events. Now what is of importance for us is that finding the location of an event is what makes possible the grasp of numerical identity of that event. This in turn allows the fact that other properties can hang on that numerical identity. We here have the neurophysiological ground for the functional distinction between an object and its properties.

Now someone could object that, even though there are separate pathways for spatial and semantic information, still a perceiving animal tries to grasp the characteristics, useful or dreadful, of an external event. In that case, it must already have categorized that object or event to attribute to it a certain probability of appearance at a certain location. This objection would be relevant if recalibration depended for its operation on an organism's expectations. Some authors, like Welch and Warren (1980) made the hypothesis that human subjects recalibrated their perceptual inputs because they were expecting to perceive some particular event or object. Again, if this was the case, calibration would suppose that representations are already at work, and could not, without circularity, be said to contribute to forming a representational capacity. But this hypothesis turned out to be false. Work on the ventriloquism effect in human subjects comforts the view that recalibration is a modular, cognitively impenetrable mechanism. Radeau and Bertelson (1977) show that the same adaptive after-effects obtain after crossmodal conflict, whether the situations used are realist or not, and whether the subjects are told or not that there is a spatial conflict in the sensory inputs. ( In a realist situation, subjects see a face and listen to a voice, or see the hands of a musician and hear the music they produce. In a non-realist situation, subjects see meaningless lights and sounds. Signals in both cases are synchronous but spatially separated by 20°). The current state of research should then lead us to take calibration to be a purely modular, perceptual, non-conceptual ability. Now let us try to understand what is the connection between that perceptual mechanism and intentionality.

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The contrast between an aplysia and, say, an owl, in respect to their representational capacities, will help summarize why there are at least two very different types of cognitive capacities in animals. The very first step for having representations, and therefore a crude form of cognition, consists in the ability to extract regularities in the world, and to use them in the control of one's behavior. The animal possesses devices that respond to external stimuli according to their intensities ; it may also integrate those intensities, and monitor its output in adequate preestablished ways. For example, the aplysia will withdraw its siphon in order to prevent functional damage. Or the coastal snail will make its way to the surface using several taxes. But all the information that the animal uses is located at the surface of its receptors. It can only process proximal stimuli, and therefore fails to respond to external facts. What it does is adjust selectively to its environment on the basis of rudimentary input-output correlations. Although the capacity for integrating inputs and for elementary learning (habituation and sensitization) allows some kind of flexibility in behavior for reacting to present inputs, still the animal does not have any capacity for storing information on the world, neither can it plan to act on it. The second step in the evolution of representational capacity puts an animal in a position where responding to external conditions as such is not any more a structural impossibility. The animal now possesses a perceptual system that has the means for extracting invariants in the world that can be of significance for its own survival. It can calibrate its own receptors to achieve a spatially coherent picture of the world, and if necessary, recalibrate them. Now this perceptual capacity does not provide yet such a system with mental representations.

Having a system of mental representations obviously goes beyond having a spatially coherent perceptual layout. But an animal that already has "objective" perceptual and mnemonic capacities is not far from acquiring the ability to extract from inputs the types of invariants that should influence present and future

behavior, i.e. to make concepts. Once spatial organization of perception has been reached, proto-objects and proto-events are up for grabs. A proto-object is some invariant in space, with several modal properties ; a proto-event is some invariant in time, with particular dynamic properties affecting a given object. Having these anchors is the source of a substantial modification for learning and planning capacities. It is one of the essential conditions that make mental representation possible.

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